ERP
Avraham Shtub • Reuven Karni

ERP

The Dynamics of Supply Chain and Process Management

Second Edition
<table>
<thead>
<tr>
<th>Avraham Shtub</th>
<th>Reuven Karni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty of Industrial Engineering &amp; Management</td>
<td>Department of Industrial Engineering &amp; Management</td>
</tr>
<tr>
<td>Technion - Israel Institute of Technology</td>
<td>Shenkar College of Engineering &amp; Design</td>
</tr>
<tr>
<td>32000 Haifa</td>
<td>52526 Ramat Gan</td>
</tr>
<tr>
<td>Israel</td>
<td>Israel</td>
</tr>
<tr>
<td><a href="mailto:shtub@ie.technion.ac.il">shtub@ie.technion.ac.il</a></td>
<td><a href="mailto:rkarni@mail.shenkar.ac.il">rkarni@mail.shenkar.ac.il</a></td>
</tr>
</tbody>
</table>
We would like to dedicate this book to our loving wives Doreen Karni and Ailona Shtub, to Reuven Karni’s sister, Avis Goldberg and to Avy Shtub’s late brother, Israel Shtub.
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Preface

To an increasing extent, corporations are recognizing that successful management is based on three basic functionalities; and these organizations are discovering that a focus on customer needs is effective only if these functionalities are designed and managed to meet those needs. The operations function extends from acquiring raw materials to fabricating parts, to assembling products, and to making sure that the right products, in the right quantities, are ready at the right time for delivery to the customer. A systems perspective can enable us, in ideal circumstances, to fashion an operations function like the inner workings of a finely tuned machine. The service function extends from acquiring customer orders to monitoring progress, to delivering the product to the customer, to providing in-house or field service for maintaining the product, and to providing advice and help to the customer on how to use the product. A systems perspective can enable us, in ideal circumstances, to ensure that our product will be used by the customer in the best way to help him achieve his goals. The enterprise or business process function visualizes the organization as a set of business processes representing the working and flow of goods, services, information, decisions and control throughout the enterprise. A systems perspective can enable us, in ideal circumstances, to ensure that these processes cooperate effectively to deliver results or deliverables, and thus achieve the goals of the enterprise.

Life would be uninteresting without change, however; so we can be thankful that the functioning of the organization is dynamic in nature. We alter one element – to improve or upgrade it – and others are affected. The customer or the outside environment introduces variability into one or more points; and we watch the ripple effects spread across the organization over time. These system behaviors can be difficult to grasp – and even more difficult to predict or manage.

In addition to understanding the dynamic, interactive and integrated nature of the operations, service and process systems, it is important to understand and to practice using the tools supporting the management of these systems. Teaching the concepts of modern information systems and the processes they support, and their ability to serve the customer in order to enhance competitiveness, constitute an important challenge to any IE or MBA program.

Modern information systems combine models (production processes, service processes) in a model base, data (resources, products, schedules, orders) in a data base and knowledge (methodologies, decision processes) in a knowledge base. They support the perspective of an enterprise-wide approach to organizational activity, be it focused inwards on the provision of a product or service, or interfaced outwards with suppliers and customers. Enterprise Resource Planning software
systems provide comprehensive management of financial, manufacturing, sales, distribution, service and human resources across the enterprise. The ability of ERP systems to support data “drill down,” to eliminate the need to reconcile across functions, and to integrate the working of the operations, service and process functions is intended to enable organizations to compete on the performance along the entire supply chain. To utilize these capabilities, managers have to learn how to manage processes using the model, data and knowledge bases in the ERP environment. Recognizing this need, modern schools have installed commercial systems for production process simulation, business process design, and ERP. The amount of time required to teach and learn all the screens and functions of these tools is enormous as they are not designed a priori as teaching media.

Until now, there has not been an effective mechanism for teaching students and professionals to understand the dynamics of operation systems by illustrating how production, service and business processes are designed and how ERP systems are used. This book and the accompanying software will fill this need. The book has been written with an emphasis on manufacturing firms, but the principles it demonstrates are transferable to more service-oriented environments. With this in mind, both manufacturing and service operations issues have been included in the problems at the end of each chapter. The book and the accompanying software have been designed for use in academic and executive programs aimed at teaching students, and professionals to understand how integrated operational systems work.

In terms of the book’s use as a course book, a course on planning, operations and control systems would probably be the ideal place in business school settings. Some basic understanding of operating systems is needed by the reader. In an industrial engineering school, in addition to these, the book may give students their first, and perhaps only, introduction to business issues such as market demand and relationships with customers and suppliers.
The map and its decomposition provide an excellent integrative picture of the SCM and ERP views of enterprise operations (© 2008).

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Table 3.7: Process classification framework™, abstracted from Process Classification FrameworkSM (PCF) version 5.0, American Productivity and Quality Center (www.apqc.org/pcf). It is highly recommended that the reader download the PCF and study it as an organized framework for business processes in the manufacturing and service industries (© 2008).

Table 8.8: “Uses of a process model” from System Engineering, Volume 5 (3), Browning TR, “Process integration using the design structure matrix,” 180–193, with permission of John Wiley & Sons, Inc. (© 2002).


Table 13.1: “Business process improvement patterns” and Table 13.2: “Business process improvement impacts,” adapted from Omega, Volume 33 (4), Reijers HA and Mansar SL, “Best practice in business process redesign: an overview and


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1 Introduction

1.1 The Theme of this Book

This book is designed for use in academic and executive programs, which are aimed at teaching students how integrated systems work. The book assumes no prior knowledge in operating systems; we recommend this material as a textbook for the basic Operations Management course or as a textbook for courses on ERP systems and the development of business processes. A course on integrated planning and control systems would probably be the ideal place in a business school setting. In an industrial engineering school, this book may give students their first, and perhaps only, introduction to business issues such as market demand and supplier relationships.

1.2 Operations Management Defined

Operations management is a term used to define all the activities directly related to the production of goods or services. Operations Management is therefore the function involved in delivering value to the customers. For many years the focus of operations management was on intra-enterprise operations. With the advancement in supply chain management inter-enterprise operations became as important as the intra-enterprise operations.

Traditionally the operations manager managed the activities directly related to the production of goods or services. Legacy information systems supported the operations managers’ activities quite well. The pressure of competition and the development of cost-effective computers and software (MRP – Material Requirement Planning Systems) gradually replaced the legacy information systems as the backbone of operations management. Further development in information systems along with globalization shifted the focus to ERP systems designed to support the management of the entire organization.

Management is a combination of art and science. Shtub et al. (2004) list seven functions of management: planning, organizing, staffing, directing, motivating, leading and controlling. In this book we focus on three of these functions: planning, directing and controlling of the flow of information, material and services from raw material suppliers, through factories and warehouses, to the end customers.
Due to its central role in most organizations, numerous books have been written on Operations Management, and a course in this area is required in most MBA (Master in Business Administration) and in undergraduate I.E. (Industrial Engineering) programs. Some books on ERP systems are available on the market. However, there is a need for a book that focuses on the support ERP systems provide to the intra- and inter-enterprise operations management – the management of the supply chain.

Organizations are frequently divided along functional lines. The underlying assumption is that the operations people do not have to deal with aspects of marketing, finance, and purchasing. Consequently, they need little knowledge about these functional areas while people in these functional areas need to know little about Operations and its management.

Supply Chain Management (SCM) is an effort to apply “a total system approach to managing the flow of information, material, and services from raw material suppliers through factories and warehouses to the end customers” (Hill 2005).

Enterprise Resource Planning (ERP) systems are information systems that handle the data, information and communication requirements of the whole organization. Proper use of ERP systems is a key to successful Supply Chain Management (SCM).

The introduction of ERP systems and the efforts to manage the whole supply chain made the integration of the enterprise management efforts a central issue. The focus shifted from intra-enterprise to inter-enterprise; and consequently, the traditional functional organizations and legacy systems are no longer effective in managing the supply chain.

A new approach is emerging – a process-based organization in which processes are performed by members of different functional units supported by ERP systems. In their pioneering book, Hammer and Champy (1993) suggested the reengineering of business processes as a new approach to inflicting changes on organizations. According to Hammer and Champy, there are five “core processes” in a typical organization:

- The development process – from an idea for a new product or service to a working prototype.
- Preparation of facilities – from a working prototype of a new product or service to the successful completion of design, implementation and testing of the production/assembly or service facility and its supporting systems and resources.
- Sales – from the study of the market and its needs to the receipt of a firm customer order.
- Order fulfillment – from a firm customer order to the delivery of the required products or services and payment by customer.
- Service – from customer call for a service to the fixing of the problem and a satisfied customer.

Based on this approach, a new role of operations management is emerging: managing the order-fulfillment process from customer order to the delivery of the
goods and services required to achieve customer satisfaction. This process is integrated as it involves the marketing function – dealing with customers; the purchasing function – dealing with suppliers and subcontractors; and traditional operations – managing the resources of the organization. This process is dynamic as customer orders may come at any time and for any combination of products and services; customer orders may be modified after reception; while the arrival of raw material from suppliers and the availability of resources are subject to uncertainty and changes over time. We define the management of the order-fulfillment process as Integrated Production and Order Management – IPOM.

### 1.3 The Need for Integrated Production and Order Management

The rapidly changing environment, in which the life cycle of products is short and global competition is fierce, forces most organizations to develop adequate policies, tactics and information systems in order to survive. In some industries new product models are introduced every year or two. Technology is ever changing; and customers’ needs are changing along with it. In today’s markets, flexibility, quality, cost and time are the four dimensions or cornerstones of competitiveness leading to the survival of an organization and to its success.

Many books and articles discuss time-based competition (Blackburn 1991; Zhang et al. 2007), quality and its management (Deming 1982; Matsubayashi 2007), cost and flexibility (Zhang 2007). To balance the four dimensions of competitiveness a dynamic approach to Operations and proper integration within and between the different disciplines or functions of the organization are required.

New managerial approaches are developed to cope with today’s markets. In the product development process organizations are able to develop new products to satisfy changing customer needs in a short time by using Concurrent Engineering (Nevis and Whitney 1989) and Integrated Product Development Teams (IPT) (Leenders 2007), which are integrated, dynamic approaches to new product development.

Concurrent Engineering is based on new product development teams composed of experts from different functions: marketing people who are aware of the customers’ needs and expectations; engineers and designers who know how to translate the customers’ needs into specifications, blueprints, assembly instructions etc.; experts in the operations and maintenance of the new product who are focusing on developing a quality, cost-effective product that gives the customer the best value throughout its life cycle. By assigning experts from different functional areas into a team with common goals and objectives, an integrated, dynamic approach to new product development is made possible.

Concurrent Engineering is a team-based, integrated, dynamic approach to new product development. A similar approach is needed for the order-fulfillment process: an Integrated Production and Order Management approach dealing with the
delivery of products or services. This order-fulfillment process should yield a fast response to the changing markets, shorter lead times and improved cash flows as a result of efficient use of human resources, money tied in inventories, equipment, information and facilities.

Organizations attempting to cope with the new environment are adopting philosophies such as Just-In-Time (JIT). This approach (Monden 1983) is based on low in-process inventories, cross training of workers to achieve workforce flexibility, and high flexibility of machines and equipment that can change from one product to another in a very short time (reduced setup time). Just-in-time is a process-oriented approach – the whole process is integrated by the flow of information through a special set of cards called Kanban as explained in later chapters. When implemented successfully, JIT increases the competitiveness of the order-fulfillment process; but the approach does not fit all types of organizations and it does not fit all types of competitive environments. Furthermore its implementation is difficult and not always successful. Organizations trying to adopt JIT report mixed results – success depends not only on good planning and execution of the changes into the new process but also on the kind of industry, the technology used and the competition in the market (Fullerton et al. 2003; Takahashi 2005).

Another approach used to improve flexibility in operations is based on the Pareto Principle, according to which only few of the resources in most manufacturing organizations have a limited capacity and therefore limited flexibility. Management should focus on the scarce resources (bottlenecks) and use their available capacity in the best way to maximize overall performances. This approach known as Drum-Buffer-Rope or DBR was developed by Goldratt and Fox (1986) who extended it later to “The Theory of Constraints” (Umble et al. 2006).

A third approach is based on dividing the manufacturing organization into a number of focused “cells” each of them specializing in a small number of similar products. This approach known as Group Technology or Cellular Manufacturing is based on the assumption that it is possible to achieve better performances by managing a small, focused operation. By locating all the facilities required for manufacturing and delivering a family of products in a dedicated cell and by assigning all the people involved in the order-fulfillment process of the product family to this “focused” cell, an efficient, well managed process is formed. The difficulty with this approach is in the need to physically move machines and other hardware to the same location and to relocate equipment when the family of product changes (Hyer and Wemmerlov 2002). A partial solution is to develop “virtual cells” based on proper use of information technology (Basu et al. 1994; Basu et al. 1995).

Other approaches to Operations Management such as agile manufacturing, constant work in process (CONWIP), synchronized manufacturing, and lean manufacturing are discussed in the literature. Each approach represents an attempt to improve competitiveness by integrating and synchronizing the order-fulfillment process (Gershwin et al. 2007).

Along with the effort to develop new managerial approaches, information systems that support these new approaches were developed. The early transaction
processing systems evolved into Material Requirement Planning (MRP) systems that support production planning and control. Integration of the MRP logic with modern Data Base Management Systems (DBMS), Decision Support Systems (DSS) and Management Information Systems (MIS) yield the new generation of Enterprise Resource Planning (ERP) systems that manage the data and information requirements of the whole organization. These systems provide the support required for a new, process-based approach to management.

ERP systems provide the information and decision support that management was trying to get by other means, such as Kanban cards in JIT or the ability to watch the whole process in Cellular Manufacturing. With ERP systems it is possible to implement Group Technology concepts without the physical relocation of machines, to implement JIT without Kanban cards, or even better, to design an order-fulfillment process that combines the most appropriate of all the techniques discussed earlier.

Integrated Production and Order Management (IPOM) is based on a team approach similar to the new product development team in concurrent engineering. An integrated team that handles the order-fulfillment process and is supported by an advanced ERP system is the cornerstone of IPOM.

1.4 Summary: Viewpoints of Enterprise Operation

To summarize: this book is based upon the viewpoint of an enterprise as a system of business endeavor within a particular business environment, comprising an assemblage of processes, which represent the functioning and flow of goods, services, information, decisions and control throughout the enterprise. These cooperate to carry a product through its entire life span from concept through manufacture, logistics, distribution, sales and service; and to achieve a set of enterprise goals. These processes are divided into business, industrial and informational domains.

The business domain of the enterprise covers the following activities or processes: policymaking, economic, commercial (purchasing, marketing and sales), financial, human resource and administrative activities. The industrial domain relates to activities dedicated to the production and maintenance of commodities – goods and services: research and development, industrialization, operations (manufacturing, service provision), logistics, and after-sales service. The informational domain encompasses data handling, information and knowledge dissemination, and decisionmaking. All these combine and collaborate to support the central activity of the enterprise: the order fulfillment process – from a firm customer order to the delivery of the required products or services and payment by the customer.

The process viewpoint is not the only perspective for visualizing an enterprise; other perspectives include marketing, the customer, and information and decision-making. These can be summed up as follows:
1 Introduction

• Process perspective
  What  what must we do to produce products or provide services (enterprise resource planning processes)?
  Who  how should we organize to produce products or provide services (roles)?
  Where where must we be to produce products or provide services (plant or service location)?
  Where how can we distribute products or services (channels and locations)?
  When how can we manage production (product or service life cycle)?
  Why  how do we measure success (efficiency, punctuality)?

• Marketing perspective
  What  what can we sell (products)?
  Who  who will buy them (customers)?
  How  how should we organize to sell them (roles)?
  Where where will they buy them (market)?
  When for how long will they buy them (product life cycle)?
  Why  how do we measure success (sales, profits)?

• Customer perspective
  What  what must we do to attract customers (customer relationship management)?
  Who  how should we organize to attract customers (roles)?
  Where where will they come to buy products (channels and locations)?
  When for how long can we manage customer loyalty (customer life cycle)?
  Why  how do we measure success (sales, satisfaction)?

• Information and decisionmaking perspective
  What  what must we do to gather information and make decisions (information and knowledge processes)?
  Who  how should we organize to gather information and make decisions (roles)?
  Where where must data be gathered and information and decisions disseminated (input-output locations)?
  When how can we keep information and decisions updated and relevant (information life cycle)?
  Why  how do we measure success (appropriateness, applicability)?

1.5 Operations Management Frameworks

In this book we describe and utilize three central frameworks for ERP and operations management: business functions, business processes and IT support:

• Business functions relate to centers of professionalism or expertise within the organization
• Business processes relate to activities – actions and decisions – carried out by employees within the organization
• IT support relates to the computerization of data-based and knowledge-based activities and transactions

These frameworks require the operations manager to realize that:
• All business operations – not just manufacturing – involve processes
• Processes often cross functional boundaries
• IT must provide support to all business processes
• IT must be aligned with the processes it supports
• The organization, processes and IT systems must be integrated, coordinated and aligned across the enterprise (and even along the supply chain) and must be viewed and managed “as a whole.”

1.6 Modeling in Operations Management

Problem solving and decisionmaking is an important part of the Operation Manager’s role. Textbooks and Operations Management courses are frequently organized according to problem types. Thus, in typical Operations Management textbooks there are chapters dealing with inventory-related problems, problems of scheduling production, problems in purchasing, etc. These problems are analyzed by an appropriate model and/or discussed using a representative case study.

A model is a simplified presentation of reality. Most real problems are very complex because of sheer size, the number of different factors considered and the dynamic, stochastic (uncertain) nature of the interactions between many of these factors. By making simplifying assumptions, it is possible to develop a model of the problem which is simple enough to understand and analyze, and yet provides a good presentation of the real problem.

Many models are mathematical, for example mathematical programming which defines an objective function and a set of constraints. Such models are solved by adequate techniques to find the values of the “decision variables” that satisfy the constraints while maximizing (or minimizing) the objective function.

Conceptual models are also common. The organizational structure chart is a frequently used conceptual model describing the relationships between different components of the organization.

When the level of uncertainty is high, statistical models are used to represent the stochastic nature of important factors. Techniques like regression analysis and stochastic dynamic programming are designed to analyze such models.

By analyzing the model, decision-makers try to find a good solution to the problem represented by the model. This solution may be useful for the original problem if it is not too sensitive to the simplifying assumptions on which the model is based. Thus, it is important to carry out a sensitivity analysis on the solution obtained to assess its usefulness for the original problem. The relationship between the real problem, the model and the solution are illustrated in Fig. 1.1.
Fig. 1.1 The use of models

The model-based approach to decisionmaking is quite common and many of the software packages for Operations Management are based on this approach. These models are usually static in the sense that they assume a given value for each input parameter, while in reality many of the input parameters are dynamic – their value is a continuous function of time. Furthermore many of the input parameters are random variables that represent uncertainty in the real problem.

Decision makers adopting the modeling approach have to close the gap between the static models and the dynamic nature of many problems. Implementing the static models periodically whenever a new decision is necessary does this. Thus, it is convenient to classify decisions into routine decisions and one-time or non-recurrent decisions.

Routine decisions are repetitive in nature and can be analyzed by an appropriate model fed by the current set of input parameter values. Inventory management is a typical example where orders for new shipments are issued when the current inventory level drops below the “reorder point.” An appropriate model calculates the value of that “reorder point.”

One-time decisions are not repetitive and require special management attention. A typical example is the decision to sign a long-term contract with a major customer committing a substantial proportion of a factory’s output to that customer over a
long period of time. In this case marketing, economical and operations factors are involved and in most companies management makes an ad-hoc decision.

Commercial software packages for Operations Management are designed to automate recurrent decisions by implementing appropriate policies. Many of these packages support management by providing data important for the one time or ad-hoc decisions as well. Thus, for example, automatic replenishment orders for inventory items are issued by some software systems based on MRP logic. These systems also provide historical data that is essential for the development of policies and supports estimates regarding the cost of labor and material thus helping management in bidding and marketing.

1.7 Modeling in Process Management

Process management, incorporating both action and decisionmaking, is also an important part of the Operation Manager’s role. As processes are so pervasive, a large number of factors need to be modeled in order to obtain a complete picture of business and industrial activity. A well-known “multi-view” framework is that of the “Architecture of Integrated Information Systems” (ARIS) (Scheer 1998b) (Fig. 1.2). It portrays five views that need to be modeled:

- **Organizational units** are usually modeled by an organization chart. However, business process applications use the role concept (see Sect. 3.2 (h)). Roles describe the capabilities a person must have to perform a certain job position. Thus the model must delineate roles within the organizational units.
- **Data and data flow** are first modeled as clusters, which are inputs or outputs of processes. During design these are detailed in terms of the entities and structure of the data clusters. Finally they are modeled using data flow diagrams.
- **Functions** or high-level tasks (see Sect. 3.2 (b)) are modeled using the enterprise process model concept (see Sect. 3.6), which uses a three-level function tree to categorize processes to be implemented manually or through a software system such as ERP.
- **Business processes** or detailed task sequences are modeled using flowcharts, which specify triggers, actions, decisions and sequences (see Sect. 6.3 (b)); or event-driven process chains (EPC) (Scheer 1998a) which specify events (start and stop states), tasks, organization units (roles), information objects (input and output), connectors (sequences) and branch and merge logic (e.g., AND, OR).
- **Outputs** specify the business objects created or otherwise transformed by the processes: information, documents, physical materials, etc. These are specified, rather than modeled.
1.8 The Dynamic Aspect: Simulation and Systems Dynamics

The modeling approach is static in nature, i.e., it is based on taking a “snapshot” of the organization and its environment and dealing with this momentary situation. In reality, time plays a very important role in the decisionmaking process. The values of the different factors in the organization and in its environment change
over time. Information is also gathered over time and inventories of materials, as well as availability of resources, are time-dependent. New competitors enter the market and new products are developed, etc.

Furthermore, the whole planning process is performed within a specified time frame. In long range or strategic planning, Operations Managers deal with the design of manufacturing facilities, locating those facilities and acquiring long lead-time resources. In the short range, the focus is on the utilization of available resources to compete in the market and to satisfy customers.

During the 1960s, the approach of Systems Dynamics (Forester 1961, 1968) captured the attention of many researchers as a new tool for analyzing the dynamic nature of managerial processes. Today, advanced simulation tools are based on the dynamic approach of Forrester (Ithink, Powersim, Vensim; see Sterman 2000).

Forrester assumed that most processes involve two types of entities – levels and rates. Rates cause changes in the levels while the levels serve as state variables, i.e., the value of the levels at a given point of time determine the state of the system.

This concept is best illustrated by an example. Consider a simple inventory system such as the inventory of paper for your printer. In this system the new inventory level is determined by the old inventory level and the rate of printing. The decision to purchase new paper is based on the current inventory level. When a new order arrives the inventory level increases and the process starts again. When the rate of printing is a stochastic variable (i.e., it is subject to uncertainty) most of us keep some safety stock. We do it by purchasing new paper when the current level of inventory is still enough for a few days of printing.

Using these concepts, it is possible to model complex systems as a collection of rates, levels, and other “auxiliary variables” that interact with each other. This Systems Dynamics modeling approach is useful for analyzing and understanding the dynamic nature of systems.

Most simulation models developed by tools such as Arena (Kelton et al. 2004) also capture the dynamic nature of systems. These general-purpose simulation languages are user friendly, powerful and flexible. Simulation is considered an important tool for the analysis of complex systems.

When simulation is used as a decision support tool, it should capture three aspects of the real world:

1. The flow of material
2. The flow of information
3. The decisionmaking process.

Thus, in a simulation of an inventory system, part of the simulation is devoted to the description of material flow as it enters, is stored and leaves the system. Each unit of material is “generated” by a pre-specified process (that can be stochastic, i.e., random, or deterministic). The model controls the unit movements in the system. In some models the units of material are “tagged” to facilitate a trace mechanism designed to reveal the history of each unit in the system.
Information regarding the flow of material in the system is collected during the simulation run. The exact time that a tagged unit is generated, moves or leaves the system can be traced. Summary statistics is also available in the form of histograms or frequency tables that summarize the per unit information. The data collected during a simulation run is the basis for understanding and analyzing the inventory system.

The trigger for moves in the system is the decisionmaking logic built into the simulation model. Such logic, for example, can be based on a simple reorder point model that issues an order for new material whenever the inventory level drops below the “reorder point” like the inventory of printing paper discussed earlier. By specifying the decisionmaking model, its input parameters and its logic, decisions are built into the simulation model and are automated during simulation runs.

The advantage of this approach is that a simulation run can be performed offline, i.e., when the decision makers are not present. Thus, it is possible to run large simulation models at night and receive the results the next morning for analysis.

The disadvantage of this approach is that in reality many decisions are based on intuition and experience and it is very difficult (or impossible) to automate these decisionmaking processes. Furthermore, Group Decisionmaking is a very complex process and so far our knowledge of this process is not sufficient to model it with reasonable accuracy.

1.9 Overview of the Book

This book presents a new approach to the teaching of ERP systems and business processes. The proposed Integrated Production and Order Management (IPOM) approach is process based and ERP supported, unlike the traditional functional based Operations Management approach. Three processes are discussed in this book: the order-fulfillment process – from the reception of a customer order to the supply of the right goods on time, the required quantities and at a competitive cost; a telesales service process; and the operations of the front desk of a hotel.

Each of the following chapters presents a concept of IPOM:

Chapter 2 – Organizations and organizational structures: The focus of this chapter is on the difference between traditional functional organizational structures and the process-based approach of IPOM. The chapter discusses the functional structure and compares it to the project-based structure. Each organizational structure is presented, along with its advantages and disadvantages. The matrix structure is also presented as a compromise between the functional structure and the project structure. Concurrent Engineering is discussed as a process-oriented approach to new product development. The idea of a multidisciplinary team responsible for a complete process and supported by a common information system, which is demonstrated by Concurrent Engineering, is later implemented in the order-fulfillment process.

Two common layouts or physical structures for manufacturing facilities are discussed next – the job shop and the flow shop. The relationship between the
The role of Operations Management in the functional organization and its interaction with other functions is discussed in order to explain the need for a different approach – the process-based approach.

Chapter 3 – Enterprise process modeling: This chapter focuses on the creation of a process viewpoint of a given organization. The enterprise is visualized as a set of business processes representing the functioning and flow of goods, services, information, decisions and control throughout the enterprise. These processes cooperate to deliver results or deliverables, which achieve the goals of the enterprise. They are clustered into coherent groupings, or business functions. The modeling process (i.e., the compilation and categorization of the enterprise processes) starts from a large set of functions and processes, usually obtained from industrial-sector-specific or professional consortium models provided directly by ERP vendors, by professional consortia, or through Internet searches. Examples of such models are provided in the chapter. The model designer abstracts those functions and processes relevant to the specific organization. He then performs a gap analysis to determine the differences between the abstracted model and further specific functions and processes existing in the organization, which are then added, resulting in an enterprise process model specific to the organization. We illustrate the modeling procedure through a detailed case study of Hotel Front Desk operations. 136 hotel front desk processes were obtained from an Internet search of “hotel management systems”; the final model corresponding to the case study scenario comprises 72 processes.

Chapter 4 – Information and its use: This chapter focuses on the relationship between information, decisionmaking and the ERP concept. The difference between recurrent decisions that can be automated by adopting a proper policy and one-time decisions that need special management attention and ad-hoc actions is discussed. The message is that a well-designed process is accompanied by a system that collects relevant data and presents it as useful information that is the basis for policies and actions.

The terms data and information are discussed first; data sources, data processing and data storage and retrieval are defined and explained.

The concept of MIS – Management Information System – is presented next, with an emphasis on the ERP approach – separation of the data base from the model base. Data sharing among different functions in a functional organization is also discussed.

The accounting system is used as an example of a typical MIS and the concepts of data collection and processing are illustrated. Using this example the problem of setting goals and performance measures in the functional organization is discussed. Alternatives to the traditional accounting system are presented to show how the same raw data can be collected, processed, and analyzed by different models. The quality of information and relevant performance measures are also discussed.

Uncertainty and the difficulty of forecasting future data needed for decision-making are the subjects of the next section. The idea of time series analysis and
decomposition of a time series into its major components are explained along with techniques such as moving averages, weighted moving averages and exponential smoothing used for forecast. The trade-off between the cost of data and its accuracy is discussed and common measures for forecasting errors such as BIAS and MAD are presented.

Chapter 5 – *Marketing considerations*: The relationship between the order-fulfillment process and Marketing in a functional organization is the link between the customer and the delivery system. In the integrated order-fulfillment process, from a strategic viewpoint, the question facing the order-fulfillment team is how to reduce cost and lead time while increasing the service level. Policies such as “make to stock,” “make to order” and “assemble to order” are discussed and their effect on cost and lead time are explained in this chapter.

The interface between marketing and the order-fulfillment process is the MPS – Master Production Schedule; the concept of MPS and its management are explained and discussed. Competition and its pressure to cut lead times (time-based competition) to increase quality (quality-based competition), to cut cost (cost-based competition) and to increase flexibility to changing customer needs and market conditions are discussed next. The relationship between the Operations strategy and the achievement of a competitive advantage is illustrated by the Just-In-Time (JIT) and the Drum Buffer Rope (Goldratt and Fox 1986) approaches.

Chapter 6 – *Purchasing and inventory management*: In this chapter purchasing policies are discussed. Common models for inventory management are presented along with their underlying assumptions, and a discussion of their advantages and disadvantages. The link between production planning and control and purchasing is explained. The concept of a value chain that links suppliers and manufacturers to the market by means of a logistic system is the backbone of this chapter. Focusing on Value Added activities along the supply chain, and understanding the significance of reliable sources and shorter lead times are two of the chapter’s objectives. By introducing the concepts of inventory costs – capital related costs, costs of inventory management operations and cost of risks related to inventories – the reader gets a feeling for the economic performance measures used for inventory management. Other performance measures such as inventory turns and service level are also discussed.

The question of outsourcing – make or buy – is presented along with a discussion on break-even analysis.

Dealing with suppliers is an important issue. Establishing a long-term relationship with a supplier and information sharing with suppliers are commonly used techniques to improve the supply chain performances. Questions of economies-to-scale and long-term commitments are also presented.

The static nature of most inventory management models causes implementation difficulties in a dynamic, uncertain environment. Thus, buffers are used to protect the manufacturing system against shortages of raw materials and supplies resulting from uncertainty in demand and in supply. The concept of buffer management and control is introduced and the effect of such buffers on the performances of the systems is explained.
Chapter 7 – Scheduling: Scheduling is an interesting example of a dynamic aspect of operations that is frequently analyzed by static models. The common scheduling technique – implementation of priority rules – is usually based on the assumptions that no new jobs enter the production system during the planning period, and resource capacity is a deterministic variable.

The chapter starts with a discussion of priority rules and the performances of such rules in a static job shop. The repetitive production environment where a number of similar products are manufactured repetitively on the same resources is discussed next. The concept of flow shop scheduling is explained and techniques for scheduling and sequencing in the repetitive manufacturing environment are presented. This discussion leads to the introduction of the Just-In-Time (JIT) approach and its implementation.

The question of flexibility and management of change in the production plan leads to a discussion of the dynamic job shop where a continuous stream of new orders exists and availability of resources is a random variable. The concept of bottlenecks is introduced along with the Drum Buffer Rope (DBR) technique for production planning and control.

Chapter 8 – Design of business processes: This chapter details a multi-perspective procedure for the design of a business process. It gives instructions how to build a flowchart or map of the process, using a simple set of symbols; how to verify the structure of the map; how to supplement the map with a perspective table listing additional information about the process; and how to evaluate the design, based on a set of criteria including SWOT analysis. Perspectives encompass positioning of the process within the organization and the context of other processes; the deliverable(s) provided; process performers and authorizers; data and knowledge required; and fallback actions should the process fail through ERP system breakdown. We illustrate the design procedure through a detailed stage-by-stage study of a telesales process: the current situation as told by the sales manager, new process design, design evaluation, and design comparison with the current situation.

Chapter 9 – The integrated order fulfillment using material requirement planning (MRP): This chapter presents the logic of the commonly-used MRP system. The data files are presented first. The concept of a Master Production Schedule (MPS) is presented and the role of the MPS as a link between production and marketing is explained. The Bill Of Material (BOM) that contains information on the structure of products and the inventory files, which provide updated information on the current inventory level are discussed.

The MRP logic that translates the MPS to work orders and purchase orders by the gross-to-net and time-phasing processes is explained. The way each of the data files presented earlier and the MPS interact with the MRP engine is illustrated and common difficulties discussed. The simple MRP (also known as MRP I or open loop MRP) is extended to a closed loop system that takes capacity constraints into account. Rough Cut Capacity Planning (RCCP) techniques are explained with an emphasis on the assumptions and limitation of these models. The Capacity Requirement Planning (CRP) logic is discussed as a more accurate approach to capacity planning.
Chapter 10 – The integrated order-fulfillment process using ERP: In this chapter the three aspects of the order-fulfillment process: Purchasing, Marketing and Production scheduling are integrated within a dynamic environment. The role of management in the process is discussed. A distinction is made between the activities of organizing, staffing, motivating and leading people which are related to the building and leading of the order-fulfillment team and the activities of planning, directing and controlling the order-fulfillment process. This chapter deals mainly with the last three activities. The importance of goal setting is discussed first. The role of management in establishing and communicating a clear set of goals is explained and the relationship between goals and performance measures is discussed. The way to achieve the goals, i.e., the plan and its development, is the issue of the next section. An integrated plan for the order-fulfillment process is illustrated via the concepts of MRP and the Drum Buffer Rope approach.

Given the dynamic and uncertain nature of the environment of the order-fulfillment process, any plan is subject to change. The role of a control system in the order-fulfillment process, the early identification of problems and the need to take actions are discussed next. Finally the difference between a policy and an action is discussed and the idea of changing policies when too many ad-hoc actions are required is presented.

Chapter 11 – Teaching and training integrated production and order management: This chapter bridges the gap between the individual learning process and the learning process of teams. Starting with the learning curve and the ability of individuals to improve by repeating the same process again and again, the concept of individual learning is developed. Next the idea of organizational learning that is more than a simple extension of individual learning is presented. To promote organizational learning, individual learning is coupled with team building, teamwork and team decisionmaking. The activities of organizing, staffing, motivating and leading people who are related to the building and leading of the order-fulfillment team are discussed. The learning of the order-fulfillment process management team is based on a continuous team effort to improve processes, to discuss and analyze past experience and to develop an integrated approach to the management of the process.

IPOM and ERP can change our approach to the management of the order-fulfillment process. This book has been designed for use in academic and executive programs aimed at teaching how integrated systems work.

Teaching IPOM to executives and managers helps the introduction of ERP and promotes change through organizational learning. The design of new processes, and the development of appropriate performance measures and control systems, support the management process in a dynamic, uncertain, competitive environment. Management that understands and practices IPOM has better tools for selecting, implementing and using ERP systems.

Chapter 12 – Business process management: In this chapter we take a management-oriented viewpoint of the totality of business processes comprising the enterprise model. First, we use the model as a master plan for specifying all the business processes needed to be supported by an ERP system for the organization. It then serves as a reference for comparing vendor offerings in order to select the
most appropriate vendor. The functions and processes in the model enable the organization to determine function and process interfaces with partners along the supply chain to ensure operational and informational continuity, compatibility and complementarity. We illustrate vendor compatibility by comparing the hotel management system offerings of two vendors, taken from the Internet, to the requirements of the scenario model developed in Chap. 3, and the interfaces between front desk operations and other hotel operations and departments.

Second, we wish to obtain a précis of the large number of processes in the model in order to focus management efforts. This is done through process action analysis: we only look at the action performed by the process – or the verb in the process descriptor – which allows us to combine processes with common actions. For example, the process “Negotiate purchase order with supplier” demonstrates the action of “negotiating.” We search the model to find all negotiation processes (i.e., the verb “negotiate” in the process descriptor). If many processes concern “negotiate,” a general negotiation protocol needs to be established to train employees in how to negotiate (e.g., with customers, suppliers, sub-contractors, potential employees) and to empower them to set conditions and make decisions when negotiating. We illustrate the analysis procedure and the management advantages obtained through a detailed study of the Hotel Front Desk process suite.

Chapter 13 – Business process improvement: In this chapter we recognize that business processes need to be modified and improved as a result of problems with current processes, feedback from process performers and customers, changes in the modus operandi of the organization, enhancement of IT and knowledge resources, and adaptation of the enterprise to developments in the external environment. Our improvement scheme deals with three issues: How is a business process improved? How is the process performer (re)qualified to carry out the improved process? How is the designer additionally qualified to improve the process and (re)integrate it into the enterprise process suite? We show how to improve a process by means of a set of general improvement patterns (e.g., replace a process step); how to requalify the performer – guided by a performer capability maturity model (e.g., IT skill enhancement); and how to empower the designer using a designer capability maturity model (e.g., authority to consult and coordinate with other designers outside the specific function or department owning the process).

Problems

1. Explain the tasks of the operations function in a hospital.
2. Describe and explain the five core processes in a fast food chain.
3. Explain the difference between traditional Operations Management and IPOM – Integrated Production and Order Management.
4. Which organizational functions are involved in each process in a fast food chain? Explain the tasks of each function in each process and the interfaces between the different functions.
5. Describe a model used to solve real problems in each of the following areas: marketing, transportation, finance.

6. Select a process in an organization you are familiar with, describe the process and the major decisions required to perform the process. Explain which of the decisions are automated. Explain why it is impossible to automate ad hoc decisions.

7. Use the concepts of levels and rates and show the relationship between the number of applicants to a vacant position, the level of unemployment, and other relevant economic factors.

8. Explain the relationship between the flow of material, the flow of information and the decisionmaking process while shopping at the supermarket.

9. Maps are models of reality. Show how a real problem can be solved using a map as a model and explain the simplifying assumptions and under what conditions the solution of the problem may not be applicable for the real problem.

10. Find an article about the ERP concept and explain the differences between this concept and traditional Management Information Systems.
2 Organizations and Organizational Structures

2.1 Functional and Project Organizations, Typical Goals and Performance Measures

The history of organizations is probably as long as the history of mankind. Early organizations like families or groups of hunters evolved into tribes, kingdoms and empires. The need to survive in a hostile world, to carry out missions too great for a single person and to share scarce resources, are just some of the reasons for the creation of early organizations.

Our modern society and its rapidly developing, complex technology, which results in the specialization of experts in very narrow fields, created an additional reason for the existence of organizations. Most products and services today are based on the integration of hardware, software, data and human expertise – a combination which a single person usually does not fully master. Thus, organizations in the form of expert teams are created to compete in today’s markets.

Organizations designed to produce goods and services are as old as the pyramids in Egypt or the Temple in Jerusalem. Both required the coordinated work of many people in order to be accomplished. The principles of division of labor and specialization are fundamental to many of these organizations. Adam Smith in his book *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776) describes the manufacturing of pins using these principles. The operation that he describes is a result of a well-designed process based on division of labor – each person involved repetitively performs a small part of the work required to manufacture a pin, thus rapidly becoming very efficient in performing the task assigned to him.

The principles of division of labor and specialization are useful only if good coordination is maintained between the different components of the organization. Coordination in a highly repetitive environment is relatively easy to achieve, as exactly the same processes are performed repeatedly by each person involved. Thus special approaches such as the synchronized assembly line can be implemented. If the variety of products or services supplied by the same facility is significant, the problem of coordination is much more difficult to handle. The problem of coordination is most difficult when unique products or services are required by each customer and very little repetitiveness exists. In this case special attention to the scheduling of resources and activities is required and special techniques for project planning and control are used (Shtub et al. 2004).
There is a difference between formal and informal organizations. Most formal organizations are based on a clear definition of responsibility, authority and accountability, while informal organizations are based on common interests, common beliefs, social values, feelings, tradition, etc. The following discussion focuses on formal organizations. There are many forms of such organizations. A few “prototype” organizations are common in business and industry:

The *Functional Organization* is based on grouping individuals into organizational units according to the function they perform. Thus, individuals dealing with customers and markets are in the marketing division; those responsible for the purchasing of goods and services for the organization are in the purchasing division, while engineers are members of the engineering group. In large organizations each division is usually subdivided into smaller groups to facilitate better coordination and management. Thus, engineers may be divided into those dealing with new product development, and those responsible for manufacturing, quality or field service. The organizational structure of a typical functional organization is depicted in Fig. 2.1.

An advantage of the Functional Organization is the pooling together of similar resources. By pooling people who share a common expertise and responsibility, and providing these groups of experts with suitable facilities and equipment, better
utilization of resources is achieved. Furthermore, the flow of information within each part of the organization is made simple due to common background, terminology and interests of the people in each group. A good flow of information is an important factor that affects organizational learning.

A disadvantage of the functional organization is in its relationship with customers who have special needs. A customer who needs a special service, product or information that is not part of a repetitive business may have to deal with several organizational units. Since communication between different organizational units may be difficult due to the different goals, different interests and different background of the members of these organizational units, the customer may have difficulty getting what he wants.

For individuals in the functional organizations, future career paths are easily developed, authority and responsibility can be clearly defined and, due to its hierarchical structure, the “line of command” is clear.

The functional structure tends to be stable and rigid; thus it fits well organizations competing in a stable market where the same products or services are sold and demand is stable enough to support mass production. Over the years each organizational unit develops its ways and means of performing its function; local objectives become more and more important and a “tradition” is developed that may cause slow reaction to changes in the business, such as changing markets and changes in the technological environment. This stability is valuable when dedicated facilities are used to manufacture large quantities of products using special purpose equipment over a long period of time.

In a functional organization, the order-fulfillment process may cross the functional boundary lines: marketing people deal with the customers trying to obtain orders; the purchasing department is responsible for the on-time delivery of raw materials and component parts needed for the manufacturing process; while operations people are responsible for the scheduling, sequencing and monitoring of the jobs running on the shop floor. The interfaces between different organizational units are difficult to manage due to different goals and different performance measures used by each organizational unit.

In the functional organization, efficient utilization of resources is a typical goal of the operations function. Measures of productivity, efficiency and resource utilization are frequently used, and are in many instances the basis for promotion decisions and wage incentives. Similar measures are used for other functional areas as well. Total sales per salesperson per month, and the number of purchasing orders executed by the purchasing department per period, are examples of performance measures used in a functional organization.

The use of performance measures that encourage high utilization of resources may lead to poor overall performance of the organization. For example, to achieve high productivity, production people may produce more than required or earlier than needed, thus generating excess inventories. In a similar way, the marketing department may promise unrealistic delivery times to increase the volume of sales, assuming that production will be able to cope with it somehow.
Management of the order-fulfillment process in a functional organizational structure is efficient in a mass production environment where a single product or a well-defined family of products is manufactured on a dedicated facility and delivered to a relatively stable market over a long period of time.

The Project Organization is based on grouping people with a common mission. A task force is a typical example. A project has a starting point and a termination point. Thus, the project structure is temporary by definition. In this organizational structure, experts from different disciplines team up to achieve a one-time mission within a given budget and a predetermined timetable. An organization adopting the project-oriented structure will typically have some staff positions that serve all the ongoing projects, along with project managers who are responsible for their corresponding projects.

The organizational structure of a typical project organization is depicted in Fig. 2.2. The advantage of a project structure is that the focus of each team is on the mission and on the customers for whom the project is performed. The project team is structured accordingly to carry out the project mission. Thus, in a Research and Development (R&D) project, scientists and engineers will be the core of the project team while in a construction project architects and construction engineers will take the leading roles.

![The project organization](image-url)
The problem of boundaries between organizational units that is typical to the functional organization is minimized in the project structure. However, a different problem is common to the project structure: resources are not pooled. For example, in a high-tech organization where several R&D projects are performed in parallel within a project structure, the same expertise may be needed on several projects. In a pure project structure the required experts will be assigned to each project even if it is not necessary to have these people on the project all the time, full time.

Since projects are unique – one-of-a-kind undertaking – it is difficult to promote learning. Individual learning may take place if individuals perform the same type of activities again and again in one or more projects. However, organizational learning is a problematic process in the project structure as the organizational structure is continuously changing with the introduction of new projects and the termination of existing projects.

Management of the order-fulfillment process in a project structure is efficient when each customer order is large enough to justify a dedicated project team with a minimum waste of resources. This is the case, for example, in a heavy industry such as shipbuilding.

To overcome the problem of duplicate resources and consequently the low utilization of resources, a combination of the functional structure and the project structure was developed – the *matrix structure*. In a matrix structure, the functional organization is the basis. Project teams are formed when needed by assigning part-time experts from the functional units to the project managers. Thus, most resources are still pooled together while the customer has a single contact point – the project manager. There are many variations of the matrix structure: if the projects are small, even the project manager may devote only part of his time to the project while being a member of a functional unit. On the other extreme, in a large, complex project, a core project team may be formed with a few experts assigned full time to the project. The project team is supported by people from the functional part of the organization on a part-time-as-needed basis.

The organizational structure of a typical matrix organization is depicted in Fig. 2.3.

In general, the design of an organizational structure is a difficult yet extremely important task. A structure that has been very effective over a long period of time may not perform properly when the environment changes. Thus an order-fulfillment process managed successfully in a functional organization serving a stable market may suddenly fail if competition increases, pushing lead time down while increasing the pressure for a larger variety of end products.

Consider for example the process of new product development. For many years, functional organizations used to have special organizational units responsible for new product development. When marketing identified a need for a new product, the product development department designed the product and produced all the drawings and related documents that define the physical and functional properties of the product. Manufacturing engineering, based on the product definition, developed the processes for manufacturing, assembly and testing of the product and logistics found suppliers for raw materials and components, developed packaging and shipping procedures, etc. In recent years, this functional-oriented process of new
product development has been severely criticized: it is too slow and it does not provide sufficient “value” to the customers.

The process is slow because of its sequential nature. Each organizational unit is like a link in a chain – it gets its input from the previous unit in the process and produces output, which is the input for the next organizational unit that participates in the process. Since only one organizational unit is involved at a time, the duration of the development cycle is the sum of the duration of the processes performed in the participating organizational units.

The problem with a product that provides insufficient value to the customer originates from important decisions regarding the characteristics of the product that are made in the early stages of the product life cycle (product definition and product development stages). These decisions, regarding the product’s physical and functional characteristics, have a major influence on the product’s life cycle cost and therefore on its value to the customer. Since many experts in new product development were not trained to minimize the cost of manufacturing, operating and maintaining products, their decisions represented a local optimum, and frequently resulted in a product design with many functions and options but also very expensive to manufacture, operate and maintain.
In today’s competitive markets, a fast product development process that yields new products with high value to the customers is a must for survival. In many organizations, a new approach to new product development is implemented – Concurrent Engineering (CE). In CE, teams of experts in new product development, manufacturing, operation and maintenance collaborate with the customer to design products with the highest value possible, i.e., the performances that the customer wants for the lowest life cycle cost. In CE, experts from the different areas team up in the process of developing the best possible product (Leenders et al. 2007). CE represents a new organizational structure, which is based on the process, performed by a team. It is different from the project and functional structures as it deals with a specific process: the process of new product development.

An approach similar to CE in new product development is needed for the order-fulfillment process. A new organizational structure – a team responsible for the entire order-fulfillment process – is required. A team of experts in marketing, operations and purchasing is needed to manage the order-fulfillment process from receiving a customer order to the delivery of the required goods and services. A team-based approach to the order-fulfillment process is the key to success in today’s competitive market. The objective of CE is to develop high quality products (quality-based competition) with the lowest life cycle cost (cost-based competition) in the fastest way (time-based competition). A similar objective should be adopted by the team managing the order-fulfillment process, i.e., to develop and maintain an order-fulfillment process that minimizes the lead time from receiving a customer order to supplying it. The order-fulfillment process should minimize the cost of the process and yield high quality in terms of eliminating deviations of actual supply dates from the promised dates.

2.2 The Job Shop, Flow Shop, and Group Technology

The organization of people according to the functional areas in the functional organization, according to a mission in the project organization, or according to the process they perform is in many ways similar to the organization of physical resources on the shop floor. In a manufacturing organization physical resources are machines, tools, inventories of goods, material-handling systems, furniture, office equipment, etc. In a service organization, furniture and office equipment are also used as well as machines of different types (food-processing equipment and refrigerators in a restaurant, or x-ray machines and operating room equipment in a hospital). Like people in the organizational structure, physical resources can be organized or laid out in several ways:

The job shop: This is a functional-oriented layout where machines and equipment, which perform a similar function, are grouped together. Job shops can process a variety of products by routing each product according to the specific process it requires. Like a functional organization, pooling of similar resources is the advantage of the job shop. However, coordination of the manufacturing process of a product requiring processing in different “departments” is difficult, as
each product type has a special manufacturing process and consequently a special sequence of operations on the machines. The layout of a typical job shop is depicted in Fig. 2.4.

*The flow shop:* This is a process-oriented layout in which products with similar routing or manufacturing processes are manufactured on a dedicated facility in which the layout of machines follows the processing sequence of the products. Product movement in the shop follows the machine layout, which follows the product routing; thus management of the flow shop is made easier. Flow shops are a natural approach to the facility layout when a family of products with similar processing requirements is manufactured by an organization. The layout of a typical flow shop is depicted in Fig. 2.5.

*Group technology* is a technique designed to identify products with similar process requirements and to group these products into families processed by the same equipment arranged in a manufacturing cell. By using the Group Technology concept, it is possible to transform a job shop into several flow shops, each processing a family of products that requires a similar sequence of operations. Group Technology is an example of a transformation from a functional structure to a process-oriented structure of the physical layout of a facility. The layout of a typical shop laid out according to the Group Technology principles is depicted in Fig. 2.6.

![Fig. 2.4 The job shop layout](image-url)
Fig. 2.5 The flow shop layout

Fig. 2.6 The group technology layout
When Group Technology principles are correctly applied, the order-fulfillment process of the family of products manufactured in a technology cell is managed by the team assigned to the cell. In this case, a team responsible for the entire process manages the order-fulfillment process. The problem is to implement the same approach when families do not exist or when physical relocation of equipment is too expensive. ERP systems provide a solution. It is possible to define “virtual” cells in the model base and to manage these cells based on information provided by the ERP system, as explained in Chap. 10.

2.3 Operations Management and Its Interface with Other Functional Areas: Restructuring the Order-Fulfillment Process

Coordination between functional organizational units performing the order-fulfillment process in the functional organization is a difficult task. This is due to the fact that similar goals, terminology and experiences are shared between people in the same organizational unit but not across different units in the organization. To improve the order-fulfillment process, a solution similar to product development teams in Concurrent Engineering, new product development and a solution similar to the order-fulfillment process in Group Technology is needed – a solution based on assigning the responsibility for the whole order-fulfillment process to one team having a common goal to achieve better coordination among everybody involved in the process.

The order-fulfillment process begins with the customer. Two pieces of information are needed at this point: The cost of the product, and the delivery lead time. As discussed in the next chapter, in the functional organization we assume that marketing can receive the first information from the accounting system, while lead-time information is readily available from operations. In reality, however, both cost and lead time are changing continuously over time, i.e., both are dynamic; and their momentary value depends on the current load on the shop floor (Feldman and Shtub 2006).

Once a customer’s order is generated, the interface with suppliers is important: purchasing of raw materials and parts, as well as subcontracting (make or buy) decisions are part of the next step in the process. Purchasing people need to know what to order, in what quantities and what is the required due date for these orders. The common assumption, that the operations function provides a clear-cut answer to these questions may be misleading, as explained later in detail. This is due to the basic assumption that lead time is an input to the operations planning and control information system. In reality this input is a guess and the actual value depends not only on the shop load but also on the very same guess that is used as input. Furthermore, required quantities of purchased parts and material as well as required due dates change continuously over time due to the dynamic nature of operations. Finally, make or buy decisions are based on the current and future load on the shop floor – information that is ever changing and usually not known to
Problems

1. Select an organization that you are familiar with and draw its organizational chart. Explain the tasks performed by each function, its goals and performance measures.
2. Discuss the application of division of labor in a restaurant and in a supermarket.
3. Explain the difference between the formal organization and the informal organization in a university.
4. Under what conditions is the project organizational structure most appropriate? Give an example.
5. Write a job description for a project manager for a Research and Development project and a job description for a manager of an engineering department in a matrix organization. Explain the goals and responsibilities of each position.

6. Find an article about a successful organization. Based on the article explain how success is measured and assessed.

7. Consider the layout of a typical hospital. Is it similar to a job shop, a flow shop or a group technology-based layout?

8. Explain the interfaces between the operations manager of a fast food chain and other functional managers. Focus on the flow of information and on the decisionmaking processes.

9. Discuss the pros and cons of group decisionmaking. Under what conditions is group decisionmaking the preferred approach? Give an example where group decisionmaking is preferred and a counter-example where group decisionmaking is not recommended.

10. Use democracy as an example of group decisionmaking. Discuss the different levels of group decisionmaking based on this example.
3 Enterprise Process Modeling

3.1 The Reference Model Approach to Enterprise Process Modeling

Enterprise process modeling is a core vehicle to analyze, design, implement, and deploy ERP-related business process suites and the ERP information systems supporting them. However, the modeling process often requires extensive resources and is often incomplete. As a way to cope with these hurdles and to improve the quality of enterprise-specific models, the idea of reference modeling has become the accepted methodology to develop an enterprise-specific application. While an application model represents a particular enterprise system, a generic model represents a class of similar enterprise systems. It is a conceptual framework that can be used as a blueprint and progressively adapted to the requirements of a particular enterprise. The ultimate aim of enterprise modeling is to enable the designer to obtain a definitive picture of the business functionalities of the organization and the suite of business processes required. (For more information on the idea of business process reference models readers are referred to Kindler and Nuttgens (2005).) He/she can then proceed with the design of the business processes required, planning of the corresponding IT support as exemplified by ERP systems, and elaboration of a program for business process management. These topics are discussed in this and other chapters in the book.

3.2 Basic Concepts in Enterprise Process Modeling

To deepen our understanding of the business process viewpoint and its application in enterprise process design and implementation we define a series of concepts “top down” from the enterprise to the individual process activity.

(a) The process view of the enterprise constitutes the first central concept. We bring several definitions to highlight how it is viewed.

- An enterprise is a system of business endeavors within a particular business environment. It comprises a set of functions that carry a product through its entire life span from concept through manufacture, distribution, sales and service. The enterprise architecture is a design for the arrangement and interoperation of business components (e.g., policies, operations,
infrastructure, information) that together make up the means of operation of the enterprise (Balanced Scorecard 2006; PeraNet 2006).

- An enterprise is an assemblage of business processes, which represent the functioning and flow of goods, services, information, decisions and control throughout the enterprise. These processes cooperate to deliver a specific result or “product,” and to achieve a set of enterprise goals. Processes are clustered into coherent groupings, or business functions. One type of enterprise is differentiated from another by the nature of the functions and processes comprising them (Vernadat 1996; Gulledge et al. 2002). Compare, for example, Table 3.2 (Hotel Front Desk), Table 3.3 (Procurement/Purchasing), Table 3.4 (High Tech Industry) and Table 3.5 (Retail Industry).

- An enterprise encompasses bodies and activities that have the objective of supplying commodities – goods and services. The business side of the enterprise pertains broadly to policymaking, economic, commercial (buying and selling), financial, human resource and administrative activities; as opposed to the industrial side, which pertains to activities dedicated to the production (manufacturing or service provision) of commodities – goods and services (Webster 1999; Gulledge et al. 2002). This perspective is reflected in the function map in Sect. 3.5 below.

(b) A business function is a coherent group or cluster of activities or processes that are related by specific and common skills, competencies or objectives. It represents the group as a “black box.” The set of specific functions for a given enterprise provides the fundamental concept of the business, and answers the question “what should we do?” (Van Es and Post 1996; Van Es 1998) or “what things are to be done?” (AMICE 1993). Our scheme comprises two levels of business functionalities: major functions and main functions. In Table 3.5 (Retail Industry), for example, the left-hand column displays major functions (“enterprise management,” “customer relationship management,” etc.); the right-hand column displays, for the “category management” major function, main functions (“merchandise and assortment planning,” “product introduction and maintenance,” etc.); and, for “the price and promotion management” main function, processes grouped under this function (“competitive pricing,” “market basket pricing and analysis,” etc.).

(c) The business process constitutes the second central concept. We bring several definitions to emphasize how it is viewed. An example of a business process and its associated components is presented in Sect. 3.3.

- A business process is an ordered set of actions or activities, linked by precedence relationships, and triggered by an event that terminates in some observable end result, which achieves some business goal. It represents the flow and control of things happening in the enterprise (Vernadat 1996). The set of specific processes subsumed in a function defines the modus operandi of that function and answers the question “how should we do it?” (Van Es and Post 1996) or “how are things to be done?” (AMICE 1993).
3.2 Basic Concepts in Enterprise Process Modeling

- A **business process** is a collection of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how the work is done within an organization, in contrast to a product’s focus on what. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs: a structure for action (SPARKX 2004).

- A **business process** is a collection of related, structured activities—a chain of events—that produce a specific service or product for a particular internal or external customer or customers. It comprises a set of activities that represent all the alternative methods of performing the work needed to achieve a business objective (GAO 2005).

- A **process** is a completely closed, timely and logical sequence of activities that are required to work on a process-oriented business object. A **business process** is a special process that is directed by the business objectives of the company and by the business environment. Essential features of a business process are interfaces to the business partners of the company (e.g., customers, suppliers) (Becker et al. 2003).

- **Business processes** elaborate mechanisms and methods defining the functioning of people and resources in carrying out enterprise-goal-related courses of action. They comprise three main components: actions, decisions and controls (Van Es and Post 1996; Vernadat 1996; Sparrow 1998).

- A **business process** is a sequence (or partially ordered set) of enterprise activities, execution of which is triggered by some event and will result in some observable or quantifiable end result. The process output may be a material object (e.g., a physical part), or information object (e.g., a purchase order), or a designated system state (e.g., closure of a sale) (Vernadat 1996).

- A **business process** is a specific ordering of work activities across time and place, with a beginning, and an end, and with clearly identified inputs and outputs—a structure for action (Davenport 1993; Davenport et al. 1998).

(d) An **action** is something done or carried through (WordNet 2006).

(e) A **decision** is a ruling or conclusion reached or given—determining an outcome regarding an action, course or judgment to be taken or made (Webster 1999).

(f) A **control** is a mechanism to initiate, manage and regulate a process within the framework of the enterprise process ensemble. The main controls are start and end triggers, and transfer activities which relocate a task or a business object to a subsequent or parallel process (cf. Microsoft 2006; Wikipedia 2007).

(g) A **trigger** is an act that sets in motion some course of events. Within our framework it is an internal or external act that initiates a process, or an internal act at the termination of a process, which initiates a subsequent process (cf. WordNet 2006; GeoConnections 2006).

(h) A **role** is a set of expected activities attributed to an employee occupying a given position in an organizational framework (Robbins 1996). It answers the question “how should we organize (internally) to do it?” In a business model,
a role is attached to each activity, and thus specifies which role holder is
qualified and authorized to carry out the activity; and when he or she will be
notified that the activity is to be carried out. This latter property of role
attachment is a unique advantage of an *enactive* business process model.

(i) An *external* agent is an actor or instrumentality – usually a person or a
corporation – outside the boundaries of the enterprise. It answers the question
“how should we coordinate with businesses and individuals outside the
organization?” In a business model, agents provide inputs to the business, and
receive outputs from it. Communication between agents and the enterprise is
usually indicated by means of interfaces.

(j) A *capstone model* is a definitive conceptual representation of a generalized or
specific enterprise as a two-level assemblage of major and main business
functions, which depict in a consistent manner the flow of goods, services,
information, decisions and control throughout the enterprise. A capstone
model for the High Tech Industry is given in Table 3.4 (a).

(k) A *function decomposition model* is a definitive conceptual representation
of a major business function as a two-level assemblage of its main business
functions and corresponding clusters of processes that depict the totality of
business activity subsumed under the major function. A decomposition model
for the procurement/purchasing major function is given in Table 3.3.

(l) An *enterprise reference model* is a standardized/generalized conceptual
representation of an enterprise as an assemblage of business functions and
business processes which depict in a consistent manner the flow of goods,
services, information, decisions and control throughout the enterprise. It com-
prises a generalized capstone model and a corresponding generalized set of
function decomposition models. Such a model is given in Table 3.1.

(m) An *enterprise-specific process model* is a specialized definitive conceptual
representation of a particular enterprise as an assemblage of business functions
and business processes that depict in a consistent manner the high-level flow
of goods, services, information, decisions and control throughout the enterprise.
It comprises a specific capstone model and a corresponding set of specific
function decomposition models. Specific examples are given in Table 3.2 (Hotel
Front Desk), Table 3.3 (Procurement/Purchasing), Table 3.4 (High Tech
Industry) and Table 3.5 (Retail Industry).

(n) A *business process model* is a graphical representation of a business process
which describes in flowchart form the low-level functioning and flow of
goods, services, information, decisions and control throughout the process.
Each process is a sequence of activities to be carried out, with branches at
decision points. Two processes are mapped in Chap. 8: a telesales process
(Fig. 8.1) and a shop floor order process (Fig. 8.2).

(o) A *gap analysis* is a formal assessment of a deficiency or variance between
some aspects of a business requirement and the current capabilities or features
of an organization and its systems in meeting that requirement. The goal of
gap analysis is to identify what is required to close the gap, usually through an
optimized allocation of resources, inputs or capabilities. In this book we employ
and illustrate three types of ERP and business process related gap analysis:
• Type I: We wish to determine the differences between a reference model (generality) and specific enterprise requirements (specificity). This leads to the addition of any functionality or process capability required from an understanding of the organization and operations of the enterprise and results in a customized enterprise model (see Sect. 3.6 (e)).

• Type II: We wish to determine the differences between enterprise requirements (enterprise model – specificity) and vendor model offering (generality) when assessing and deciding on the acquisition of an ERP system for the enterprise (see Sect. 12.2 (a)).

• Type III: We wish to determine the differences between enterprise requirements and the ERP system implemented. This leads to an indication where the enterprise needs to augment its functionality or process capability through BPE and BPR efforts (see Sect. 12.2 (d)).

3.3 An Example of a Business Process

A shop floor order creation process is mapped in Fig. 3.1. A production order has been released for execution. The expeditor has to decide whether to release the order to the shop floor as-is, or to modify it, reschedule it, or even put it on hold. His decisions depend on current inventory and the options available to offset shortages, the current shop floor loading and the options available to provide added capacity. The map demonstrates the various components of a business process:

• Trigger: “production order released for execution”
• Actions: “check material availability,” “authorize shop floor order,” “create urgent purchase requisition”
• Decisions: “substitute materials available?,” “rescheduling possible?,” “extra shift possible?”
• Control: “transfer purchase requisition to purchasing”
• Role: expeditor

Design, mapping and analysis of a business process is the subject of Chap. 8.

3.4 Enterprise Modeling Principles

Vernadat (1996) provides several principles applying to enterprise models:

(a) Range or scope: the functionalities and processes (Sect. 3.6) to be included in the model
(b) Viewpoint: aspects of business activity to be covered or to be left out in the model (Sect. 8.2)
3.5 Enterprise Functionalities

From a comprehensive study of the functional composition of a range of enterprises (Lincoln and Karni 2003) we create a “generic” map of a superset of enterprise functionalities, which provides an insightful picture of the function/process viewpoint of a “universal” enterprise.

(a) Business and industrial functionalities – An enterprise encompasses bodies and activities that have the objective of supplying commodities: goods and services. The business domain of the enterprise pertains broadly to policy-making, economic, commercial (buying and selling), financial, human resource and administrative activities; as opposed to the industrial domain, which pertains to activities dedicated to the production of commodities – goods and services (manufacturing or service provision) (Karni 1999; Webster 1999).

(b) Manufacturing and service functionalities – Industrially-oriented major functions are further partitioned into those which are considered as being oriented towards manufacturing, and those oriented toward service.
Fig. 3.1 Shop floor order creation process
### Table 3.1 A generic framework for enterprise functionality

<table>
<thead>
<tr>
<th>1 Enterprise management</th>
<th>2 Financial management</th>
<th>3 Asset management</th>
<th>4 Human resource management</th>
<th>5 Business development</th>
<th>6 Investment management</th>
<th>7 Purchasing (acquisition)</th>
<th>8 Supply chain management</th>
<th>9 Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic management</td>
<td>Strategic planning</td>
<td>Category planning</td>
<td>Recruitment</td>
<td>Candidate selection</td>
<td>Investment strategy</td>
<td>Procurement strategy</td>
<td>Supply chain positioning</td>
<td>Market research and analysis</td>
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<td>Portfolio management</td>
<td>Profit management</td>
<td>Innovation planning</td>
<td>Employee</td>
<td>Human resource planning</td>
<td>Investment monitoring</td>
<td>Requisition management</td>
<td>Resource planning along the supply chain</td>
<td>Lead management</td>
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<td>Business risk management</td>
<td>Business intelligence</td>
<td>Business analytics</td>
<td>Time management</td>
<td>Administration</td>
<td>Procurement planning</td>
<td>Procurement planning</td>
<td>Supply chain forecasting</td>
<td>Advertising management</td>
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<td>Strategic partner</td>
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<td>management</td>
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<td>Product launch management</td>
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</tbody>
</table>

**Notes:**
- **1 Enterprise management:**
  - Strategic planning
  - Profit management
  - Business intelligence
  - Strategic partner management

- **2 Financial management:**
  - Management accounting
  - Accounts payable
  - Budget planning
  - Financial forecasting

- **3 Asset management:**
  - Fixed asset management
  - Real estate management
  - Administration

- **4 Human resource management:**
  - Candidate selection
  - Human resource planning

- **5 Business development:**
  - Alignment of business development with marketing
  - Business model management

- **6 Investment management:**
  - Investment portfolio management

- **7 Purchasing (acquisition):**
  - Bid planning
  - Procurement contract management

- **8 Supply chain management:**
  - Supply network planning
  - Delivery/transportation planning
  - Delivery/transportation operations (outsourcing/partners/customers)

- **9 Marketing:**
  - Product/service/brand marketing
  - Customer management
  - Trade promotion management

**Additional Notes:**
- **Category planning:**
  - Product costing

- **Innovation management:**
  - Product pricing

- **Business analytics:**
  - Budget execution
  - Salary management

- **HR quality management:**
  - Salary management

- **Marketing strategy:**
  - Marketing planning
  - Campaign management

- **Customer loyalty management:**
  - Customer loyalty management

- **Churn management:**
  - Product lifecycle management
<table>
<thead>
<tr>
<th>Table 3.1 A generic framework for enterprise functionality (continued)</th>
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<tbody>
<tr>
<td><strong>10 Sales</strong></td>
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<td>Sales tracking</td>
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<tr>
<td>Sales planning and simulation</td>
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<tr>
<td>Quotation management</td>
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<td>Sales forecasting</td>
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<td>Raw materials receiving</td>
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<td>Finished goods management</td>
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<td>MRO management</td>
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<td>Warehouse capacity planning</td>
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<td>Item display management</td>
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<td>Quality standards management</td>
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<td>Quality assurance</td>
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<td>Facility quality management</td>
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<td>Business process analysis</td>
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<td>Document change mgt.</td>
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<td><strong>16 Project management</strong></td>
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<td>Market research and analysis</td>
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<td>Project operations</td>
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<td><strong>19 Facility management</strong></td>
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<td>Building maintenance</td>
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<td>Administration management</td>
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<td>Business travel management</td>
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### Table 3.1: A generic framework for enterprise functionality (continued)

<table>
<thead>
<tr>
<th>Function</th>
<th>22 Maintenance management</th>
<th>23 Research and development (DtO)</th>
<th>24 Product engineering (EiO)</th>
<th>25 Configuration management (AiO)</th>
<th>26 Production/operations (+ MtS)</th>
<th>27 Brand management</th>
<th>28 Front office (home site) services</th>
<th>29 Contact office (call center) services</th>
<th>30 Remote office (web) services</th>
<th>31 Mobile office (field) services</th>
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</thead>
<tbody>
<tr>
<td>Preventative maintenance</td>
<td>Crisis maintenance management</td>
<td>Intellectual property management</td>
<td>Conceptual design</td>
<td>Configuration management</td>
<td>Purchase/production support</td>
<td>Life cycle management</td>
<td>Service operations (home site)</td>
<td>Service operations (call center)</td>
<td>Product presentation management</td>
<td>Service customer management</td>
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<td>Maintenance scheduling</td>
<td>Product development contracting</td>
<td>Detailed design</td>
<td>Production order management</td>
<td>Production order management</td>
<td>Product definition</td>
<td>Service process planning</td>
<td>Service order management</td>
<td>Web site management</td>
<td>Service personnel scheduling</td>
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<td>Spare parts management</td>
<td>Contract costing and quotation</td>
<td>Engineering change management</td>
<td>Material requirements planning</td>
<td>Production/operations</td>
<td>Service operations (home site)</td>
<td>Service desk planning</td>
<td>Service operations (call center)</td>
<td>Transaction management</td>
<td>Service operations (customer site)</td>
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<td>Prototype development</td>
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<td>Catalogue management</td>
<td>Shop floor control</td>
<td>Production/operations</td>
<td>Production master planning</td>
<td>Service process planning</td>
<td>Point-of-sale planning</td>
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<td>Transaction management</td>
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<td>Customer requirement management</td>
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</table>
Table 3.2 Reference model: hotel front desk functionalities and processes

1 Reservation management

- Review current room availability and status for reservation
- Review future room availability and status for reservation
- Search available units for specified date range and unit capacity
- Select unit for single reservation
- Select multiple units for multiple reservations
- Select multiple units for group reservations
- Specify customer group name and description
- Verify single/multi/group reservation information prior to booking
- Create single/multi/group reservation
- Issue single/multi/group reservation confirmation letter and send
- Issue single/multi/group reservation cancellation letter and send
- Charge room at time of reservation
- Charge room at check in
- Charge room at check out
- Create reservation frontally
- Create reservation telephonically
- Create reservation via fax
- Create reservation via Internet
- Create reservation via e-mail
- Cancel reservation frontally
- Cancel reservation telephonically
- Cancel reservation via fax
- Cancel reservation via Internet
- Cancel reservation via e-mail

2 Rate and yield management

- Provide information on regular rates
- Provide information on seasonal and weekend rates
- Provide information on special rates
- Provide information on different rate packages at time of reservation
- Offer different rate packages for different seasons
- Offer multiple rate types and rates during a single stay
- Maintain tour operator account

3 Check-in management

- Welcome regular guest
- Welcome VIP guest
- Check in guest arriving on time to reserved room
- Check in guest arriving early to reserved room
- Check in guest arriving late to reserved room
- Check in walk-in guest
- Search guest by key (Name, Company, Address, Home/Work Phone, E-mail)
- Review current room availability and status for occupation
- Review future room availability and status for occupation
- Replace guest reservation with another guest
- Provide information on predefined deposit
- Provide information on alternative means of payment
- Provide information on vehicle parking and parking fees
- Record customer credit card number
- Handle credit card invalidity
- Record customer driver license number
Table 3.2 Reference model: hotel front desk functionalities and processes (continued)

4 **Check-out management**
- Check out guest leaving on time
- Check out guest leaving early
- Check out guest leaving late
- Issue check-out invoice with list of guest fees
- Adjust bill amount by providing discounts or fees
- Receive single currency (cash) payment
- Receive multiple currency (cash) payments
- Receive credit card payment
- Issue final receipt

5 **Guest relationship management (guest services)**
- Exchange room before or during stay
- Handle complaints
- Handle guest queries
- Handle conference guest queries
- Reserve dinner for guest
- Record guest instructions or other notes on guest record
- Charge additional services to guest record
- Charge additional expenses to guest record
- Charge point of sale expenses to guest record
- Supply newspaper to guest
- Supply travel directions to guest
- Provide information on guest policy to guest
- Rent car for guest
- Order taxi for guest
- Coordinate guest request for wake-up call
- Issue wake-up call
- Allocate safe to guest
- Issue safe receipt
- Supply (free/digital) photographs of guests
- Record outgoing ticket and flight information on guest record
- Confirm outgoing ticket and flight information for guest
- Issue special (cheap) tickets for public transportation
- Direct visitors to guest

6 **Guest information service management (hotel amenities)**
- Provide information on meal timetables
- Provide information on meal/restaurant menus
- Provide information on currency exchange rates
- Provide information on hotel facilities
- Provide information on hotel shop
- Provide information on conference program
- Record information on lost items
- Provide information on found items
- Provide information on babysitting services

7 **Guest information service management (external amenities)**
- Provide information on travel agencies
- Provide information on vehicle rental agencies
- Provide information on bicycle rental agencies
### Table 3.2 Reference model: hotel front desk functionalities and processes (continued)

- Provide information on tourist agencies
- Provide information on restaurants
- Provide information on cultural attractions
- Provide information on entertainment attractions
- Provide information on tourist attractions and sites
- Provide information on shopping facilities
- Provide information on organized tours
- Provide information on sports facilities and events
- Provide information on public transport facilities
- Provide information on airlines and flight schedules
- Provide information on telephone numbers
- Provide information on medical services and hospitals
- Provide information on city maps and guides
- Provide information on country-wide maps and guides
- Provide information on local and country-wide weather

8 **Communication management**

- Record and/or post messages for guest
- Deliver messages to guest
- Deliver incoming mail to guest
- Transfer telephone call to guest
- Enable guests to receive e-mail messages
- Enable guests to send e-mail messages
- Enable guests to receive fax messages
- Enable guests to send fax messages

9 **Service support coordination management**

- Coordinate guest request with housekeeping
- Coordinate guest request with maintenance
- Coordinate guest request with room service
- Coordinate guest request with computing services
- Coordinate guest request with laundry and dry-cleaning facility
- Coordinate guest request with porterage
- Coordinate guest request with valet parking
- Coordinate guest request with transportation (e.g., airport, city)
- Coordinate guest request with restaurant

10 **Front desk zone management**

- Manage front desk (including flowers)
- Manage lobby
- Manage lobby billboard(s)
- Manage ambient music
- Manage cash drawer
- Manage front desk audit
- Manage night audit
- Manage clock-in and clock-out

11 **Special databank management (hotel services)**

- Maintain wait list for reservations
- Maintain historical VIP guest data
- Maintain historical guest data
- Maintain historical DNR (do not rent!) data
- Maintain historical complaint data
The following map details an overview of enterprise functionality (cf. Lincoln and Karni 2003). A more detailed capstone model is given in Table 3.1 (Lincoln-Wasser 2002; Karni 2005).

<table>
<thead>
<tr>
<th><strong>Business-oriented functions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Enterprise management</td>
</tr>
<tr>
<td>2 Financial management</td>
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<tr>
<td>3 Asset management</td>
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<tr>
<td>4 Human resource management</td>
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<tr>
<td>5 Business development</td>
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<tr>
<td>6 Investment management</td>
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<tr>
<td>7 Purchasing (acquisition)</td>
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<tr>
<td>8 Supply chain management</td>
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<td>9 Marketing</td>
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<td>10 Sales</td>
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<td>11 Inventory management</td>
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<td>12 Warehouse management</td>
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<td>13 Quality management</td>
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<td>14 Change management</td>
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<tr>
<td>15 New product/service development</td>
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<td>16 Project management</td>
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<td>17 Information management</td>
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<td>18 Knowledge management</td>
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<tr>
<td>19 Facility management</td>
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<tr>
<td>20 Security and safety management</td>
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<tr>
<td>21 Corporate support services</td>
</tr>
<tr>
<td>22 Maintenance management</td>
</tr>
<tr>
<td>23 Research and development (DtO)</td>
</tr>
<tr>
<td>24 Product engineering (EtO)</td>
</tr>
<tr>
<td>25 Configuration management (AtO)</td>
</tr>
<tr>
<td>26 Production/operations (MtS, MtO)</td>
</tr>
<tr>
<td>27 Brand management</td>
</tr>
<tr>
<td>28 Front office (home site) services</td>
</tr>
<tr>
<td>29 Contact office (call center) services</td>
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<tr>
<td>30 Remote office (web) services</td>
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<tr>
<td>31 Mobile (field) office services</td>
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</tbody>
</table>

(**Manufacturing-oriented functions**

<table>
<thead>
<tr>
<th><strong>Service-oriented functions</strong></th>
</tr>
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<tbody>
<tr>
<td>23 Research and development (DtO)</td>
</tr>
<tr>
<td>24 Product engineering (EtO)</td>
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<td>25 Configuration management (AtO)</td>
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<tr>
<td>29 Contact office (call center) services</td>
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<tr>
<td>30 Remote office (web) services</td>
</tr>
<tr>
<td>31 Mobile (field) office services</td>
</tr>
</tbody>
</table>

(DtO design to order; AtO assemble to order; EtO engineer to order; MtS make to stock; MtO make to order)

### 3.6 A Procedure for the Design of an Enterprise-Specific Process Model

Our model design procedure is a top-down method, moving simultaneously (1) from the general to the specific, by viewing enterprise business activity at a general level (major functionality), then at a more detailed level (main functionality), and finally at the process level; and (2) from genericity (reference model) to specificity (individualized enterprise model). It is carried out in five steps.

(a) Construct an initial reference model for the enterprise
(b) Abstract relevant major level functions from the reference model
(c) Abstract relevant main level functions from the reference model
(d) Abstract relevant business processes from the reference model
(e) Augment the model by performing a gap analysis between enterprise specificity and reference model generality

This results in a specific enterprise process model for the organization. The procedure continues with the application of the enterprise-specific model to business process modeling (Chap. 8) and ERP system acquisition and management (Chap. 12).
(a) Construct an initial reference model for the enterprise

The first step is to create an initial reference model for the enterprise – i.e., an extensive generic capstone and set of function decomposition models relating to the industry or service to which the enterprise belongs, or to its central functionality. Our purpose is to ensure that the final enterprise-specific model incorporates all required functions and processes. Reference models can be derived from four main sources:

- Internet-based models

  The Internet constitutes a powerful source of information for obtaining details of IT management systems for the enterprise as a whole, or for specific functionalities within the enterprise. Using relevant keywords (for example, “hotel front desk” – see the case study below), an extensive search often provides a wide range of details of the functions and processes incorporated in these systems. From these, a reference model can be compiled. We give two examples of reference models obtained in this way: the “Hotel Front Desk” model detailed in Table 3.2; and the “Purchasing Management” model detailed in Table 3.3.

- Industry-based enterprise-wide vendor models

  These are industry-specific models developed from the observation that a high degree of commonality of functions and processes exists amongst firms classified under the same industrial category and/or producing the same product or service. We illustrate these models through SAP industry-related offerings. The SAP web site (SAP 2007a) presents industry models in manufacturing and services. For example:

  - Manufacturing: aerospace and defense; automotive; consumer products; engineering, construction and operations; high technology; industrial machinery and components; mill products
  - Services: banking; healthcare; higher education and research; insurance; railways; retail; telecommunications; utilities; wholesale distribution

  Two models (capstone: major and main functions; decomposition: main function and processes) are illustrated in Table 3.4 (“High Technology”) and Table 3.5 (“Retail”) (SAP 2000).

- Function-based enterprise-wide vendor models

  These are business-oriented models developed from the observation that there exists a high degree of commonality of business-related activities (see above) amongst all firms. We illustrate these models through the SAP enterprise-application offerings. The SAP web site (SAP 2007a) presents generalized models in enterprise resource planning (ERP), customer relationship management (CRM), supply chain management (SCM), supplier relationship management (SRM) and product lifecycle management (PLM). Two levels of the ERP model (major and main functions; main function and processes) are illustrated in Table 3.6 (SAP 2005).
Table 3.3 Reference model: procurement/purchasing functionality and processes

<table>
<thead>
<tr>
<th>1 Procurement strategy</th>
<th>6 Supplier management</th>
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<tbody>
<tr>
<td>• Develop procurement strategy</td>
<td>• Register supplier</td>
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<td>• Develop sourcing strategy</td>
<td>• Maintain supplier master data</td>
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<tr>
<td>• Develop procurement program</td>
<td>• Accredit supplier</td>
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<tr>
<td>• Develop procurement budget</td>
<td>• Terminate supplier accreditation</td>
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<tr>
<td>• Develop procurement authorization program</td>
<td>• Maintain approved supplier list</td>
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<td>• Develop rating system for order completeness</td>
<td>• Maintain supplier catalogues</td>
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<td>• Develop rating system for on time delivery</td>
<td>• Maintain supplier prices and discounts</td>
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<tr>
<td>• Develop rating system for quality performance</td>
<td>• Maintain supplier purchasing history</td>
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<tr>
<td>• Identify critical purchase items</td>
<td>• Maintain supplier performance history</td>
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<tr>
<td>• Monitor purchasing budget status</td>
<td>• Rate supplier performance history</td>
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<tr>
<td>• Monitor purchasing budget status</td>
<td>• Identify supplier capacity</td>
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<tr>
<td>2 Requisition management</td>
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<tr>
<td>• Authorize employees to issue purchase requisitions</td>
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<tr>
<td>• Issue purchase requisition</td>
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<td>• Monitor purchase requisition status</td>
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<td>• Approve purchase requisition</td>
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<td>• Change purchase requisition</td>
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<td>• Consolidate purchase requisitions</td>
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<td>• Block purchase requisition</td>
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<td>3 Procurement planning</td>
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<tr>
<td>• Develop catalogue-based procurement plan</td>
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<td>• Develop BOM-based procurement plan</td>
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<tr>
<td>• Evaluate purchase item quality</td>
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<td>• Maintain purchase item price history</td>
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<td>• Decide on make-or-buy</td>
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<td>4 Bid planning</td>
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<td>• Prepare bid package</td>
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<td>• Select possible suppliers</td>
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<td>• Issue bid</td>
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<td>• Negotiate bids</td>
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<td>• Monitor bid status</td>
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<td>• Analyze bids</td>
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<td>• Award bids</td>
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<td>• Authorize bid by client</td>
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<td>5 Procurement contract management</td>
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<td>• Develop procurement contract conditions</td>
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<td>• Develop procurement contract template</td>
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<tr>
<td>• Negotiate procurement contract</td>
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<td>• Authorize procurement contract</td>
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<td>• Issue procurement contract</td>
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<td>• Monitor procurement contract status</td>
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<tr>
<td>7 Procurement operations management</td>
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<tr>
<td>• Create purchase order from requisition</td>
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<td>• Create purchase order from bid</td>
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<tr>
<td>• Authorize ERP-generated purchase order</td>
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<td>• Select supplier for purchase order</td>
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<td>• Negotiate purchase order conditions with supplier</td>
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<tr>
<td>• Authorize purchase order</td>
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<td>• Issue regular purchase order to local supplier</td>
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<td>• Issue urgent purchase order to local supplier</td>
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<tr>
<td>• Issue regular purchase order to foreign supplier</td>
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<tr>
<td>• Issue urgent purchase order to foreign supplier</td>
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<tr>
<td>• Receive purchase order confirmation from supplier</td>
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<tr>
<td>• Monitor purchase order status</td>
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<tr>
<td>• Issue supplier performance letter</td>
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<td>• Issue supplier corrective action letter</td>
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<tr>
<td>• Change/correct purchase order</td>
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<tr>
<td>• Monitor changed/corrected purchase order status</td>
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<tr>
<td>• Handle advanced shipment notification</td>
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<td>• Handle delayed shipment notification</td>
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<td>• Manage compliance with regulations</td>
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<td>• Determine import duties</td>
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<td>• Issue import documents</td>
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<td>• Release shipment from customs</td>
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</table>
Table 3.3 Reference model: procurement/purchasing functionality and processes (continued)

8 **Receiving operations management**
- Receive purchase order
- Inspect purchase order
- Log receipt of fully or partially delivered orders
- Issue goods received note
- Issue return note for rejected items
- Route accepted items for storage
- Route rejected items for return
- Handle treatment of undelivered items
- Authorize accepted items by client
- Notify requester of purchase order delivery
- Analyze invoice discrepancies
- Approve supplier invoice for payment
- Close purchase order
- Block supplier invoice
- Transfer supplier invoice to accounts payable

9 **Catalogue management**
- Maintain own catalogue
- Match own and supplier catalogues
- Maintain item assortment and substitutes
- Maintain base prices

10 **Spend analysis**
- Classify spend across multiple dimensions and categories
- Maintain supplier database for spend analysis
- Maintain item database for spend analysis
- Analyze spend across multiple dimensions and categories

Table 3.4 (a) High tech industry capstone (SAP 2000)

**Enterprise management**
- Strategic enterprise management
- Business intelligence and data warehousing
- Managerial accounting
- Financial accounting

**Customer relationship management**
- Sales channels
- Sales management
- Service agreements
- Customer service
- Service fulfillment
- Marketing program management

**Value added distribution and resale**
- Product management
- Collaborative planning
- Sourcing
- Sales/mass customizing
- Kitting assembly and integration
- Distribution
- Installed base management

**Software**
- Custom development
- Standard development
- Implementation
- Maintenance
- License and installed base management

**Original equipment design and manufacturing**
- Product data management
- Supply chain planning
- Component and service procurement
- Order management
- Contract and in-house manufacturing
- Assembly
- Installed base management and upgrades

**Contract manufacturing**
- Customer product master data entry
- Planning
- Sales
- Component procurement
- Assembly
- Distribution
- Assembled configuration documentation

**Component distribution**
- Product specification and cataloging
- Collaborative planning
- Sourcing
- Sales
- Kitting
- Distribution
- Returns management
### Table 3.4 (a) High tech industry capstone (SAP 2000) (continued)

<table>
<thead>
<tr>
<th>Semiconductor and component manufacturing</th>
<th>Business support</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Product and process technology development</td>
<td>• Human resource management</td>
</tr>
<tr>
<td>• Design win</td>
<td>• MRO procurement</td>
</tr>
<tr>
<td>• Order booking</td>
<td>• Treasury</td>
</tr>
<tr>
<td>• Collaborative supply chain planning</td>
<td>• Fixed asset management</td>
</tr>
<tr>
<td>• Manufacturing</td>
<td>• Foreign trade</td>
</tr>
<tr>
<td>• Logistics execution</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3.4 (b) High tech industry function decomposition for the “Original equipment design and manufacturing” function (SAP 2000)

#### Product data management
- CAD integration
- Master data maintenance
- Document management
- Object classification
- Project management
- Workflow
- Document archiving
- Engineering change request/order creation
- Sales knowledge base management
- Pricing variant specification
- AML creation

#### Supply chain planning
- Statistical forecasting
- Characteristic planning
- Collaborative demand planning
- Product life cycle planning
- Multi-plant MRP/MPS
- Constrained production planning
- Supply and distribution network modeling
- Supply network optimization
- Capable to match
- Vendor managed inventory

#### Contract and in-house manufacturing
- Order profitability analysis
- Design registration
- Agreement negotiation
- Special buy agreements
- Ship and debit agreement claims processing

#### Component and services procurement
- Quality specification
- RFQ/quotations
- Source determination
- Purchase price determination
- Contract management
- Supplier delivery signaling
- Incoming inspection

#### Order management
- Quotation processing
- Order entry
- Order scheduling and promising
- Product configuration
- Order costing

#### Installed base management and upgrades
- Customer installed base modeling
- Configuration/change management
- Serial number tracking
- Upgrade management
- Warranty management
- Spare parts management
- Factory service and repair

#### Assembly
- Delivery processing
- Shipping
- Transportation planning
- Inventory management
- Warehouse management
- RF date entry
- Shipment costing and settlement
- Inventory tracking by distributor/reseller
- Price protection
- Ship/debit and special buy POS reporting
- Data collection
Table 3.5 Retail industry capstone model and function decomposition for the “Category management” function (SAP 2000)

<table>
<thead>
<tr>
<th>Capstone</th>
<th>Category management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterprise management</strong></td>
<td></td>
</tr>
<tr>
<td>• Strategic enterprise management</td>
<td>• Develop assortment strategy</td>
</tr>
<tr>
<td>• Business intelligence and data warehousing</td>
<td>• Vendor planning</td>
</tr>
<tr>
<td>• Managerial accounting</td>
<td>• Merchandise planning</td>
</tr>
<tr>
<td>• Financial accounting</td>
<td>• Promotion development</td>
</tr>
<tr>
<td><strong>Customer relationship management</strong></td>
<td>• Space and shelf planning</td>
</tr>
<tr>
<td>• Market research and analysis</td>
<td><strong>Product introduction and maintenance</strong></td>
</tr>
<tr>
<td>• Sales support</td>
<td>• Reference data maintenance</td>
</tr>
<tr>
<td>• Customer service</td>
<td>• Category hierarchy management and reclass</td>
</tr>
<tr>
<td>• Customer loyalty</td>
<td>• Store group management</td>
</tr>
<tr>
<td><strong>Category management</strong></td>
<td>• Assortment management</td>
</tr>
<tr>
<td>• Merchandise and assortment planning</td>
<td>• Space and shelf management</td>
</tr>
<tr>
<td>• Product introduction and maintenance</td>
<td><strong>Vendor relationship management</strong></td>
</tr>
<tr>
<td>• Vendor relationship management</td>
<td>• Integrated support of category management projects</td>
</tr>
<tr>
<td>• Price and promotion management</td>
<td>• Management strategic vendors</td>
</tr>
<tr>
<td>• Merchandise performance analysis</td>
<td>• Supplier fund management</td>
</tr>
<tr>
<td><strong>Buying</strong></td>
<td>• Collaboration management</td>
</tr>
<tr>
<td>• Forecasting and allocation</td>
<td>• Vendor exception analysis</td>
</tr>
<tr>
<td>• Purchasing</td>
<td>• Condition and bonus management</td>
</tr>
<tr>
<td>• Settlement</td>
<td>• Trade fair and market buying</td>
</tr>
<tr>
<td><strong>Supply chain management</strong></td>
<td><strong>Price and promotion management</strong></td>
</tr>
<tr>
<td>• Distribution planning</td>
<td>• Competitive pricing</td>
</tr>
<tr>
<td>• Inventory management</td>
<td>• Market basket pricing and analysis</td>
</tr>
<tr>
<td>• Warehouse management</td>
<td>• Two-phased wholesale/retail pricing</td>
</tr>
<tr>
<td>• Shipping and transportation</td>
<td>• Pricing/promotions performance</td>
</tr>
<tr>
<td>• Replenishment</td>
<td>• Markdown planning</td>
</tr>
<tr>
<td><strong>Channel execution</strong></td>
<td><strong>Merchandise performance analysis</strong></td>
</tr>
<tr>
<td>• Store retailing</td>
<td>• Financial and profitability analysis</td>
</tr>
<tr>
<td>• Wholesale and agency business</td>
<td>• Opportunity gap analysis</td>
</tr>
<tr>
<td>• Catalog and Internet retailing</td>
<td>• Activity based costing</td>
</tr>
<tr>
<td>• Food services and restaurants</td>
<td>• Product catalog management</td>
</tr>
<tr>
<td><strong>Business support</strong></td>
<td>• Exception reporting</td>
</tr>
<tr>
<td>• Human resource management</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.6 Generic ERP capstone model and function decomposition for the “Procurement and logistics” function (SAP 2005)

<table>
<thead>
<tr>
<th>Capstone</th>
<th>Procurement and logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analytics</strong></td>
<td><strong>Procurement</strong></td>
</tr>
<tr>
<td>• Strategic enterprise management</td>
<td>• Managing catalog content</td>
</tr>
<tr>
<td>• Financial analytics</td>
<td>• Self-service procurement</td>
</tr>
<tr>
<td>• Operations analytics</td>
<td>• Service procurement</td>
</tr>
<tr>
<td>• Workforce analytics</td>
<td>• Purchase order processing</td>
</tr>
<tr>
<td><strong>Financials</strong></td>
<td>• Receipt confirmation</td>
</tr>
<tr>
<td>• Financial supply chain management</td>
<td>• Service confirmation</td>
</tr>
<tr>
<td>• Financial accounting</td>
<td>• Invoice verification</td>
</tr>
<tr>
<td>• Management accounting</td>
<td>• Sanctioned party list screening</td>
</tr>
<tr>
<td>• Corporate governance</td>
<td>• Import control</td>
</tr>
<tr>
<td><strong>Human capital management</strong></td>
<td><strong>Supplier collaboration</strong></td>
</tr>
<tr>
<td>• Talent management</td>
<td>• Development collaboration</td>
</tr>
<tr>
<td>• Workforce process management</td>
<td>• Purchase order collaboration</td>
</tr>
<tr>
<td>• Workforce deployment</td>
<td>• Invoice processing</td>
</tr>
<tr>
<td><strong>Procurement and logistics execution</strong></td>
<td>• Account and payment information</td>
</tr>
<tr>
<td>• Procurement</td>
<td><strong>Inventory and warehouse management</strong></td>
</tr>
<tr>
<td>• Supplier collaboration</td>
<td>• Cross docking</td>
</tr>
<tr>
<td>• Inventory and warehouse management</td>
<td>• Warehousing and storage</td>
</tr>
<tr>
<td>• Inbound and outbound logistics</td>
<td>• Physical inventory</td>
</tr>
<tr>
<td>• Transportation management</td>
<td><strong>Inbound and outbound logistics</strong></td>
</tr>
<tr>
<td><strong>Product development and manufacturing</strong></td>
<td>• Inbound processing</td>
</tr>
<tr>
<td>• Production planning</td>
<td>• Outbound processing</td>
</tr>
<tr>
<td>• Manufacturing execution</td>
<td>• Product classification</td>
</tr>
<tr>
<td>• Enterprise asset management</td>
<td>• Duty calculation</td>
</tr>
<tr>
<td>• Product development</td>
<td>• Customs communication service</td>
</tr>
<tr>
<td>• Life cycle data management</td>
<td>• Trade document service</td>
</tr>
<tr>
<td><strong>Sales and service</strong></td>
<td>• Trade preference processing</td>
</tr>
<tr>
<td>• Sales order management</td>
<td>• Letter of credit</td>
</tr>
<tr>
<td>• Aftermarket sales and service</td>
<td>• Periodic declarations</td>
</tr>
<tr>
<td>• Professional service delivery</td>
<td><strong>Transportation management</strong></td>
</tr>
<tr>
<td>• Global trade service</td>
<td>• Transportation execution</td>
</tr>
<tr>
<td>• Incentive and commission management</td>
<td>• Freight costing</td>
</tr>
<tr>
<td><strong>Corporate services</strong></td>
<td><strong>Procurement and logistics execution</strong></td>
</tr>
<tr>
<td>• Real estate management</td>
<td>•</td>
</tr>
</tbody>
</table>
• Specialized function-based vendor models

These are business- and industry-oriented models developed for specific industries or functions within those industries. The “Hotel Front Desk” or “Purchasing Management” models offered by a single vendor would fall under this category.

• Professional consortium models

These models are categorized sets of business processes established by various professional associations to create process paradigms and compendia for focused groups of activities. These consortia include organizations such as the Supply Chain Council (2007), the Open Applications Group (OAGi 2007), RosettaNet (2007) and the American Productivity and Quality Center (APQC 2008). We illustrate these models through the APQC paradigm for manufacturing functions and processes.

The American Productivity and Quality Center (APQC) is an internationally recognized non-profit organization for business process and performance improvement, providing expertise in benchmarking and best practices research. Its activities focus on benchmarking and best practices, knowledge management, metrics and measures, and performance measurement (APQC 2008). In order to create a common basis for these endeavors, the APQC provides, and continually updates, a taxonomy of business processes, which it terms the Process Classification FrameworkSM (PCF) (APQC 2008; Bruno 2002). The PCF was developed by APQC and its member companies as an open standard to facilitate improvement through process management and benchmarking, regardless of industry, size or geography. It is a high-level, industry-neutral enterprise model that allows organizations to see their activities from a cross-industry process viewpoint and to measure the performance of these activities. The “activities” are, in effect, high-level processes. The PCF encompasses 12 enterprise level categories, 62 process groups, and over 1,000 business processes and associated activities. The categories include: (1) develop vision and strategy; (2) develop and manage products and services; (3) market and sell products and services; (4) deliver products and services; (5) manage customer service; (6) develop and manage human capital; (7) manage information technology and knowledge; (8) manage financial resources; (9) acquire, construct and manage property; (10) manage environmental health and safety (EHS); (11) manage external relationships; (12) manage knowledge, improvement and change. The categories and process groups are detailed in Table 3.7 (APQC 2008). It can be appreciated that the complete PCF provides an extremely rich source of information regarding enterprise-wide business functionalities and processes. It can be downloaded free from the APQC site.

(b) Abstract relevant major level functionalities from the reference model

The designer assesses the relevancy of the major functions in the reference model and creates a reduced capstone model incorporating those functionalities, which he or she considers applicable to the enterprise.
Table 3.7 Process classification framework\textsuperscript{SM} (APQC 2008\textsuperscript{*})

<table>
<thead>
<tr>
<th>1.0</th>
<th>Develop vision and strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Define the business concept and long-term vision</td>
</tr>
<tr>
<td>1.2</td>
<td>Develop business strategy</td>
</tr>
<tr>
<td>1.3</td>
<td>Manage strategic initiatives</td>
</tr>
<tr>
<td>2.0</td>
<td>Develop and manage products and services</td>
</tr>
<tr>
<td>2.1</td>
<td>Manage product and service portfolio</td>
</tr>
<tr>
<td>2.2</td>
<td>Develop products and services</td>
</tr>
<tr>
<td>3.0</td>
<td>Market and sell products and services</td>
</tr>
<tr>
<td>3.1</td>
<td>Understand markets, customers and capabilities</td>
</tr>
<tr>
<td>3.2</td>
<td>Develop marketing strategy</td>
</tr>
<tr>
<td>3.3</td>
<td>Develop sales strategy</td>
</tr>
<tr>
<td>3.4</td>
<td>Develop and manage marketing plans</td>
</tr>
<tr>
<td>3.5</td>
<td>Develop and manage sales plans</td>
</tr>
<tr>
<td>4.0</td>
<td>Deliver products and services</td>
</tr>
<tr>
<td>4.1</td>
<td>Plan for and acquire necessary resources (Supply Chain Planning)</td>
</tr>
<tr>
<td>4.2</td>
<td>Procure materials and services</td>
</tr>
<tr>
<td>4.3</td>
<td>Produce/Manufacture/Deliver product</td>
</tr>
<tr>
<td>4.4</td>
<td>Deliver service to customer</td>
</tr>
<tr>
<td>4.5</td>
<td>Manage logistics and warehousing</td>
</tr>
<tr>
<td>5.0</td>
<td>Manage customer service</td>
</tr>
<tr>
<td>5.1</td>
<td>Develop customer care/customer service strategy</td>
</tr>
<tr>
<td>5.2</td>
<td>Plan and manage customer service operations</td>
</tr>
<tr>
<td>5.3</td>
<td>Measure and evaluate customer service operations</td>
</tr>
<tr>
<td>6.0</td>
<td>Develop and manage human capital</td>
</tr>
<tr>
<td>6.1</td>
<td>Develop and manage human resources (HR) planning, policies, and strategies</td>
</tr>
<tr>
<td>6.2</td>
<td>Recruit, source, and select employees</td>
</tr>
<tr>
<td>6.3</td>
<td>Develop and counsel employees</td>
</tr>
<tr>
<td>6.4</td>
<td>Reward and retain employees</td>
</tr>
<tr>
<td>6.5</td>
<td>Re-deploy and retire employees</td>
</tr>
<tr>
<td>6.6</td>
<td>Manage employee information</td>
</tr>
<tr>
<td>7.0</td>
<td>Manage information technology</td>
</tr>
<tr>
<td>7.1</td>
<td>Manage the business of information technology</td>
</tr>
<tr>
<td>7.2</td>
<td>Develop and manage IT customer relationships</td>
</tr>
<tr>
<td>7.3</td>
<td>Manage business resiliency and risk</td>
</tr>
<tr>
<td>7.4</td>
<td>Manage enterprise information</td>
</tr>
<tr>
<td>7.5</td>
<td>Develop and maintain IT solutions</td>
</tr>
<tr>
<td>7.6</td>
<td>Deploy IT solutions</td>
</tr>
<tr>
<td>7.7</td>
<td>Deliver and support IT services</td>
</tr>
<tr>
<td>7.8</td>
<td>Manage IT knowledge</td>
</tr>
<tr>
<td>8.0</td>
<td>Manage financial resources</td>
</tr>
<tr>
<td>8.1</td>
<td>Perform planning and management accounting</td>
</tr>
<tr>
<td>8.2</td>
<td>Perform revenue accounting</td>
</tr>
<tr>
<td>8.3</td>
<td>Perform general accounting and reporting</td>
</tr>
<tr>
<td>8.4</td>
<td>Manage fixed asset project accounting</td>
</tr>
<tr>
<td>8.5</td>
<td>Process payroll</td>
</tr>
<tr>
<td>8.6</td>
<td>Process accounts payable and expense reimbursements</td>
</tr>
<tr>
<td>8.7</td>
<td>Manage treasury operations</td>
</tr>
<tr>
<td>8.8</td>
<td>Manage internal controls</td>
</tr>
<tr>
<td>8.9</td>
<td>Manage taxes</td>
</tr>
<tr>
<td>8.10</td>
<td>Manage international funds/consolidation</td>
</tr>
<tr>
<td>9.0</td>
<td>Acquire, construct, and manage property</td>
</tr>
<tr>
<td>9.1</td>
<td>Design and construct/acquire non-productive assets</td>
</tr>
<tr>
<td>9.2</td>
<td>Maintain non-productive assets</td>
</tr>
<tr>
<td>9.3</td>
<td>Obtain, install and plan maintenance for productive assets</td>
</tr>
<tr>
<td>9.4</td>
<td>Dispose productive and non-productive assets</td>
</tr>
<tr>
<td>9.5</td>
<td>Manage physical risk</td>
</tr>
<tr>
<td>10.0</td>
<td>Manage Environmental Health and Safety (EHS)</td>
</tr>
<tr>
<td>10.1</td>
<td>Determine health, safety, and environment impacts</td>
</tr>
<tr>
<td>10.2</td>
<td>Develop and execute health, safety, and environmental program</td>
</tr>
<tr>
<td>10.3</td>
<td>Train and educate employees</td>
</tr>
<tr>
<td>10.4</td>
<td>Monitor and manage health, safety, and environmental management program</td>
</tr>
<tr>
<td>10.5</td>
<td>Ensure compliance with regulations</td>
</tr>
<tr>
<td>10.6</td>
<td>Manage remediation efforts</td>
</tr>
<tr>
<td>11.0</td>
<td>Manage external relationships</td>
</tr>
<tr>
<td>11.1</td>
<td>Build investor relationships</td>
</tr>
<tr>
<td>11.2</td>
<td>Manage government and industry relationships</td>
</tr>
<tr>
<td>11.3</td>
<td>Manage relations with board of directors</td>
</tr>
<tr>
<td>11.4</td>
<td>Manage legal and ethical issues</td>
</tr>
<tr>
<td>11.5</td>
<td>Manage public relations program</td>
</tr>
<tr>
<td>12.0</td>
<td>Manage knowledge, improvement and change</td>
</tr>
<tr>
<td>12.1</td>
<td>Create and manage organizational performance strategy</td>
</tr>
<tr>
<td>12.2</td>
<td>Benchmark performance</td>
</tr>
<tr>
<td>12.3</td>
<td>Develop enterprise-wide knowledge management (KM) capability</td>
</tr>
<tr>
<td>12.4</td>
<td>Manage change</td>
</tr>
</tbody>
</table>

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3.7 A Case Study: “Hotel Front Desk”

Hotel, motel and resort desk agents perform a variety of services for their guests. Regardless of the type of accommodation, most desk agents have similar responsibilities. Primarily, they register arriving guests, assign rooms, and check out guests at the end of their stay. They also keep records of room assignments and registration-related information either on cards or on computers. When guests check out, desk agents prepare and explain the charges for accommodation, room service, restaurant meals and other hotel amenities, and process the payments. The agents are always in the public eye and, through their attitude and behavior, greatly influence the clientele’s impressions of the establishment. When answering questions about hotel services, checkout times, the local community, amenities in the area, or other matters of interest to the guests, they must be courteous and helpful. An important part of the job is to respond to concerns and complaints (and compliments!) from guests. Should guests report problems with rooms or with service, members of the housekeeping or maintenance staff have to be contacted in order to correct the problems. In some smaller hotels and motels, agents may have a variety of additional responsibilities that are usually performed by specialized employees in larger establishments. For example, they perform the work of a bookkeeper, advance reservation agent, cashier, laundry attendant, and telephone...
switchboard operator. They may accept and confirm reservations by telephone, letter, e-mail and in person. They handle telephone and fax messages for guests and, possibly, incoming conventional and electronic mail, packages, baggage and other items. From this short job description, it is clear that the front desk functionality not only encompasses a wide range of processes, but that it requires careful operations and staffing design. Defining these operations in terms of business processes creates a firm basis for subsequent facility and operations design of the hotel front desk (HFD). Our case study uses the following scenario:

The Excelsior hotel wishes to redesign and refurbish its front desk and client reception service. The hotel is located in a small country town currently undergoing a business boom as a new semi-conductor facility is being established in the area. In addition, the management plans to provide a shuttle service between the hotel and the nearest airport. The local tourist bureau is also gearing up to serve the businessmen and other guests who wish to visit the scenic views around the town.

(a) Construct an initial reference model for the enterprise

We developed a reference model through an Internet search using the terms “front desk management” and “front desk management system” and performed a subsequent analysis of the functionalities and processes implicit or explicit in the descriptions of the systems retrieved. The resultant reference model is detailed in Table 3.2 (adapted from Meiren and Karni 2005); it comprises 11 main functions and 136 processes. (Note that “Front Desk Management” is a major function within the Hospitality Management industry.)

(b) Abstract relevant major level functionalities from the reference model

“Hotel Front Desk Management” constitutes the (single) major function of relevance.

(c) Abstract relevant main level functionalities from the reference model

From the 11 main level functionalities we decided that nine were relevant: reservation management, rate and yield management, check-in management, check-out management, guest relationship management, guest information service management (hotel amenities), guest information service management (external amenities), communication management, and service support coordination management. These comprise a first reduced reference model comprising 123 processes. The size of the hotel and its clientele did not justify keeping a wait list or historical records; lobby maintenance was provided by the general maintenance staff, and financial control was provided by the hotel accountant.

(d) Abstract relevant business processes from the reference model

From the 123 processes in the reduced model we selected 72 relevant processes. The final reduced reference model for the nine main level functionalities is shown in Table 3.8.
Table 3.8 Final enterprise-specific hotel front desk model

1. **Reservation management**
   - Review future room availability and status for reservation
   - Search available units for specified date range and unit capacity
   - Select unit for single reservation
   - Verify single/multi/group reservation information prior to booking
   - Create single/multi/group reservation
   - Issue single/multi/group reservation confirmation letter and send
   - Charge room at check-in
   - Create reservation frontally
   - Create reservation telephonically
   - Create reservation via e-mail
   - Cancel reservation via fax

2. **Rate and yield management**
   - Provide information on regular rates
   - Maintain tour operator account

3. **Check-in management**
   - Welcome regular guest
   - Welcome VIP guest
   - Review current room availability and status for occupation
   - Check in guest arriving on time to reserved room
   - Check in guest arriving early to reserved room
   - Check in guest arriving late to reserved room
   - Provide information on predefined deposit
   - Provide information on alternative means of payment
   - Provide information on vehicle parking and parking fees
   - Record customer credit card number
   - Handle credit card invalidity

4. **Check-out management**
   - Check out guest leaving on time
   - Check out guest leaving early
   - Check out guest leaving late
   - Issue check-out invoice with list of guest fees
   - Receive single currency (cash) payment
   - Receive credit card payment
   - Issue final receipt

5. **Guest relationship management (guest services)**
   - Handle complaints
   - Handle guest queries
   - Reserve dinner for guest
   - Record guest instructions or other notes on guest record
   - Charge additional services to guest record
   - Charge additional expenses to guest record
   - Charge point of sale expenses to guest record
   - Supply newspaper to guest
   - Supply travel directions to guest
   - Rent car for guest
   - Order taxi for guest
   - Coordinate guest request for wake-up call
   - Issue wake-up call
   - Allocate safe to guest
   - Issue safe receipt

6. **Guest information service management (hotel amenities)**
   - Provide information on meal timetables
   - Provide information on meal/restaurant menus
   - Provide information on currency exchange rates
   - Provide information on hotel facilities
   - Provide information on hotel shop
   - Provide information on found items

7. **Guest information service management (external amenities)**
   - Provide information on vehicle rental agencies
   - Provide information on tourist agencies
   - Provide information on restaurants
   - Provide information on tourist attractions and sites
   - Provide information on organized tours
   - Provide information on medical services and hospitals

8. **Communication management**
   - Record and/or post messages for guest
   - Deliver messages to guest
   - Transfer telephone call to guest
   - Enable guests to receive e-mail messages
   - Enable guests to send e-mail messages
   - Enable guests to receive fax messages
   - Enable guests to send fax messages
Table 3.8 Final enterprise-specific hotel front desk model (continued)

<table>
<thead>
<tr>
<th>9 Service support coordination management</th>
<th>10 Gift shop management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coordinate guest request with housekeeping</td>
<td>• Coordinate with purchasing on item inventories</td>
</tr>
<tr>
<td>• Coordinate guest request with maintenance</td>
<td>• Coordinate with sales on item prices</td>
</tr>
<tr>
<td>• Coordinate guest request with room service</td>
<td>• Maintain display items on shelves</td>
</tr>
<tr>
<td>• Coordinate guest request with computing services</td>
<td>• Handle guest queries</td>
</tr>
<tr>
<td>• Coordinate guest request with porterage</td>
<td>• Record item purchase on guest record</td>
</tr>
<tr>
<td>• Coordinate guest request with transportation (e.g., airport, city)</td>
<td>• Handle purchase payments</td>
</tr>
<tr>
<td>• Coordinate guest request with restaurant</td>
<td></td>
</tr>
</tbody>
</table>

(e) Augment the model by performing a gap analysis (Type I) between enterprise specificity and reference model generality

The hotel runs a small gift shop, adjacent to the front desk. Management of the shop is in the hands of the front desk staff. Thus an additional function “Gift Shop Management” and its associated processes were added (Table 3.8). This results in a final enterprise-specific model for the Excelsior Hotel with 78 business processes. Application of the remaining steps of the design procedure is outside the scope of this book.

Problems

1. The SAP Corporation provides a Solution Map Composer (free download), a handy PC-based tool that helps to create enterprise process models. It incorporates a library of selected sample industry-specific business solutions (industry models) from which a specific model can be assembled from the stored functionalities and processes. Download the Composer (SAP 2007b) and use it to synthesize an enterprise process model.

2. Construct a reference model for your company or for one of the primary functions within your company, using an Internet search. Make a list of the ERP or software vendors who have provided a rich source of information during your search. Use your reference model and the offerings of these vendors to carry out a gap analysis (Type II: enterprise model compared to vendor model) to determine which system is most suited to your requirements.

3. Carry out the enterprise process model design procedure for the purchasing department in your company, starting from the reference model set out in Table 3.3. What functions or processes would you add that are specific to your company?

4. After developing a specific model, use the APQC Process Classification FrameworkSM (it can be downloaded free from the site) as a checklist to evaluate your enterprise or functional model with the processes in the APQC framework.
5. Go to the SAP industry model site and analyze the industry-related business solutions. Compare the functionalities and sub-functionalities and determine which are common to several industries, and which are exclusive to a particular industry.

6. Go to the SAP industry model site and compare the functionalities of manufacturing industries to those of service industries. Determine those which are common to both sectors, those which are common within each sector, and those which are specialized within each industry.

7. Comment on the usefulness of the “business function” concept as a categorization for clustering business processes. For example, obtaining a part for a product into stores requires a cross-enterprise process sequence including requisition management (product engineering), requisition management (project engineering), requisition management (purchasing), procurement operations (purchasing), receiving operations (purchasing), and inventory management (warehousing). Does the separation of the material flow management into four functions make it more difficult to implement?

8. One of the “axioms” of the functional approach is that enterprise design and management is first defined on the basis of business processes (how should we operate to develop and produce the product?) and then on the basis of roles and agents for carrying out these processes (how should we organize to develop and produce the product?). This means that functions, even though they may have similar or identical names, are not necessarily synonymous with organizational units or departments. It therefore has to be decided to which organizational unit each function, or even each sub-function, should be allocated. Comment on this dilemma and determine, using a reference model, which functions can be allocated to a single unit, and which functions may have to be allocated to several units.

9. ERP systems were originally developed to support a manufacturing framework, and only later applied to services. This is probably because the level of commonality between manufacturing enterprises is high (see “Function-based enterprise-wide vendor models” in this chapter), whereas that between services is far lower. Try to construct a function-based enterprise-wide reference model for the industrial (service-product-based) functionality of service enterprises using Table 3.1 (functions 28–31) and other service sector models. Is such a model feasible?

10. The service functionalities in Table 3.1 are based on “customer communication,” expressed through the concept of “office”: front office (frontal), contact office (call center), remote office (web site) and mobile office (field service). Comment on the effectiveness of the “office” perspective as a basis for major service functionality.
4 Information and Its Use

4.1 From Data Collection to Decisionmaking

The order-fulfillment process as defined earlier – from the acceptance of a customer order to the delivery of the right product, in the right quantity, at the right time to the customer – has three integrated aspects:

- The data aspect – data collection, storage, retrieval and analysis
- The decisionmaking aspect – making decisions regarding the usage of information, resources and materials
- The physical aspect – handling and processing of material (raw material, parts and finished products)

The first aspect deals with the generation and collection of data, such as a new customer order that enters the system. New data is generated when transactions take place; new data is also collected from a variety of internal and external sources by data collection systems.

Data can be classified based on its importance and urgency. Urgent data may have to be processed, analyzed and made available to the decision makers immediately; while important data may wait in storage from where it can be retrieved for further processing and analysis when needed. Data classified as unimportant should not be collected in the first place and if collected it should be discarded. The technical aspects of data storage and retrieval are discussed in detail in books dealing with IT-Information Technology and IS-Information Systems (see, for example, Laudon and Laudon 1995; Sauter 1997).

Data is used to support decisionmaking. There are two types of decisions associated with the order-fulfillment process:

Routine decisions – these decisions are based on the same type of data processed routinely in the same way. An example is decisions regarding the payment to suppliers. Given the cost of goods supplied and agreed upon, the quantity supplied, and the payment agreement (say 30 days after delivery) the decision of how much to pay and when, is routine and can be automated.

Ad-hoc or non-routine decisions – these decisions are difficult or impossible to automate. A decision to discontinue a product line, to change the quoted price of a product or to give a special, one-time discount to a customer, are examples of non-routine or ad-hoc decisions. See Sect. 8.7 for a detailed discussion.
It is not always simple to distinguish between the two types of decisions. One guideline is the amount of intuition, experience and emotion involved in the decisionmaking process. Another point to consider is the frequency in which each decision is made. Frequent decisions that are based on well defined (and preferably quantifiable) logic are candidates for automation, while decisions that are very rarely made and are largely based on the decision maker’s intuition and experience are less suitable for automation.

One attribute of a poor order-fulfillment process is the lack of automatic decisionmaking. When this is the case, each decision is treated as one-of-a-kind and top management spends most of its time dealing with an endless stream of routine decisions that should have been automated in the first place. In a well-designed order-fulfillment process, routine decisions are made by the information system in an automatic mode. In case a routine decision cannot be automated for some reason, an effort should be made to transfer such a decision to the employees who execute the decisions. They should be instructed on how to make the routine decisions, and should be supported by providing all the information and applicable decision rules (the appropriate analysis of information required to make the decision). Employee empowerment constitutes one of the central principles of business process design (Chap. 8). See also Table 8.1 factors 33 and 47.

In a well-designed order-fulfillment process, top management handles only non-routine, special decisions. Top management should be busy monitoring the environment and the performances of the process in an effort to identify the need for changes in the current process early on. When decisionmaking is automated, it is important to watch the resulting performances by means of a monitoring and control system designed to alert management when a currently-used decision-making process produces poor results. This is especially true when competition takes place in a rapidly changing environment with high levels of uncertainty.

An important step in the design of the order-fulfillment process is to decide which of the decisions to automate, how to do it and how to monitor automated decisionmaking processes to detect poor performance, and when to make ad-hoc decisions or to modify an existing process. The design of the decisionmaking aspect in the process should therefore focus on the following:

- The ability of the information system to support automatic decisionmaking
- Type of decisions to automate
- The logic used for automated decisions
- Data required for automated and non-automated decisions
- The way the data should be collected, processed and presented as information to support decisionmaking processes
- The establishment of monitoring and control systems that are needed to detect problems in the process early on

When the needed data is collected, processed and supports decisionmaking, the third aspect of the order-fulfillment process – the physical aspect: processing and handling of material – is reduced to understanding and implementing the decisions, which is mostly a matter of information sharing and proper training for the workforce.
Information sharing is a key element in redesigning the order-fulfillment process. Unlike the typical functional organization in which each function has its “own” data, in the Integrated Production Order Management approach, with the support of the ERP systems, data is shared by everybody involved in the process. Thus, when decisions are implemented those responsible for the implementation understand not only what they have to do but also why it has to be done.

4.2 Information Systems: The Data Base and the Model Base

Three types of information systems support the order-fulfillment process:

- **Transaction processing system** – a system that performs and records all routine transactions such as sales order entry, inventory transactions and shipments to customers
- **Management information system** – a system that serves the purposes of planning, decisionmaking and controlling, by providing the output of automated decision processes as well as routine summaries and exception reports
- **Decision support system** – a system that combines data and analytical models to support semistructured and unstructured decisionmaking

All three systems use data that come from internal and external sources. An important component of a well-designed information system is a database in which the data is managed and stored. The database is managed by a Data Base Management System (DBMS), whose most important feature is its ability to separate the logical and physical views of data so that users can retrieve data without being concerned with its physical location in the database. There are three important types of logical database systems: *Hierarchical systems* that are high in processing speed but limited in flexibility, *Network systems* and *Relational systems* that are very flexible in supporting ad-hoc requests for information but are relatively slow. The design of databases is beyond the scope of this book. This important topic is discussed in books on Databases and Information systems (e.g., Thalheim 2000).

The model base that supports the order-fulfillment process includes three types of models:

- **Models for well-structured, routine, decisionmaking processes** – these models can be completely automatic, as, for example, a decision to reorder raw material when its inventory level reaches the calculated reorder point. In some applications the information system may automatically issue a purchase order while in other applications the system only recommends and the order is issued manually by low-level management. These models are typically part of a Management Information System.
• **Models for non-structured or non-routine problems** – in this case the output of the model does not provide a decision that can be implemented but rather the result of the analysis provides some insight into a situation. Models for capacity planning, for example, are routinely used in the order-fulfillment process to estimate current and future load on resources. These estimates are helpful for identifying overloaded resources (bottlenecks), modifying delivery schedules, outsourcing (using subcontractors), etc. These models are typically a part of a Decision Support System.

• **Models for process control** – these models are designed to alert management in cases where the process gets out of control. Typical examples are an alert that some customer orders might not be ready for shipment on time; an alert that a work center is overloaded; or an alert regarding an expected shortage of raw materials.

Models are used when a real problem is too complicated to analyze and to solve. To facilitate analysis and solution, simplifying assumptions are made and a model is developed. Thus, a good model is simple enough to facilitate understanding and analysis of a real problem and yet it is close enough to the real problem so that the solution obtained from the analysis of the model is useful for the real problem. To test the applicability of a solution obtained from a model, sensitivity analysis is conducted where the effect of the simplifying assumptions is tested.

In the past, functional units in the organization tended to develop dedicated information systems. Thus the accounting information system supported monetary transactions and cost accounting analysis, while the production planning and control information system focused on the management of materials and resources. The need for integration and the understanding that local decisions made by functional units affect other functional units promoted the development of integrated information systems. These systems, known as Enterprise Resource Planning (ERP) systems, integrate the data of the whole organization in a single data base (see Sect. 8.6), and provide models for decision support that consider the processes performed by the whole organization to achieve its global objectives. These systems are designed to support all the processes in the organization:

• The development process – from an idea for a new product or service to a working prototype
• Preparation of facilities – from a working prototype of a new product or service to the successful completion of design, implementation and testing of the production/assembly or service facility and its supporting systems and resources
• Sales – from a study of the market and its needs to the reception of a firm customer order
• Order fulfillment – from a firm customer order to the delivery of the required products or services and payment by customer
• Service – from a customer’s call for a service to the fixing of the problem and a satisfied customer
An important consideration in the design of an information system that supports the processes that the organization performs is which models to use in the system. The models are separated from the database so that (1) the same model can be used to solve different problems by applying it to different sets of data in the database; and (2) the model can be changed without affecting the way in which data is stored in the database. The collection of models in the information system comprises the model base of the system. Another important aspect of the design of an information system that supports the order-fulfillment process is the integration between the model base and the database. Ensuring that all the required models are in the model base and all the data required for the selected models are in the database and can be retrieved easily by the appropriate models is of utmost importance. Incorporation of data and knowledge linkages in a business process is discussed in Sect. 8.3 (d) and (e).

When an organization develops its own information system to support its processes it can select the models and DBMS most appropriate for its needs. Due to the high cost of developing and maintaining a tailor-made, one-of-a-kind, information system, most organizations tend to purchase off-the-shelf software and set it up to fit their needs as much as possible. However, commercial software, which is typically less expensive to purchase and maintain, has limited flexibility. Therefore, it is highly recommended to design the processes prior to purchasing the supporting software and then to select the software product that fits the proposed processes best (see Sect. 12.2). If this is not done in the above sequence and the software is purchased before the processes are designed, limitations of the software may constrain the design of the various processes and a real dynamic integrated process may not be possible. This is especially important in selecting an ERP-type system that supports all the processes in the organization. The danger is that system selection is based on the needs of one process while the other processes are not well supported by the ERP system.

There are many different software packages on the market that support a specific process such as the order-fulfillment process. Some are designed to support parts of the process such as packages using finite capacity scheduling logic for shop floor control, while other packages are supposed to support the whole order-fulfillment process, such as advanced Material Requirement Planning packages known as MRP II. Enterprise Resource Planning (ERP) systems are designed to support all the processes performed by the organization simultaneously.

A case study on software package selection is presented in Sect. 12.2.

### 4.3 The Accounting Information System

The most common information system is probably the accounting system, which is a specialized MIS designed to collect, process, and report information related to financial transactions. Legal, tax and reporting requirements, as well as the need to
manage and control scarce financial resources of the organization, promoted the use of accounting systems in organizations. Over the years these systems were extended to support decisionmaking and performance measurement. Cost accounting is a collection of models commonly used to support decisions on pricing, outsourcing and purchasing.

Following Gleens et al. (1993) the major components of the accounting information system are:

1. The order entry and sales entry system – the system that interfaces with customers and markets.
2. The billing, accounts receivable, and cash receipts system – the system that bills customers, monitors customer accounts, and records cash receipts.
3. The purchasing, account payable, and cash disbursements system – the system that supports purchasing of goods and services, monitors open payable accounts, and processes and records cash disbursements.
4. The inventory system – the system that monitors inventory and its value.
5. The human resources management system – the system that maintains employee and payroll records, and prepares and records payroll transactions.
6. The general ledger, and financial reporting system – the system that maintains the general ledger and prepares accounting reports.
7. The integrated production system – the system that collects, processes and records production costs.

The accounting information system is a very important source of information for management. However, the information generated by this system should be well understood to avoid misinterpretation and erroneous decisions. For example, traditional cost accounting models tend to assume that production volume, direct material, and direct labor are the main factors that influence costs. This assumption was valid when the level of automation on the shop floor was low and direct material and direct labor costs were the major cost components of a manufacturing organization. Furthermore, some cost accounting models are based on the assumption that direct labor is flexible, and its level of usage can be easily changed with the production volume. Today, due to advanced manufacturing technology, direct labor costs are frequently just a fraction of the total cost of a product or a service and are practically fixed, at least in the short range. Consequently, the analysis of traditional cost accounting models may be misleading. Newer approaches to cost accounting are based on a different set of assumptions. One example is Activity Based Costing (ABC), which is based on a detailed analysis of the activities performed in a process. Both value added and non-value added activities are accounted for and the system assigns the costs of activities to products based on the actual time each activity is performed on each product and the actual cost of resources used to perform the activity. The concepts of ABC were developed by the Consortium for Advanced Manufacturing-International, now known simply as CAM-I (White 2002).
A second example is the system of three financial performance measures suggested by Goldratt and Fox (1986):

- **Throughput (T)** – The rate at which the system generates money through sales. It is the difference between the dollar sales for the period and the expenses generated by these sales (the expenses that would not occur if the sales were canceled).
- **Inventory (I)** – The entire amount of the money the system invests in purchasing items the system intends to sell. This is the original purchase cost of raw materials, parts and components stored in the system.
- **Operating Expenses (OE)** – The entire amount of money the system spends in turning inventory into throughput, which is not directly dependent on the level of sales (i.e., not included in the throughput calculations).

The accounting information system collects data, analyzes it and provides the user with financial and cost accounting information. Understanding and using this system to support the management of the order-fulfillment process is an important part of teaching the IPOM concept.

### 4.4 Quality of Information

Earlier in this chapter we categorized data as urgent, important and unimportant. The information generated by processing the data has a value only if it is useful in the decisionmaking process. The usefulness of information is the result of several qualities and it can be measured by the following:

- **Understandability**: Information can support the decisionmaking process only if decision-makers understand it. Thus, if the information is in a language not understood by decisionmakers, its usefulness is doubtful. As an example, consider an organization in Russia that is interested in implementing a new ERP system. A major factor in selecting the new system is whether a Russian version is available. If a candidate ERP system supports only the English language, the information it provides might be useless unless the users understand English.
- **Validity**: Valid information describes an actual and relevant reality. Thus, if a production lot is specified in a work order, and the whole lot is rejected after processing due to poor quality, the information that the lot is completed is not valid as none of the units is of accepted quality.
- **Relevance**: Information is relevant for the decisionmaking process if it reduces uncertainty and either reinforces the decision that would have been made without that information, or change the outcome of the decisionmaking process. For example, information about the development of a new version of the ERP system that is used by the organization is irrelevant to the scheduling decisions currently made on the shop floor. The very same information is very relevant to a decision on whether to replace the current ERP system or not.
- **Accuracy**: This is a measure of the level of agreement between the information and actual reality. For example, if according to the inventory records there are 50 units of a finished product in stock, but actual counting reveals that there are only 45 units on the shelf, the information in the inventory records is not accurate.

- **Completeness**: Measures the level of coverage of every relevant object by the information. For example, if there are 1001 different items in inventory but the information system contains records for only a thousand of them, then even though each record might be perfectly accurate, the information in the inventory system is not complete.

A major aspect in the design of the information system is to ensure that the information is understood, valid, relevant, accurate and complete. The way to do this is to perform a thorough analysis during the design stage of the process, to understand the needs for information and to develop a cost-effective system to support these needs. The information system should be managed throughout its life cycle to ensure that its performances do not deteriorate over time.

### 4.5 Forecasting

An ideal information system provides only high quality information that is understandable, valid, relevant, accurate and complete. In reality, some information is simply not available and the best we can do is to estimate it. This is particularly true when future events are considered. For example, information about future interest rates, future inflation rates and future money exchange rates is important for investment decisions. Information about future demands and future competition is important for marketing decisions and information about future absenteeism of employees, future yield of machines and future breakdown of machines is important for production planning. However, exact information of this type is simply not available and the best we can do is to try and forecast it.

Forecasting is an art as well as a science. Some people can forecast future events with remarkable accuracy, based on their experience and intuition. For example, some farmers are known to forecast the weather with outstanding results without using any sophisticated models, computation or computers. In this book, however, we concentrate on forecasting models that are based on time series analysis, i.e., an attempt to forecast the future based on the analysis of past data. The future value of a time series is called a forecast while past values are called observations. A time series is depicted in Fig. 4.1.

The analysis of past data can focus on specific patterns in a time series. Pattern recognition by either mathematical analysis or by simple observation helps in identifying the components of a time series. The simplest time series has only a fixed (constant) component. If, for example, the speed of light is measured daily in exactly the same conditions, the data collected over time will form a time series with a constant component only. This situation is depicted in Fig. 4.2.
In reality, we know that it is very difficult to repeatedly measure a physical phenomenon in exactly the same conditions; furthermore there is always a measurement error. Therefore, most time series will have an additional component – a random one. A random component in a time series represents everything we cannot explain by the other components. Statistical tools are used to deal with the random component; thus we might be interested in measuring its stability over time, its average size, its standard deviation, the shape of its distribution, etc. It is important to analyze the random component of a time series to get an estimate of the quality of forecasts. Special performance measures are used to estimate the forecasting error in order to help the user of forecasting techniques to assess the accuracy of the forecasts. A time series with random components is depicted in Fig. 4.3.

Other components of a time series include trend (a tendency to consistently increase or decrease over time), a seasonal component (alternating maximum and minimum values correlated with the 12 months or the four seasons of the year), and a cyclical component that is similar to the seasonal except that the gap between adjacent maxima or minima (the cycle) is other than 12 months. Autocorrelation might also affect a time series when a current value of the time series is highly correlated with some of its past values.
Fig. 4.2 A constant time series

Fig. 4.3 A time series with a random component
Techniques for time series analysis, such as those of Box and Jenkins (1976), are designed to detect the components of a time series and to apply appropriate forecasting models that minimize the forecasting error. Based on the components of a time series, an appropriate forecasting model can be selected and its parameters set to get the best possible forecast.

The moving average: This is a simple forecasting model that is applicable when a time series is composed of mainly a constant and a random component. If the random component distribution changes slowly over time, a simple average of the last few periods will cancel out positive and negative random deviations. The resulting forecasting error depends on the number of observations included in the averaging process. Averaging over a large number of periods reduces the forecasting error (the same effect as increasing the sample size when sampling at random from a homogenous population), provided no trend, seasonal or cyclical components are present. The most recent observations over the same number of periods are averaged whenever a new forecast is required. Every time a new observation is available, the oldest observation is taken out of the averaging process. This model is known as the “Moving Average” forecasting model.

A formal presentation of the moving average model follows:

\[
F_t = \frac{\sum_{i=1}^{n} O_{t-i}}{n}
\]

In this formulation \( F_t \) is the forecast for period \( t \);
\( O_{t-i} \) is the observation in period \( t-i \);
\( n \) is the number of periods in the average.

Example

Consider for example the following time series

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
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<td>32</td>
<td>31</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td>28</td>
<td>29</td>
<td>33</td>
<td>29</td>
<td>27</td>
<td>31</td>
<td>32</td>
</tr>
</tbody>
</table>

Assuming a moving average over 5 months, the forecast for next January is:

\[
F_{13} = \frac{32 + 31 + 27 + 29 + 33}{5} = 30.4
\]

A variation of the moving average model is used when a trend is detected in the data. In this case, recent observations are more affected by the trend and therefore are considered more important in the averaging process. Thus, if \( n \) observations are used, instead of assigning each one an equal weight of \( 1/n \) as in the simple moving average model, a higher weight is given to recent observations and a lower weight is given to older observations, keeping the sum of these weights equal to 1. This model is known as the weighted moving average model.
Assuming the following weights for the previous example: 0.1, 0.15, 0.2, 0.25, 0.3, the forecast for January is

\[ F_{11} = 0.1 \times 33 + 0.15 \times 29 + 0.2 \times 27 + 0.25 \times 31 + 0.3 \times 32 = 30.4 \]

The weighted moving average model follows:

\[ F_t = \sum_{i=1}^{n} w_{t-i} O_{t-i} \quad \text{where} \quad \sum_{i=1}^{n} w_{t-i} = 1 \]

In this model \( F_t \) is the forecast for period \( t \)
\( O_{t-i} \) is the observation made in period \( t-i \)
\( W_{t-i} \) is the weight assigned to the observation of period \( t-i \)

A difficulty with the weighted moving average model is to find the set of weights that yields the best forecast. There are infinite combinations of different weights. A weighting scheme that simplifies the process of weight generation and selection is needed as well as a performance measure to evaluate the quality of different forecasts.

The exponential smoothing model is a weighting scheme that simultaneously generates all the weights for a time series so that recent observations are given heavier weights while the total of all the weights is always equal to one. The fundamental relationship of the exponential smoothing model is:

\[ F_t = F_{t-1} + \alpha (O_{t-1} - F_{t-1}) \]

where \( F_t \) is the forecast for period \( t \)
\( F_{t-1} \) is the forecast made for the prior period
\( O_{t-1} \) is the observation in the prior period and
\( \alpha \) is a smoothing constant.

By substituting \( F_{t-1} \) into the equation for \( F_t \) it can be shown that the sum of all the weights is equal to 1.

Consider the previous example, using a smoothing constant of 0.5; the following forecast is obtained based on the last five observations:

\[ F_t = 0.5 \times 32 + (0.5)^2 \times 31 + (0.5)^3 \times 27 + (0.5)^4 \times 29 + (0.5)^5 \times 33 = 29.96 \]

To select the best value of \( \alpha \) a performance measure is defined and a search for the constant \( \alpha \) that yields best value of the performance measure is conducted. The smoothing constant that minimizes the performance measure is selected for the exponential smoothing model of that time series.

One performance measure used to evaluate the quality of forecasts is the Mean Absolute Deviation or MAD. The MAD value is calculated as follows:

\[ MAD = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{\text{forecast}_i - \text{observation}_i}{n} \right| \]
An alternative performance measure is the Mean Squared Error (MSE). The MSE value is calculated as follows:

\[
MSE = \frac{\sum_{i=1}^{n} (\text{forecast}_i - \text{observation}_i)^2}{n-1}
\]

Advanced forecasting packages are designed to search for the best smoothing constant given a performance measure such as the MAD or MSE. The selected smoothing constant is used to calculate the weights of all past observations in the forecasting model.

**Problems**

1. Describe the order-fulfillment process in a Pizza restaurant that has a dining facility and also makes home deliveries. Explain the differences between the two types of service focusing on the aspects of decisionmaking, flow of information and flow of material in each service.
2. In problem 1, discuss the possibilities of automating the decisionmaking processes of each service.
3. What kind of data is handled by the transaction processing system of a hospital?
4. Describe a Decision Support System that you are familiar with and explain one of the models used in this system.
5. Why is it important to separate the database from the model base in the ERP environment?
6. Select an organization and describe its accounting system’s seven major components, based on the approach of Gleans et al. Explain each component.
7. Under what conditions will “Throughput” and “Sales” be exactly the same?
8. Study a map of the city where you live and discuss the quality of information presented and its relation to the scale of the map.
9. Based on the inflation rate during the last 10 years, forecast the rate of inflation for next year using three different forecasting techniques. Using MAD as a performance measure, select the best forecasting method and explain your analysis.
10. Find an article about ERP implementation and discuss the elements of the database and the model base mentioned in the article.
5 Marketing Considerations

5.1 Manufacturing Policies: Make to Stock, Make to Order, Assemble to Order, Engineer to Order

Like many other processes in modern organizations, Integrated Production and Order Management (IPOM) is an integrated process that crosses traditional functional and organizational lines (see Sect. 1.5). This process, that starts with customer orders for end products (in the following discussion the term “end products” will be used for products or parts supplied to customers), proceeds with purchasing from suppliers and subcontractors and includes production, assembly, packaging and shipping of the finished products. The whole process is aimed at fulfilling customer orders to ensure the long-term success of the organization. Since the process is triggered by customer orders, and is designed to fulfill such orders, it is important to manage such orders and thus we start this chapter by defining what exactly constitutes an order that triggers the process.

A customer order may be a formal document, i.e., a written form specifying the goods ordered, quantities, the required due date, terms of payment and the customer’s legal obligation to pay; it might be a long-term contract with periodical (daily, weekly) deliveries or, it might be an order issued by marketing based on a demand forecast. In the ERP environment, these may be all electronic transactions that are aggregated in the Master Production Schedule (MPS) into a master plan as explained later in this chapter. The selection of the triggering mechanism that drives the whole order-fulfillment process is an important decision as it defines the interface between the market and the rest of the process. This decision affects the whole order-fulfillment process.

Competition in the order-fulfillment process has several dimensions: time, cost, flexibility and quality. The performance of the organization in each of these dimensions has a significant effect on its competitiveness and on its ability to survive. A competitive market that demands low cost, high quality products in a short lead time, coupled with a flexibility to respond to changing needs of the customers and a changing environment, forces management to continuously seek ways to improve the order-fulfillment process, so as to ensure the long-term success of the organization.

The design of the order-fulfillment process should focus on each of the above dimensions and on the interactions between them. Thus the way production and purchasing orders are initiated is a key design factor in the order-fulfillment process. As discussed earlier, the process can be triggered by a firm customer...
order or by a forecast of future demand. When the trigger is a forecast of future demand, inventories of finished goods are frequently used to buffer against the uncertainty. Uncertainty causes forecasting errors, as we saw in the discussion on forecasting. When the trigger is a forecast of future demand, the promised lead time to the customer is relatively short, as it is determined by the time required for information processing (order processing) and the shipping time from the storage to the customer. This promised lead time is typically shorter than the lead time that is required in the case that the process is triggered by a firm customer order. In the latter case, the lead time promised to the customer should be long enough to include not only order processing time and shipping time but also the actual manufacturing time of the goods ordered and sometimes the time required for obtaining raw materials or parts from suppliers as well. Since most suppliers are customers of their own suppliers, the lead time is a function of the supply chain used and the way it is managed. The competitive advantage of the first alternative – the ability to supply in a shorter lead time – does not come for free. As we saw in the previous chapter, forecasts are subject to forecasting errors. Forecast-based manufacturing orders generate excess inventories whenever the forecast exceeds actual demand. If, however, the forecasts turn out to be lower than actual demand, the results are shortages, and consequently late deliveries or even worse – lost sales. This interaction between the dimensions of time and cost is further complicated since the buildup of inventories reduces the flexibility of the organization to modify the design of its products, to introduce new models to the market and to change the production schedule when a customer requests it.

In most organizations, manufactured goods are made of purchased parts and raw materials, which make the triggering decision even more complicated. Management can decide to trigger the purchasing activities based on a demand forecast, but to start production and assembly only when firm customer orders exist. The designer of the order-fulfillment process has several alternatives to initiate purchasing orders and production orders, for example:

- Issue purchasing orders and/or production orders based only on firm customer orders
- Issue purchasing orders and/or production orders based on demand forecasts; and maintain inventories of some purchased raw materials and parts
- Issue purchasing orders based on the current inventory of these purchased parts and raw materials and issue production orders based on firm customer orders

The number of different alternatives is large, as each part or raw material may be managed differently according to its cost, lead time, the structure of its supply chain, the characteristics of the end products, and the markets for which it is being used. Again, the trade-off between the dimensions of lead time, flexibility and the cost of inventory emerges.

The above discussion brings up the need for a well-integrated order-fulfillment process: conflicting marketing, production and purchasing considerations create the dilemma of how to trigger production and purchasing orders. Without a well-defined
process for triggering new orders, every order is an ad-hoc decision that requires management’s attention, which in turn may cause delays and long lead times.

There are extreme policies for triggering new production and purchasing orders. One such policy is stocking enough finished goods to guarantee off-the-shelf delivery of every existing end product; the opposite approach is “no stock production” (Shingo 1983; Anderson 2004), according to which manufacturing and purchasing orders are issued only when firm customer orders are on hand, and the quantities manufactured and ordered are exactly equal to the customer requirements. In practice, mixed policies are commonly used in industry.

One mixed policy is based on the “supermarket approach.” A comparison is made between the actual lead time of the entire order-fulfillment process and the required lead time. If the lead time acceptable to the customers is longer than or equal to the actual lead time of the order-fulfillment process, no inventory is needed and the whole process is triggered by customer orders. If, however, the customers lead time is shorter than the actual lead time, the quantity of finished goods required to cover demand during the difference in lead times is stocked and a continuous effort is made to reduce the delivery lead time to the point that it is shorter or at least equal to the lead time required by the customers. When this goal is achieved, no stock is required and the only triggers for new production orders are firm customer orders.

Once the mechanism that triggers production and purchase orders is defined, the design of the order-fulfillment process can proceed. For example, an effort to reduce setup times and batch sizes may be needed if the no stock approach is adopted. An effort to develop an appropriate forecasting system is required if demand forecasts are used to trigger production or purchasing orders. An effort to train employees to understand and to execute the process correctly should always follow in order to guarantee successful, error-free implementation.

The discussion so far has focused on the trigger for new production or purchasing orders. A related decision is the size of each order (the batch sizes). Economy-to-scale and technological considerations might play an important role here. For example, a fixed shipping cost may be charged to each purchase order. If this cost is substantial (as in the case where goods are shipped from the supplier by trucks and shipping cost is per truck, i.e., it is not a function of the actual load on the truck), larger orders (e.g., orders that fully utilize the capacity of the trucks) may seem more economical; however, orders larger than the actual requirements create inventories.

The above discussion leads to the four types of policies frequently used in industry. On one extreme is the make to stock policy that triggers new production and purchasing orders based on forecasts. This policy minimizes the promised lead time to the customers at the cost of carrying inventories. The other extreme is engineer to order policy that triggers new design efforts based on customer order. The make to order policy according to which no stocks are carried and the only legitimate reason to issue a purchase order or a production order is a firm customer order. The last policy is assemble to order. In this case, some raw material, parts or subassemblies are stocked, but final assembly of end products is triggered by a firm customer order.
The decision as to which policy to adopt and how to implement it is not trivial. It is product and market dependent. Thus orders for products sold in a competitive market may be issued based on demand forecasts to guarantee off-the-shelf delivery, while orders for less competitive products may be issued based on actual customer orders. In some situations, the same product is sold off-the-shelf to small retail customers but production of large lots ordered by wholesale customers is triggered by firm customer orders.

Technology may play an important role in this decision. If, for example, a single raw material is used to manufacture a variety of end products, and the raw material lead time is relatively long, stocking this raw material may be the right approach. This is typically the case in refineries, where crude oil is a single raw material from which a variety of finished products are manufactured. Another technological issue is the shelf life of end products, raw material parts and components. If the finished product has a short shelf life, the best choice might be to stock raw materials in order to shorten the delivery lead time.

As we will see later in the book, the end result of this effort is an appropriate design of the supply chain and the development of policies for managing the chain – policies that will guarantee a sustainable competitive edge for the organization.

The result of any order-triggering policy is a list of planned, future, gross requirements of end products. In a make-to-stock environment, some of these future gross requirements are based on demand forecasts for the end products and part of these requirements can be supplied from existing or planned inventories of end products. In a make-to-order environment, these future gross requirements are based on firm customer orders. This list is known as the Master Production Schedule (MPS) and serves as the interface between the marketing aspects of the order-fulfillment process and the production/purchasing activities.

5.2 The Master Production Schedule

The Master Production Schedule (MPS) is a statement of planned, future, gross requirements of end products. To implement this plan, the required production capacity should be available when needed, along with the required quantities of raw materials, parts and subassemblies supplied by subcontractors and outside vendors. The MPS is triggered by the market demand according to the triggering policy selected by management (make-to-stock, make-to-order, etc.) and it triggers all manufacturing and purchasing activities in the order-fulfillment process. Since the MPS may be based on a combination of firm customer orders and forecasts, some of the future gross requirements may be committed to firm customer orders while the rest of these future requirements may be available as off-the-shelf stock used to supply customers demanding a short lead time in the future. Future gross requirements not committed to a specific customer are known as Available To Promise (ATP).
Management of the MPS is an important aspect of the order-fulfillment process. Books written about the subject (Proud 1999) stress the importance of master scheduling for competitive manufacturing. Since the MPS represents future commitments to customers on the one hand and the allocation of manufacturing capacity among different end products on the other, its construction and updating should mirror the integration of marketing, production and purchasing considerations. When the order-fulfillment process is not well integrated, a conflict between marketing and production/purchasing is highly likely. This conflict is driven by different objectives: marketing is frequently measured by its ability to supply customers on a short lead time and to respond quickly to changing customer needs, while manufacturing is frequently measured by its ability to maximize utilization of available resources. Purchasing is measured by its ability to minimize the cost of purchased parts and raw materials while supplying all required material on time and in the right quantities to avoid disturbances in production due to material shortages. Thus the marketing tendency is to continuously update the MPS according to the changing customer needs while manufacturing and purchasing prefer a stable “frozen” MPS, at least for the near future.

To avoid this conflict the whole order-fulfillment process should be integrated to achieve a common set of goals with respect to cost, time, flexibility and quality. Appropriate performance measures should be developed and applied to the order-fulfillment process to support its management and control. The MPS is an integrating device in the order-fulfillment process. By making the MPS known to all members of the IPOM team and by introducing a team approach to the management of the MPS, a common goal for the order-fulfillment process is established, maintained and made known to the whole team.

The management of the MPS is a complex task in which three major activities require special attention:

- Introduction of new requirements into the MPS
- Updating of existing requirements – changing the required time and/or the required quantities, and/or changing the status from available to promise to a firm customer order
- Monitoring and control of the actual performance of the order-fulfillment process compared to the goals established by the MPS

Each of these activities requires an integrated approach: The introduction of new requirements into the MPS should be based on market demand, on the current and future load on the shop floor and on the availability of purchased parts and raw materials. Changes in existing MPS records should serve market needs subject to capacity and material availability constraints. The monitoring and control of the MPS should produce early warnings regarding late manufacturing or late purchasing orders that may result in a delay in supplying the planned gross requirements. Such early warnings can support the order-fulfillment process management team in setting priorities, expediting orders or utilizing additional sources of capacity such as overtime, additional shifts and subcontracting.
The MPS represents the gross requirements for end products. Figure 5.1 depicts a schematic MPS:

Translation of the MPS into work orders and purchasing orders that in turn trigger the material handling and processing activities of the order-fulfillment process are performed by production-related Management Information Systems such as MRP or production planning and control systems such as JIT, as explained in the following chapters.

5.3 Lead Time and Time-Based Competition

Time plays an important role in the order-fulfillment process (Stalk 2003). As explained in the previous section, in some markets a shorter lead time promised to customers improves the competitiveness of the organization and its ability to get new business.

A reliable order-fulfillment process that consistently delivers on time maintains customer satisfaction and loyalty. The relationship between the lead time promised to customers and the actual lead time of the order-fulfillment process is a key factor in the decisions on how to structure and manage the supply chain, e.g., how much inventory and what kind of inventories (raw materials, parts, or finished goods) should be carried. Thus, a continuous effort to reduce the lead time of the order-fulfillment process is critical for developing and maintaining the competitive edge of an organization.

The order-fulfillment process is a collection of operations dealing with data processing, decisionmaking and the physical processing and handling of materials,
parts and finished products. The lead time of the order-fulfillment process is determined by the time required to perform this collection. The duration of each operation, delays before, after and during operations, and the ability to perform operations in parallel, constitute key factors affecting the total lead time of the order-fulfillment process. Thus to reduce lead time, each operation should be studied and optimized. Furthermore, the process as a whole – the sequence in which the individual operations are performed should also be analyzed to minimize the total duration of the process. This effort should concentrate on four points:

1. Elimination of unnecessary operations
2. Minimization of the duration of necessary operations
3. Minimization of dependencies between operations to enable parallel operations.
4. Minimization of delays before, after, and during the operations (see also Sect. 13.3 (b) (1))

The first step calls for a critical review of each operation in the process asking WHY the operation is performed and if it is necessary. The crucial question is what is the value added of each operation. Operations that do not add value to the customer should be eliminated. Typically, “Move” and “Store” operations do not add any value to the customer and should be eliminated or at least reduced to a minimum by selecting a proper layout that follows the processing sequence of the products and minimizes the need for material handling. Similarly manual copying of data, double entry of data and mailing of hard copies should be eliminated. Operations that add value to the customer should be combined if possible to eliminate transportation and delays between such operations. For example, quality control operations add unnecessary time to the order-fulfillment process. An effort to develop stable, reliable processes and to integrate quality control activities within each operation so that each operator is responsible for the quality of his work can substantially reduce the time of a process.

The next step concentrates on the question of HOW value-added operations are performed – is it possible to reduce time and effort or, alternatively, to automate these operations? Time and motion studies are basic means in this analysis. An effort to develop tools, jigs and fixtures that reduce the duration of operations related to material handling and processing is part of this step. A simultaneous effort to improve data processing and decisionmaking activities by developing appropriate management information systems and decision support systems can reduce the lead time of the order-fulfillment process further.

In the third step of the analysis, the focus is on delays. Delays are found in all aspects of the order-fulfillment process. Two types of delays are common: operations delays and process delays.

Operations-related delays are generated when, due to a relatively long setup time, large batches (or lots) of the same product are processed. When operations are performed on one unit of the product at a time, the whole batch is delayed until every unit is completed, i.e., the delay is equal to the setup time plus the processing time per unit multiplied by the batch size. To eliminate this delay, an effort to reduce setup time is required. A short setup time makes large lots unnecessary and
the delay is eliminated. If setup time reduction is not possible, the batch-related delay can still be reduced by transferring single product units from operation to operation without waiting for the completion of the whole batch. Thus, by reducing the setup time and the size of the processing batches, the operation delays can be minimized. In addition, processed units should be transferred as soon as they are finished to the machine performing the next operation (this is known as using one unit transfer batch).

**Process delays** are caused by bottlenecks in the process. A bottleneck is created when the load on a machine is close to or exceeds its available capacity. In this case, if operations feeding the bottleneck generate output at a rate higher than the bottleneck production rate, a queue of batches waiting to be processed is accumulated in front of the bottleneck and causes a process delay. To eliminate this type of delay, the bottleneck production schedule should serve as a driver for the schedule of all other operations. The scheduling technique called Drum Buffer Rope (DBR) is based on these principles and discussed later. Another possibility is to use finite capacity scheduling (Plenert and Kirchmier 2000), a technique that schedules production according to the available capacity of resources on the shop floor.

In data processing and decisionmaking processes, delays are introduced when data and information are made available to users sequentially. In the days when information and data were transferred by means of written documents, the transmission of data was performed by physical transfer of these documents. The time to circulate documents introduced a necessary delay in the process. Today’s ERP technology supports the parallel distribution of data by computer communication to eliminate this type of delay.

**Decisionmaking delays** – delays in the decisionmaking process are common to organizations in which information is transferred through the different hierarchy levels in the form of documents, and the formality of the decisionmaking process requires management signatures on the documents. They are also generated in organizations that do not have well-established policies regarding repetitive decisions. In this case many decisions are treated as one time, ad-hoc decisions that require special management attention. The sheer number of such decisions and the need to reach consensus among different organizational units involved in the order-fulfillment process translates frequently into an endless number of meetings in which group decisionmaking is taking place. Scheduling such meetings and reaching consensus is time consuming and decisions are often delayed which delays the whole process. Two approaches help to reduce delays: ensuring that all employees are aware of the common goals of the organization; and suitably empowering individual employees to make decisions without the necessity for group decisionmaking (see Sect. 13.8).

The introduction of control points in data processing and data distribution processes is also a common source of operations delays. When control is exercised by regulating the flow of information, it delays the flow of information and forces a sequential decisionmaking process.

Data acquisition causes further delays when it requires manual data entry. Sometimes the entry of the same data several times in the process is the source of
delay (and errors). By introducing electronic data acquisition and computer communication technology, data captured anywhere in the process can be made available to all users simultaneously.

The last step in the analysis focuses on the question WHEN each operation is performed in the process. This step concentrates on the longest sequence of operations in the process (analog to the critical path analysis in a project – see Shtub et al. 2004) and on the duration of setups. The objective of the analysis is to reduce the duration of the longest sequence by checking the precedence relations among its activities and wherever possible to schedule activities in parallel. Reduction of the duration of setups is of utmost importance, as shorter setups enable smaller batch sizes, thus minimizing delays that reduce the duration of the whole process.

By adopting a dynamic team approach to the order-fulfillment process, including data sharing, elimination of non-value-added operations and delays, parallel operations, and a consistent effort to reduce setup and operations times, the duration of the order-fulfillment process can be compressed to provide a competitive edge in the framework of time-based competition.

### 5.4 Quality and Its Management: Quality-Based Competition

The order-fulfillment process is the link between the organization, its customers and its suppliers. The successful translation of customers’ orders into the actual delivery of goods and services is measured by customers’ satisfaction. Thus, quality management in the order-fulfillment process is the continuous effort to please customers and to achieve customer satisfaction (Dale 2003).

Customers are satisfied when their expectations are met or exceeded. These expectations are product and service related. Garvin (1987) suggested that quality-based competition has eight dimensions or performance measures:

1. **Performance**: This dimension refers to the product or service’s primary characteristics, for example, the acceleration, cruising speed and comfort of an automobile or the sound and the picture clarity of a TV set. The understanding of the performances required by the customer and the design of the service or product to achieve the required performance level is a key factor in quality-based competition.

2. **Features**: This is a secondary aspect of performance: the characteristics that supplement basic functioning. Garvin defines features as “the bells and whistles” of the product or service. The flexibility provided to a customer to select desired options from a large list of such options contributes to the quality of the product or service.

3. **Reliability**: This performance measure reflects the probability of a product malfunctioning or failing within a specified time period. It reflects on both the cost of maintenance and on downtime (non-availability) of the product.
4. **Conformance**: This is the degree to which product or service design and operating characteristics meet established standards. In the order-fulfillment process, delivery time is a major concern to customers. The promised lead time is the standard yardstick; and any deviation from it hurts the time-based competitiveness of the order-fulfillment process as discussed later.

5. **Durability**: This is a measure of the economic and technical service duration of a product. It relates to the amount of use one can get from a product before it has to be replaced because of technical or economical considerations.

6. **Serviceability**: This measure reflects the speed, courtesy, competence and ease of repair should the product fail. The reliability of a product and its serviceability complement each other. A reliable product that rarely fails, and, on those rare occasions when it does, fast and inexpensive service is available, has a lower downtime and better serves its owner.

7. **Aesthetics**: This is a subjective performance measure related to how the product feels, tastes, looks, sounds or smells and reflects individual preferences.

8. **Perceived quality**: This is another subjective measure related to the reputation of a product or a service. This reputation may be based on past experience and partial information; but, in many cases, the customer’s decisions are based on perceived quality, as exact information about the first six performance measures listed above is not readily available.

To compete on quality, the organization has to manage the quality of its processes as well as the quality of its products and services. A quality product delivered and supported by shoddy processes will suffer from poor reputation and low perceived quality. Thus, a quality order-fulfillment process enhances the competitive edge of the organization.

A quality order-fulfillment process is based on a clear definition of what needs to be done in the process, who has to do it, when should it be done and how. Performance measures are needed as part of a process monitoring and control system and the people involved in the process must learn how to execute it and how to use the information system to support decisionmaking, execution and control. By continuously monitoring the process and by implementing a policy of process improvement whenever it is possible to improve the quality of the process, the organization can develop a sustainable competitive edge (see also Chap. 13).

### 5.5 Cost Considerations and Cost-Based Competition

Cost is an important performance measure especially for for-profit organizations. Since profit per product unit is defined as the difference between the selling price of the product and its cost, organizations can increase the selling price, decrease the cost, or try to do both in order to increase profits. In a competitive market, the selling price affects the volume of sales. Although the exact relationship between the selling price and sales is hard to predict, it is possible that an increase in selling price in an effort to increase profit per product unit may cause a decrease in sales and consequently the total profit will not increase; worse, it might even decrease.
A safer way to increase profit is therefore to reduce the cost of products, services and processes. Reduced costs can translate into higher profit per unit by keeping the selling price constant or it can be translated into higher total profits by reducing the selling price per unit and increasing total sales. In both cases the key to increased profit is lower cost.

In Sect. 4.3 the problem of measuring the cost of a product unit was introduced. Traditional cost accounting systems are based on the assumption that the cost of a product is composed of two components – direct cost and indirect cost. Direct cost is the cost of labor and material invested in the product unit. Indirect cost is the proportion of all other costs required to run the organization and should somehow be attributed to the goods sold. Based on this approach, the cost of a product unit may be affected, for example, by an increase in the property taxes paid for the head office building or by the hiring of a new lawyer for the legal department.

In the early days of the industrial revolution, the direct cost of labor and material was far more significant than the indirect costs. Most of the workforce was employed on dedicated manufacturing processes producing a single product and it was possible to trace the use of purchased materials to each of the limited number of end products. Today’s manufacturing processes are capital intensive, flexible and complex. Different products or different models of the same product share many parts and materials and the same facilities are used for the production of different products. The cost of management and other overhead costs are substantial while the cost of direct labor and material is hard to allocate. Furthermore, direct labor and material may represent a small fraction of the total cost of a product unit. The result is that the cost estimates produced by the cost accounting system may lead to the wrong decisions when competition is based on cost.

Another problem with traditional cost accounting systems is the separation of total cost to a fixed cost component and a variable cost component. Direct labor and material cost are often considered variable costs. Theoretically, management can control the variable cost by changing the actual level of production. In reality, management’s ability to control this cost by adjusting direct labor to the level of production may be limited. When the daily fluctuations in the level of production are significant, and the production processes require a trained workforce, at least in the short run, direct labor cost may be reasonably constant. The following example demonstrates the difficulty of using cost accounting models to support decisions regarding cost-based competition in the order-fulfillment process:

Consider a production line used for three models of the same product: A, B and C. The direct labor and material cost data are summarized in Table 5.1.

<table>
<thead>
<tr>
<th>Table 5.1 Direct cost data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual demand [units]</td>
</tr>
<tr>
<td>Direct labor [hours/unit]</td>
</tr>
<tr>
<td>Hourly rate [$]</td>
</tr>
<tr>
<td>Direct labor cost/unit [$]</td>
</tr>
<tr>
<td>Direct material cost/unit [$]</td>
</tr>
</tbody>
</table>
The annual indirect cost of the line is $80,000. Allocating this cost among the three models based on direct labor hours, and assuming a selling price of $400 per unit of each model, the following unit costs and profits are calculated and summarized in Table 5.2.

\[ \text{Indirect cost/direct hour [\$]} = \frac{80,000}{1,000 + 1,000 + 2,000} = 20 \]

Based on the above analysis total profit from the three models is

\[ -10,000 + 20,000 + 40,000 = 50,000 \]

Since model A is losing money, it seems that the right decision is to stop its production. In this case the annual direct cost of production is calculated as follows:

- **Labor cost**: \(100 \times 200 + 100 \times 400 = 60,000\)
- **Material cost**: \(100 \times 200 + 100 \times 400 = 60,000\)
- **Indirect cost**: \(80,000\)
- **Total cost**: \(200,000\)
- **Annual sales**: \(400 \times (200 + 400) = 240,000\)

The annual profit from selling Models B and C is therefore:

\[ 240,000 - 200,000 = 40,000. \]

Thus by eliminating the money-losing model A, profit is reduced from $50,000 to $40,000. The reason, of course, is that the fixed indirect cost is now allocated only to the two models left, B and C, reducing the profit per unit of each. In reality, the above analysis may lead to greater mistakes since direct labor is usually not flexible and eliminating model A does not reduce direct labor cost of the line proportionally.

To overcome the problems of traditional cost accounting systems, it is better to base decisions on the analysis of the total cost rather than on unit cost (Feldman and Shtub 2006). This approach looks at the throughput of each model defined as the difference between its selling price and the costs directly proportional to the volume of production (e.g., the cost of direct material) (Table 5.3).
Table 5.3 Unit throughput and total throughput per model

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual demand</td>
<td>100</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Unit selling price [$]</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Direct material cost/unit [$]</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Throughput per unit [$]</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Throughput per model [$]</td>
<td>30,000</td>
<td>60,000</td>
<td>120,000</td>
</tr>
</tbody>
</table>

The total throughput is now compared to the rest of the cost:

- Total throughput = $210,000
- Direct labor cost = $80,000
- Indirect cost = $80,000
- Total operating cost = $160,000
- Total profit = $50,000

Using the same throughput model if model A is discontinued, we obtain:

- Total throughput = $180,000
- Direct labor cost = $60,000
- Indirect cost = $80,000
- Total operating cost = $140,000
- Total profit = $40,000

Thus the use of throughput as a performance measure is better than using the unit cost computed by traditional cost accounting. As explained earlier, the best approach for analyzing major ad-hoc decisions, like discontinuing a product model, is to look at the whole picture, i.e., a Profit-and-Loss statement with and without the proposed change.

**Problems**

1. Discuss the four dimensions of competition: time, cost, flexibility and quality. Explain the trade-off between these denotations and use examples of different markets, in which one of the four dimensions is clearly dominant.
2. Explain how competition motivated shorter lead times in the service industry.
3. Select an order-fulfillment process of an organization with which you are familiar and analyze its lead time. Explain how it is possible to reduce this lead time and redesign the process accordingly.
4. Discuss the difference between the following policies as applied to the service industry: make-to-stock, make-to-order, assemble-to-order and engineer-to-order. Use examples to demonstrate the use of these policies.
5. Discuss the format of the MPS used in this chapter. Can you suggest a better way to present the MPS with additional information?
6. Analyze the lead time of two end products: in a fast food restaurant and in a full service restaurant.
7. Analyze the profit of a regular meal in a fast food restaurant.
8. Analyze the competitiveness of a product in the following frameworks with which you are familiar:
   - A forecast-based competition market
   - A time-based competition market
   - A cost-based competition market
   - A quality-based competition market.
9. Discuss the different assumptions used in product cost analysis and product throughput analysis. Explain under what conditions product cost analysis is preferred.
6 Purchasing, Outsourcing and Inventory Management

6.1 The Need for Purchasing and Outsourcing

“Purchasing refers to a function in business whereby the enterprise obtains the inputs for what it produces, as well as other goods and services it requires. Outsourcing became part of the business lexicon during the 1980s and often refers to the delegation of non-core operations from internal production to an external entity specializing in the management of that operation” (Wikipedia 2007).

In this chapter we discuss the importance of purchasing and outsourcing to the order-fulfillment process, focusing on decision-making and models that can help management decide on when to use purchasing and outsourcing and how to do it. We start by introducing the term capacity and will proceed to discuss models for inventory management and control.

Capacity, measured in terms of the maximum possible output level of the order-fulfillment process for a given period, is restricted in most organizations due to limited resources (facilities, machines, workers, etc.). In the short run, additional capacity can be obtained by increasing the utilization of existing resources (e.g., working overtime or extra shifts). In the long run, capacity expansion is possible by adding resources to the order-fulfillment process (e.g., hiring and training new employees, purchasing, installing and operating new machines, and building new facilities).

Frequent changes in the level of resources or in the level of resource utilization may be impossible or may cause instability of the order-fulfillment process. Therefore, most organizations use external sources of capacity; and only a few organizations are completely self-supporting. Moreover, most organizations that deliver goods and provide services purchase some materials, parts and services from outside sources. This process is known as purchasing and outsourcing.

Purchasing and outsourcing are ways for an organization to increase its effective capacity without investing substantial capital in facilities, machines, recruiting and training. They are useful in the short run as well as in the long run. Furthermore, they may be a way to enhance the organization’s competitive edge in the areas of cost, time, quality, and flexibility by selecting the best sources and by developing long-lasting relationships with selected suppliers.
To ensure that purchasing and outsourcing enhance the competitiveness of the order-fulfillment process, the following points should be carefully evaluated:

1. Which materials, parts and services should be purchased or outsourced – this is known as the **make or buy decision**.
2. How to select the suppliers and what kind of relationship to establish with them – this is known as **supplier management**.
3. What quantities to order, when to place new orders, and how to manage the stocks of purchased goods and materials – this is known as **inventory management**.

The designer of the order-fulfillment process should consider the above points in parallel with the other aspects of the order-fulfillment process to ensure the integration and competitiveness of the process.

Purchasing and outsourcing decisions are dynamic in nature. The organization should evaluate its purchasing and outsourcing policy continuously and consider the ability to produce goods or services previously purchased. In some instances, this is achieved by merging with and/or acquisition of a supplier.

### 6.2 Purchasing and Outsourcing – Make or Buy Decisions

The decision to use an outside source for the supply of goods or services required for the order-fulfillment process is a multi-attribute decision in which the following factors should be taken into account:

1. **Capacity** – Purchasing and outsourcing provide an external source of capacity. In the short run, when additional capacity is needed due to a sudden failure of machines or an increase in the workload, and temporary sources of capacity, such as overtime and extra shifts are not available or not sufficient, purchasing and outsourcing may provide a good feasible solution. Moreover, purchasing and outsourcing may be selected as the preferred source of capacity in the long run for different reasons as explained next.
2. **Know-how** – Purchasing and outsourcing may be necessary when the organization does not possess the technological know-how and this know-how is not considered part of the core technology of the organization. In other cases, a substantial investment is required to develop needed knowledge. It is also possible that the technology is not accessible to the organization; patents owned by other organizations (the suppliers) make purchasing and outsourcing a necessity.
3. **Cost and volume** – when the cost of in-house manufacturing becomes too high, or the volume of demand for a given part or service is too low to justify the initial investment in facilities, machines and workforce training, purchasing and outsourcing may be the best way to improve cost-based competition. **Break-even** analysis is frequently used to analyze the cost aspect of make or buy decisions. In this analysis, the purchase cost per unit (Cp) is multiplied by the required volume (Q) and this total cost of purchasing (Q*Cp) is compared to the total cost of manufacturing calculated as the cost of manufacturing a unit...
6.2 Purchasing and Outsourcing – Make or Buy Decisions

(Cm) times the volume (Q). If the difference (Q*Cp – Q*Cm) is smaller than the initial investment (I) required to start in-house manufacturing, purchasing is preferred, as it strengthens the cost-based competitiveness of the organization. Figure 6.1 illustrates the break-even analysis concept.

Fig. 6.1 Break even analysis

4. Demand pattern – when the demand for a part or service is widely fluctuating or seasonal, in-house manufacturing may not be justified, especially if it requires investment in special machines, equipment and facilities that might be idle for a substantial part of the time.

5. Time – Purchasing and outsourcing may be preferred when the lead time of buying is substantially lower than the lead time of manufacturing. In this case, purchasing and outsourcing may enhance the time-based competitiveness of the organization.

6. Quality – when the quality available from vendors is better than the quality that can be obtained in-house, purchasing and outsourcing may be a solution to improve the quality-based competitiveness of the organization.

7. Control – Purchasing and outsourcing increases the dependency of the order-fulfillment process on other organizations that are not under the direct control of the order-fulfillment team, thus, reducing the level of control the order-fulfillment team has over the process. Since control is an essential tool in fighting uncertainty and is important in correcting planning errors (as explained
in Chap. 10), reliability of suppliers as well as integration with the supplier’s planning processes are significant considerations in the make or buy decision. Consequently, when purchasing and outsourcing is used as part of the order-fulfillment process, proper supplier management is an important task of the order-fulfillment team.

8. Feasibility – in some cases purchasing and outsourcing is the only option available. For example, raw materials may only be available from foreign sources and therefore have to be imported.

Make or buy decisions are made both at the strategic, policy-setting level and at the operational ad-hoc level. At the strategic level, the decision is for what parts of the product or process in-house capacity should be acquired. More important is a strategic decision on core technologies – technologies that are the basis of the competitive edge of the organization and therefore should not be purchased or outsourced. At the operational level, the ad-hoc decision is whether to use in-house capacity (when such capacity exists) or to use purchasing and outsourcing each time a need for a part or service that can be supplied by either purchasing or in-house capacity arises. In both cases, if purchasing and outsourcing is adopted, the issue of supplier management should be addressed by the order-fulfillment process management team.

### 6.3 Supplier Management

For some companies, purchases account for approximately 60% of sales dollars (Burt 1989); for others, purchases account for 30–50% of sales dollars. Supplier management (Stallkamp 2005) is therefore a key activity in the order-fulfillment process. This activity may be subdivided into three subactivities:

- Specification of requirements
- Selection of suppliers
- Contract management

**Specification of Requirements**

The purchasing process starts with a definition of the required goods or services. In this definition three issues are addressed:

1. Definition of the required product or service including functional, physical and technical specifications
2. Definition of the order-fulfillment process requirements, including required lead time, size and number of shipments, shipping arrangements and frequency of deliveries
3. Definition of the quality system the supplier should employ and quality requirements applied to the product or service
Regarding the first issue, the level of detail of the functional and technical definitions may vary considerably. For example, a car manufacturer may approach a supplier of air-conditioning systems early on in the design phase of a new car and ask him to participate in the design process and design the air-conditioning system for the car prototype. In this case, only functional requirements may be available; and the expertise of the supplier is instrumental in transforming these functional requirements into a detailed technical design. In this example, the manufacturer decided to use purchasing and outsourcing for part of the design effort. A related example is a supplier of Printed Circuit Boards (PCBs) who receives a complete design for the boards required for the control system of the air-conditioning unit and manufactures the boards exactly according to the drawings (this process is known as built to print – BTP). A third example is a manufacturer of electronic components who supplies standard, off-the-shelf components to be installed on the PCBs. In each case, information on the product or service to be delivered is required, but the type of information and its level of detail vary considerably. This type of information helps potential suppliers assess their technological ability to deliver the required goods or services.

The second issue, definition of the order-fulfillment process-related requirements, helps the potential suppliers assess their operational ability to meet volume and lead time requirements. The two important questions are whether the required capacity will be available for delivery of the specified quantities on time; and whether the required lead time is shorter or longer than the supplier’s own order-fulfillment process lead time. In the former case (as explained in Chap. 4) the supplier may have to adopt a make-to-stock policy to ensure on-time delivery.

The third issue relates to the quality of the product or service as well as the requirements from the supplier’s quality system. In the past, the quality of the goods supplied was frequently specified in terms of percent defective. Special acceptance tests based on random sampling were used to evaluate the actual percent defective in each lot shipped by the suppliers and lots with a percent defective higher than specified were rejected. This approach, which is heavily dependent on acceptance tests, assumes that some of the goods shipped are faulty. It reduces the organization’s ability to compete on cost, quality and lead time. Testing increases cost and lead time, while random sampling does not eliminate the possibility of not detecting a poor quality part and using it, which results in a poor quality product. A different approach is to define the quality of the goods supplied in terms of specifications and the use to be made of them. These specifications are designed to eliminate the need for inspection of coming lots and to enable the trace of quality problems to the source by the supplier in order to eliminate these sources. Specifying quality requirements for both the goods delivered by the supplier and its order-fulfillment process, goods shipped by the supplier can be delivered directly to the point where they are used in the production process, without the need for testing and storage. This has a major effect in improving quality, cost and time performance of the entire order-fulfillment process.
Selection of Suppliers

When the requirements are clearly defined, it is possible to deal with the selection of suppliers. The first step is to decide on the number of suppliers for each purchased part. The traditional western approach is to select several suppliers for each part and to use competition to drive down the cost. Multiple sources are also viewed as a means to reduce dependency on suppliers, thus reducing the risk of losing the source of supply due to strikes or other catastrophes, and reducing the risk of a sudden increase in cost or lead time. An opposite approach is taken by some manufacturing organizations in Japan, where a single supplier is selected for each part and strong ties are established between the supplier and the buyer. The single source supplier is selected after a careful evaluation, which focuses on his ability to enhance the competitiveness of the buyer. Richard Newman (1988) lists seven areas of evaluation for potential buyers:

1. Process capability – Can the process used by the supplier produce the parts at the specified quality level?
2. Quality assurance – Are quality control procedures employed by the supplier adequate in order to maintain consistent quality at the required level?
3. Financial capability – What is the risk associated with doing business with the supplier?
4. Cost structure – What are the actual costs of material, labor and overheads and what are the supplier’s profits? High costs and low profit may indicate future problems.
5. Value analysis effort – The supplier’s ability to perform value analysis and his past success in performing value analysis indicate how well the supplier understands the product specifications and their relative importance.
6. Production scheduling – The ability of the supplier’s production planning and control system to deliver on time, to accommodate changes, and to supply in a short lead time, enhances the competitiveness of the buying organization.

The supplier selection process can also rely on a standard specification of the elements of the quality system. The ISO 9000 series, which comprises assessment specifications for a complete program from design through servicing, is an example of such a standard specification.

Contract Management

Once the selection process is complete, the focus is on contract management, i.e., the ongoing relationship with the supplier. Pence and Saacke (1988) define three categories of relationships between buyers and suppliers regarding the quality of the order-fulfillment process:

1. Inspection – focusing on product inspection to eliminate defects.
2. Prevention – focusing on efforts to build quality into the product and process, the purchaser helps the supplier in developing and maintaining defect-free manufacturing processes.

3. Partnership – a long-term relationship between the purchaser and the supplier that is based on teamwork between the two parties in the areas of technology (joint design effort) and quality (a certified supplier that delivers directly to the point of use).

The level of coordination between the order-fulfillment processes of the buyer and the supplier can take different forms. The traditional western approach is based on one-time orders, which specify the required quantity, due date, cost and payment terms. This approach is usually linked with inspection – goods are shipped to the receiving area where they are inspected and stored until needed for the order-fulfillment process. This approach is based on the theory of inventory management discussed next. A different approach is to sign a long-term (e.g., annual) agreement with the supplier, specifying the cost per unit, estimated total requirements and the promised lead time. The buyer’s planning and control systems issue periodic orders to the supplier. In this form of coordination, there is no need to negotiate the price and the terms of every order during the agreement period, and long-lasting relationships are established between the two parties. When the buyer and the supplier use ERP systems, it is possible to link the systems and transfer the periodical requirements electronically. A third approach is based on the Just-In-Time concept, where the supplier makes daily shipments directly to the assembly or the production line. This is possible only if the supplier is certified, no inspection of deliveries is required, and the relationship between the two parties is based on a real partnership.

The ongoing management of the supply chain is heavily dependent on the management of inventories. This is discussed in the next section.

6.4 Inventory Management – Benefit and Cost Considerations

Inventory Management is concerned with the policies, decisions and actions related to the planning, monitoring and control of stocks. Stocks of different types are used throughout the order-fulfillment process including stocks of:

- Raw materials
- Parts and components
- Work in process
- Finished goods
- Supplies

The use of stocks is motivated by its benefit – it enhances several dimensions of competitiveness while making the management of the order-fulfillment process easier as explained next:
• Time-based competition – this issue was discussed earlier (Sect. 5.3). Inventories are used to bridge the gap between the lead time of the order-fulfillment process and the lead time required by the customers. When the lead time required by the customers is shorter than the lead time of the order-fulfillment process, inventories can be used to supply the demand during the time difference. It is possible to reduce the lead time by using inventories of finished goods, in-process inventories or inventories of raw materials, depending on the policy adopted by the organization (make-to-stock, make-to-order, assemble-to-order or engineer-to-order). When the market demands off-the-shelf supply, the only way to compete is to hold inventories of finished goods on the shelf.

• Coping with uncertainty – buffer inventories are used when demand or supply is uncertain. To minimize the effect of a random demand or unreliable suppliers, inventories of finished goods or raw materials are carried. These inventories are readily available to buffer a sudden increase in demand or unexpected delay in supplier’s shipments.

• Decoupling activities in the order-fulfillment process – inventories are used when two stages in the order-fulfillment process are not balanced. For example, when demand is seasonal and management adopts a policy of leveled production, inventories of finished goods are built during the seasons of low demand and consumed during seasons of high demand. Another example is decoupling of operations, when the output of one work center is the only input of another work center. A breakdown in the first work center will cause idle time in the second, as it will not have new work coming in. By keeping in-process inventories between the two work centers, the second will not be idle as long as it can work on the in-process inventory.

• Cost-based competition – carrying inventories to reduce cost is the purpose of most early models for inventory management. For example, when the opportunity arises to purchase raw material at a special, low price, it might be justified to stock some quantities of that raw material for future use. In some cases, economy-to-scale influences the price and by purchasing larger quantities, a lower price per unit can be negotiated. This might justify purchasing in large quantities, building stocks and consuming these stocks over a period of time. Another example is the case of a fixed cost associated with each order, for example the cost of transportation when containers are used and the cost of shipping a container is not affected by its weight. In this case, large orders distribute this fixed cost over a large number of units thus reducing the unit cost (see also Sect. 5.5.).

• Technological considerations – Some processes are designed for a batch of a given size. For example, heat treatment may take the same time and cost about the same for a single unit or a batch of several units treated simultaneously. To save on the cost of energy, or if heat treatment does not have sufficient capacity, i.e., it is a bottleneck operation, lot production may be adopted and inventories of treated parts are created. Another example is processes in which the setup time is long relative to the unit processing time. In this case (as for the case of a fixed cost of ordering), once a setup is completed, larger batches
reduce the total time per unit (average setup time per unit plus the unit processing time). If the process is short of capacity and it is a bottleneck, scheduling large batches can increase capacity utilization.

These benefits motivate the use of inventories – but inventories are expensive and create waste. When the cost involved is significant and measurable, a relatively simple trade-off between the benefits and costs of inventories can support inventory management decisions. However, in many cases, it is difficult to estimate the cost of inventories as explained next.

There are three categories of costs associated with inventories:

1. Capital cost – this is the cost of money tied up in the inventory system and encompasses the cost of capital invested in goods stocked, and in facilities and equipment such as storage space, warehouses, storage racks, material handling equipment, etc.

2. Operating costs – the cost of personnel managing and operating the inventory system, cost of security, cost of energy needed for air-conditioning, light and for operating material-handling equipment, the cost of maintenance of the goods stored and the equipment used for material handling. Overhead costs includes tax paid for the facilities, etc.

3. Risk-related cost – the cost of theft, damage due to fire, water, obsolescence and pilferage, or alternatively the cost of insurance to protect against these risks.

The above costs of inventories may be quite significant; and the question of whether to carry inventories and how much to carry has been for many years of great interest to researchers and practitioners throughout the world. Early research on the subject focused on the cost of inventories. Today, the trend is to take a wider viewpoint and also to consider the disadvantages of inventories whose cost is difficult to estimate (Waters 2003).

The Just-In-Time approach is based on the assumption that inventories cover problems in the order-fulfillment process and management should expose these problems by reducing inventory levels gradually to a minimum. By exposing and solving the root problems, the benefits associated with inventories are attained without incurring the inventory-related costs.

The management of raw material inventories, work in process inventories and finished goods inventories at the different stages of the order-fulfillment process across the supply chain are a key factor affecting the success of the whole process. Shortages may cause poor due date performances while excess inventories are pure waste. Some inventories are inexpensive while other inventories are too expensive and should be eliminated altogether. Some items have a very long shelf life of several years while other items can be stored for a few days at most. Clearly the same policy cannot be applied to all the different items in inventory; and a method for classifying different items for the purpose of inventory management could greatly support the decisionmaking process. A commonly-used method for classifying inventory items is the ABC or Pareto analysis.
Villefredo Pareto studied the distribution of wealth in the 18th century in Milan. He found that twenty percent of the city’s families controlled about eighty percent of its wealth. Pareto’s findings proved to be more general than the initial purpose of his study. In many populations, we find that a small percentage of the population (say 15–25%) accounts for a significant portion of a measured factor (say 75–85%). This phenomenon is known as the Pareto principle, illustrated in Fig. 6.2.

The Pareto principle is useful in inventory management. In many inventory systems, a small group of items account for a significant portion of the capital invested in inventory. The application of Pareto analysis in inventory systems is commonly known as ABC analysis, as inventory items are classified as type A (about 20% of the most expensive items that account for about 80% of the inventory cost); type B (the next 30% of the items that account for about 15% of the inventory cost); and type C (the last 50% of the items that account for about 5% of the inventory cost). Cost, as the significant parameter, may be replaced by other parameters such as the Annual Usage Value (AUV), i.e., the annual demand for an item multiplied by its unit cost.

By classifying inventory items based on cost, AUV or other factors, it is possible to develop different inventory management policies for different classes of items. For example, inventories of class A items should be tightly controlled and a great effort taken to order these items just in time when they are needed; while type C items may be ordered in large quantities to achieve economy to scale. An example of a very simple inventory management model is the two-bin
approach for managing type C items. Items in inventory are kept in two bins. The capacity of each bin is enough to cover the maximum possible demand during the lead time required to replenish the item’s inventory. Each time the currently-used bin is empty, an order for items to fill the bin is placed. This method, widely used before computing power became inexpensive, is simple and low-cost to implement; yet it provides a good buffer against uncertainty at an acceptable cost for type C items.

6.5 Inventory Management – Models and their Assumptions

Early research on inventory systems focused on two main issues: when to place an order and what quantity to order. Inventory management models are classified according to the assumptions on which they are based:

- Models for independent demand items (the demand for these items is independent of the demand for other items) vs. models for dependent demand items (the demand for these items is derived from the demand of other items of which these items are parts).
- Models that ignore the effect of uncertainty (deterministic models) vs. models that consider the effect of uncertainty (stochastic models).
- Quantitative models (formulated as an objective function to be optimized with or without some constraints) vs. qualitative models (presented as a set of rules to be followed and the logic used to derive these rules).
- Models dealing with a single item vs. models dealing with multiple items that share some common resources (same supplier, same manufacturing resources, same storage space, etc.).

In the following discussion, the focus is on the basic models: the Economic Order Quantity (EOQ) model and the Periodic Review model (s, S model). Further discussion on these and other inventory models can be found in Donald Waters (2003), Silver et al. (1998) and in Porteus (1985).

The Economic Order Quantity Model

This model is based on the following assumptions:

1. Demand rate (demand per unit of time) is a known constant (i.e., independent deterministic demand).
2. Instantaneous delivery to customers is required; no backlogs or shortages are allowed.
3. The order lead time is a known constant (it is deterministic and independent of the size of the order or the capacity of the supplier’s order-fulfillment process).
4. The cost per unit ordered is a known constant (i.e., no uncertainty and no economy-to-scale assumed).
5. The cost of placing an order is a known constant (i.e., it is deterministic).
6. The inventory holding cost is based on average inventory level and is constant.
7. The objective is to minimize the total cost per period.

Based on the above assumptions, the EOQ model is a deterministic quantitative model for independent demand of a single item. The following notation is used in the discussion:

- $D$: the per period demand
- $U_c$: the cost per unit ordered
- $O_c$: the cost of placing an order per order
- $I_c$: inventory holding cost per unit held per period
- $Q$: the quantity ordered each time an order is placed
- $LT$: the order lead time – the elapsed time from placing an order to receiving the goods

The result of the analysis is the optimal order size ($Q^*$) and the optimal level of inventory ($R^*$) at which a new order should be placed when the inventory reaches this level.

**Discussion**

Based on the model assumptions, the inventory depletes at a constant rate (assumption 1) and should reach a minimum of zero just before a new order arrives (assumptions 2 and 3) and a maximum of $Q$ immediately after a new order arrives. This pattern is depicted in Fig. 6.3.

The periodic cost of purchasing is constant and equal to $D \times U_c$.

Since $Q$ units are ordered each time an order is placed, and the periodic demand is $D$, a total of $D/Q$ orders are placed every period and the per period order cost is $(D/Q) \times O_c$.

The inventory depletes at a constant rate of $D$ units per period, its maximum level is $Q$ and its minimum level is 0; thus the average inventory is $Q/2$ and the periodic inventory holding cost is $(D/Q) \times I_c$.

Thus the total per period cost $TC$ of the system is

$$TC = D \times U_c + (D/Q) \times O_c + (Q/2) \times I_c$$

To find the optimal value of $Q$ take the first derivative of the total cost with respect to $Q$ and set it equal to zero.
Fig. 6.3 Inventory as a function of time in the EOQ model

\[
\frac{dTC}{dQ} = -\frac{D \times O_c}{Q^2} + \frac{I_c}{2} = 0
\]

Solving for \( Q \) we get the optimal order size

\[
Q^* = \sqrt{\frac{2 \times D \times O_c}{I_c}}
\]

Since the lead time is constant, each order should be placed when the inventory level is sufficient to cover the demand during the lead time:

\[ R^* = D \times LT \]

The various cost components of the EOQ model are illustrated in Fig. 6.4. This simple analysis provides an optimal solution to the total cost model under the assumptions stated previously. However, the most important question is whether this solution is applicable for real inventory systems. There are some obvious difficulties with the model assumptions:

- Demand rate is rarely constant; and frequently only an uncertain forecast of demand is available.
- The costs of real inventory systems vary over time; in some cases these are random variables and usually are not exactly known.
• Lead time is usually a random variable and, due to capacity limitations, it might be dependent on the size of the order and the current load on the shop floor.
• Interactions exist between different items ordered from the same supplier or delivered by the same order-fulfillment process.

Application of the model to a real inventory system may result in $Q^*$ and $R^*$ values that are not optimal.

However, a more difficult problem with the model is the assumption that there are only two decision variables: when to place an order and how much to order. This assumption prevents the user from thinking about the fundamental problem: why carry inventories in the first place. In the EOQ model, inventories are carried because of the fixed order cost. By reducing the order cost to zero, no inventories will be carried and the optimal solution is to place orders at a rate equal to demand rate. This observation is the basis of the Just-in-Time approach – management should try to minimize order cost (or setup cost if production is involved) and to set the order rate equal to the demand rate. As a result no inventories are needed and both the order cost and the inventory carrying costs are eliminated along with other problems created by inventories.
Another problem with the model is the assumption that lead time is independent of the order size. In reality, capacity limits dictate the output rate of the order-fulfillment process, and in most real systems, lead time will depend not only on the size of the specific order, but also on the other orders competing for the same capacity at the same time. The resource with the most limited capacity in the order-fulfillment process will dictate the actual lead time according to the total load on it. This observation is the basis of the theory of constraints and the Drum Buffer Rope scheduling approach discussed in the next chapter.

The above problems with the EOQ model result from its assumptions. Another source of problems is the lack of integration and the adoption of a static approach. The model tries to isolate the decision on how much to order and when to order an inventory item from the other decisions involved, such as when to order other items; whether to invest in more capacity; whether to invest in setup time reduction efforts; how to market the item, etc. Furthermore, the model assumes that the different parameters are constant, while in reality these parameters change over time frequently in an unpredictable way, which is influenced by the decisions taken by management.

An alternative to the EOQ model is the \((s, S)\) model in which the major assumption is that whenever the current inventory level drops below a predetermined value \((s)\), an order is placed to bring the inventory level to a higher predetermined value \((S)\). The advantage of this model over the EOQ model is that it is not based on simplifying assumptions, like the basic assumptions of the EOQ model. For example, it is not assumed necessary to place a new order when demand reaches the exact value of the reorder point \(R\). The values of \(s\) and \(S\) can be calculated under a variety of assumptions including stochastic demand, a cost structure that changes over time, etc. This model sets a framework for a policy in which the parameters can be set by intuition and experience while applying an integrated approach that considers the whole order-fulfillment process simultaneously.

### 6.6 The Dynamics of the Order-Fulfillment Process – Early Studies

The limited ability of quantitative models to capture adequately the integrated, dynamic nature of the order-fulfillment process and to provide sufficient insight into this and other complex business processes motivated the development of alternative teaching and research methodologies. These alternative tools are designed to cope with policy development and analysis in a dynamic environment. Case studies are used for the teaching of complex business situations and simulation models are used to test alternative policies. An interesting example is the Systems Dynamics approach developed by Forrester (1961). In 1980, Forrester explained the need for Systems Dynamics saying: “The best popular approach to teaching management policy is probably the case-study method. By virtue of its tremendously larger database, the case-study approach has a great advantage over the more mathematical, statistical, and analytical approaches that often dominate operations research,
economics and the management sciences. But the case-study method is still hampered by having no adequate way of interpreting its database into dynamic implications.”

An early effort to study the dynamics of the order-fulfillment process was published by Forrester in 1961 (Chap. 15 in his book). His production–distribution model deals with the problem of adjusting employment and production to meet market demands and to sustain appropriate inventory levels. In a case study of a real production and distribution system, Coyle (1978) used Systems Dynamics to study the relationships between production and distribution for an export market. In the study, he developed a policy that had the following advantages:

1. A general reduction in stock levels
2. A considerable smoothing of fluctuations in purchase quantity, and hence in production demands on the factory
3. Being very similar, organizationally, to the present system making it very easy to implement
4. Being robust in the sense that it always has much the same performance regardless of errors, or fluctuations in its environment

These early studies focused on developing and testing policies for the order-fulfillment process. However, they suffered from two problems common to most System Dynamics models:

- The models did not incorporate ad-hoc decision-making into the analysis. As Forrester (1980) explains: “A System Dynamics model contains policies that are constant for the duration of a model simulation ... Critics of System Dynamics models lament this lack of recognition of free will.” The modern simulation languages I-think and Stella partially solve this problem by integrating decision-making into the simulation model during a simulation run. Changing some parameters of the simulation model during the run does this.
- The models present an aggregate view and do not capture the details of the system. For example, in a Systems Dynamics model of the order-fulfillment process, it is impossible to trace a unit of the product or even a specific work order. Since important ad-hoc decisions, such as expediting, are based on detailed information, the aggregate approach of Systems Dynamics does not support detailed analysis of these aspects of the order-fulfillment process.

Recent models (Sterman 2000) link inventory management decisions to capacity and work force decisions and are used to predict and analyze the behavior of inventory systems including business cycles and oscillations.

Problems

1. Explain the concept of purchasing and outsourcing using a social gathering as an example. Discuss purchasing and outsourcing of catering, entertainment, etc. Explain the pros and cons of using purchasing and outsourcing and the make or buy decisions in this case.
2. Discuss the problems created by limited capacity in a restaurant. Explain how purchasing and outsourcing can be used in this case.

3. Find an article discussing supplier selection and supplier management in the service industry. Explain the differences between purchasing and outsourcing in manufacturing and purchasing and outsourcing in service provision.

4. Explain the differences between subcontracting and purchasing in manufacturing and in services. Discuss the most important factors affecting the decision and the sources of data that support the decisionmaking process.

5. Explain the role of quality and its management in the process of supplier selection.

6. What kinds of inventories are carried out in the service industry in the following sectors: retail, wholesale, health care, hospitality, education and entertainment? Discuss the benefits and costs of carrying inventories in each sector and explain how these inventories are used to enhance the competitive edge of the organizations.

7. Explain why utility companies are facing difficulties in using inventories. What kinds of policies are used by utility companies to buffer against uncertainty?

8. Discuss the cost of inventories in your family household.

9. Perform ABC analysis on the inventories carried in your family household. What are your recommendations?

10. Calculate the values of s and S for the A items in your family household.
7 Scheduling

7.1 The Job Shop: Implementing Priority Rules

Time-based competition starts with carefully planning the timing of each activity in the order-fulfillment process to meet customer due date requirements. It proceeds with an effort to execute the plan with minimum deviations despite the uncertain and ever-changing environment. Scheduling concerns the allocation of limited resources to tasks over time (Pinedo 1995, 1998; Conway et al. 2003). The driver of all scheduling efforts in the order-fulfillment process is the Master Production Schedule (MPS) that sets the timing and quantities of independent demand items and deliveries. The MPS is translated into purchasing orders and production orders. The timely execution of these orders, both in purchasing operations and on the shop floor, is essential to guarantee on time delivery to the customers.

Scheduling on the shop floor concerns the allocation of limited manufacturing resources to the manufacturing operations. A variety of operations scheduling models have been developed and implemented. Each model is based on assumptions regarding the technology used in the process, the layout of the shop floor, the objectives of the organization and its constraints, and the environment in which the operations are performed. We start our discussion with the job shop-scheduling problem because the functional layout of the shop floor presents the most general and most difficult scheduling problem. As discussed in Chap. 2, machines in the job shop performing the same function are grouped together. The job shop can process a variety of products, each product requiring a set of operations on the different machines. We define an operation performed on a product as a job. The order of processing, called the routing of each product unit, is assumed to be known, as well as the processing time of each job (the time to perform an operation on a unit of a product on a specific machine). The setup time required to switch a machine from processing one job to another (a different operation on the same product unit or on another product unit) is also assumed to be known. Since each part type has its specific operations and specific routing, the number of combinations in which the different parts can be scheduled for processing on the different machines rapidly increases with the number of different parts, different operations and different machines, creating insuperable difficulties in trying to solve this combinatorial problem. The solution of this job shop-scheduling problem
is a list of jobs to be performed on each machine, the planned starting time of each job and its planned completion time. A variety of scheduling objectives can be assumed including:

1. On-time completion according to the MPS
2. Completion of all jobs as early as possible
3. Minimization of the time that parts spend in the shop (to minimize in-process inventory)
4. Maximization of the utilization of resources by minimizing their idle time
5. Minimization of cost by using less expensive resources (e.g., using regular time and avoiding overtime and extra shifts when these are expensive)

A good schedule optimizes the objective function subject to the applicable constraints. Typical constraints are:

- Each machine can process one job at a time
- Machines are available a limited number of hours each day (due to downtime, preventative maintenance, etc.)
- Each part can be processed by one machine at a time
- Parts should be processed according to the predetermined routing

The job shop scheduling problem is complicated by the need to set up some machines when switching from one operation to another. When setup time is significant and machine capacity is limited relative to the load on the shop floor, batch processing is frequently adopted. By processing batches of the same product, there is no need to set up the machines during the processing of the entire batch and some setup time is saved.

There are several approaches for developing job shop schedules. The general approach that yields optimal solutions is to model all the different product types, the corresponding routings, the different machines and their capacity and the required quantities and lead times of the different products. This approach is applicable only for very small problems in manufacturing and service due to the complexity of the models (see for example Pinedo 1995, 1998). The simplest approach is to partition the job shop scheduling problem with \( n \) different machines into \( n \) smaller problems each with a single machine. The solution of the single machine problem is frequently based on priority rules that dictate the order in which jobs are processed on the machine. In addition, a variety of more complicated scheduling models have been developed for the single machine problem. The success of these scheduling models in solving real life problems has been limited since they are based on a local view (a single machine) of a larger problem.

Priority rules are based on one parameter (simple rules) or some combination of several parameters (complex rules). Since it is difficult to predict which priority rules are the best for a given situation (e.g., the specific objective, load, shop configuration and constraints), many simulation studies have been conducted to assess the relative effectiveness of the different rules for a variety of job shops. Simple priority rules include the following:
1. First In First Out (FIFO) – this priority rule is based on the arrival order of jobs. Jobs are processed on each machine in the same order that they arrive to the machine from the previous operation. In the service sector this is also known as first come first served (FCFS). This rule is very simple to implement. It may be useful in the case of perishable products with limited life in inventory. This rule is used in service systems when it is important to treat all the customers equally – in a “just” way.

2. Early Due Date (EDD) – the jobs are scheduled according to their due date. The earlier the due date, the higher the priority of the job.

3. Current job – this priority rule is designed to save setup time by processing all jobs that require the same setup as a single batch, thus eliminating the need for setup operations. The problem with this rule is that jobs with an early due date may be delayed, while other less urgent jobs are being processed.

4. Shortest Processing Time (SPT) – this priority rule tries to minimize the number of jobs waiting in front of a machine by processing short jobs first. The problem with this rule is that longer jobs may be completed late while short jobs are completed earlier than their due date.

In addition to the simple priority rules there is a variety of more complex rules including the following:

1. Critical Ratio (CR) – this rule is based on the difference between the due date and the current date divided by the time required to complete the remaining work. Jobs with a smaller value of CR receive higher priority.

2. Slack Time Remaining (STR) – this rule is based on the difference between the time remaining before the due date and the time required for processing the remaining jobs. The smaller the value of STR, the higher the priority of the job.

3. Slack Time Remaining per Operation (STR/OP) – this rule is based on the average slack time per remaining operation calculated as the ratio between STR and the number of remaining operations. Higher priority is assigned to jobs with a lower value of STR/OP.

An important visual aid in developing and presenting schedules is the Gantt chart that plots tasks as bars against time. To demonstrate the use of priority rules and the Gantt chart, consider the following three jobs example:

Three jobs are waiting for processing in front of a machine. The first and the second jobs require another operation on a different machine after the current operation; for the third job the current operation is the only one required. Table 7.1 lists the jobs in the order of their arrival. The remaining operations processing times are also listed (Table 7.1).

<table>
<thead>
<tr>
<th>Job number</th>
<th>Duration of first operation</th>
<th>Duration of second operation</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>3</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>5</td>
<td>–</td>
<td>10</td>
</tr>
</tbody>
</table>
Applying the FCFS rule we get the following results:

**Table 7.2 Results of the FCFS rule**

<table>
<thead>
<tr>
<th>Job number</th>
<th>Priority</th>
<th>Start time</th>
<th>Finish time</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>7</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

This schedule is depicted in Fig. 7.1.

We see that the third job completes its first operation at time 12, which is two units after its due date. The second job completes its first operation at time 7 and its second operation takes 6 thus it will be completed at the earliest at time 13 while its due date is 12.

Consider the EDD schedule summarized in Table 7.3.

**Fig. 7.1 The FCFS schedule**

**Table 7.3 The EDD schedule**

<table>
<thead>
<tr>
<th>Job number</th>
<th>Priority</th>
<th>Start time</th>
<th>Finish time</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>3</td>
<td>9</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>5</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>
This schedule is depicted in Fig. 7.2.

In this case job III completes on time 5 earlier than its due date of 10; job II can start its second operation on time 9 and since its duration is 6 it will finish no earlier than time 15 while the due date is time 12. Job I finishes the first operation at time 12, its second operation takes 8 so it can finish on its due date of 20.

Consider the STR schedule summarized in Table 7.4.

<table>
<thead>
<tr>
<th>Job number</th>
<th>STR</th>
<th>Priority</th>
<th>Start time</th>
<th>Finish time</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>20 – 11 = 9</td>
<td>3</td>
<td>9</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>12 – 10 = 2</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>10 – 5 = 5</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

This schedule is depicted in Fig. 7.3.

In the STR schedule, job II finishes at time 4 and since its second operation takes 6 it can finish by the due date of 12. Job I finishes at time 9 which is earlier than its due date of 10. Job III finishes the first operation on time 12, its second operation takes 8 thus it can be finished by its due date of 20.
The above example shows the effect of different priority rules on due date performances of the job shop. By monitoring the situation on the shop floor and selecting the right priority rules for the situation, the management can improve the performances of the delivery schedule. When a job is late, it might be necessary to expedite it by assigning high priority to that job.

The selection of the most appropriate priority rule, as well as the decision to expedite a job, is based on the shop floor control system. This system provides current information on the jobs waiting for processing in front of each machine typically in the form of a list of work orders. Another way is to represent the amount of work required to perform all the jobs waiting for processing in front of a machine by calculating the total working hours of all these jobs.

Since priority rules are based on the single machine model and ignore interactions between the machines on the shop floor, the solution developed using priority rules is at best a good solution for the single machine considered. One undesired result of interactions is starvation – a machine becomes idle because all jobs awaiting processing on that machine are held up as in-process inventory in front of preceding machines. Thus the machine remains idle while the backlog of jobs that needs its capacity increases.

To minimize starvation, the in-process inventory levels in front of each machine should be monitored continuously. The control system alerts the order-fulfillment team when in-process inventory levels in front of a machine are too
low and the machine may become idle soon, or when in-process inventory levels are too high and consequently the lead time for a new job arriving to the queue increases, due to long waiting times of parts in front of the machines.

An effective tool for scheduling control is *input-output analysis*. The queue of jobs awaiting processing in front of each machine is treated as a level of water in a pool (i.e., a level in the systems dynamic model). The input rate of the pool is the stream of arriving jobs while the output rate is determined by the machine production rate (or capacity). When the input rate is higher than the output rate, work in process inventories accumulates. The average lead time of the jobs can be estimated by the ratio between the queue in front of the machine with the highest number of processing hours backlogged as in-process inventory, and the capacity of that machine (both measured in hours). Thus, if a machine operates 8 h a day, 5 days a week or a total of 40 h a week and the queue in front of it represents 80 h of work, the average lead time for that machine is ten working days or 2 weeks. By controlling the level of work in process in front of each machine or work center, bottlenecks can be identified. Scheduling of bottlenecks is therefore the key to the lead time and due date performances of the entire shop. This observation is a cornerstone in the Drum Buffer Rope scheduling system as explained later (Sect. 7.5).

### 7.2 Scheduling the Flow Shop

In a flow shop, all product types are processed in the same order (follow the same routing). The physical arrangement of machines on the shop floor is identical to the order of processing, making material handling easier as all product units simply flow along the common route. As in the job shop, machine starvation is a problem the scheduler should consider. A second problem in the flow shop is blocking. Blocking is the case when a machine is idle because it cannot transfer the last product unit it processed to the next machine that is still occupied. Thus the unit stays on the predecessor machine and blocks it from processing another product unit. This is typical when product components are large and in-process inventory is limited or non-existent; or when the in-process inventory between adjacent machines is limited due to an inventory reduction policy as in the Just-In-Time (JIT) approach discussed in the next section.

When the capacity of a machine cannot cope with the load, two or more units of the same machine might be installed in parallel. This configuration is known as the flexible flow shop as there is flexibility in routing the product units between the parallel identical machines. The simple case of a flow shop with two types of machines can be solved optimally when the objective is to minimize the makespan (the time from the beginning of the first job on the first machine to the completion of the last job on the second machine). The solution procedure is based on the assumption that all the jobs have the same priority, the time for each job is a known constant (deterministic), and the job times are independent of the job sequence.
The solution procedure, known as Johnson’s rule, is as follows:

1. Create two lists, an “available list” of all jobs not scheduled yet and a “schedule list” of jobs already scheduled. The schedule list is composed of two sublists. The left-hand side of the list corresponds to jobs scheduled for early processing while the right-hand side of the list corresponds to jobs scheduled for late processing. Thus, the first job to be processed is the left-most job in the schedule list, while the last job to be performed is the right-most job on the schedule list. Initially all the jobs are in the available list while the schedule list is empty.

2. Select the job with the shortest processing time from the available list and delete it from the list. Break ties arbitrarily.

3. If the shortest time for processing the selected job is on the first machine, place the job after the last job in the left-hand side of the schedule list. Otherwise, if the shortest time for processing the selected job is on the second machine, place the job before the first job in the right-hand side of the schedule list.

4. If the available list contains only one job, go to step 5. Otherwise return to step 2.

5. Assign the last job as the last one in the left-hand side sub-list and the first one in the right-hand side sub-list, thus merging the two sublists into a single schedule.

6. Stop. The schedule list contains the optimal schedule.

Example

Consider the four jobs in Table 7.5 and the corresponding processing time on the two machines at the flow shop:

<table>
<thead>
<tr>
<th>Job number</th>
<th>Processing time on the first machine</th>
<th>Processing time on the second machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>III</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The solution process starts with the available list containing jobs I, II, III, IV and the schedule list is empty. The shortest operation time is that of job IV on the first machine; thus this job is assigned to the schedule list and becomes the first job on the left sub-list. Among the remaining three jobs in the available list, the shortest operation is that of job I on the second machine; thus this job is assigned to the schedule list becoming the first job on the right sub-list. Of the remaining two jobs in the available list, the shortest operation is that of job II on the first machine; thus this job is assigned the schedule list becoming the second job on the left; i.e., it is scheduled for processing after job IV, which is the first on the left. The last job, job III is scheduled after job II and before job I. The final schedule is IV, II, III, I. This schedule is optimal as it minimizes the makespan.

Johnson’s rule for the simple case of a two-machine flow shop can be extended to a three-machine flow shop if the minimum processing time on the first machine is no smaller than the maximum processing time on the second machine, or the
7.3 The Just-in-Time Approach

Just-in-time is a philosophy rooted in the fundamental economic relationship:

\[ \text{Profit} = \text{revenue} - \text{cost}. \]

To increase its profits, an organization can increase its revenues by increasing sales (increasing the number of units sold or the price per unit or both), or by reducing cost. Assuming that the volume of sales is inversely related to the selling price of a unit (in many markets, by reducing the selling price it is possible to increase sales) and assuming also that the unit price should exceed the cost per unit to avoid losses, the key to increasing profits is minimizing cost. The focus on cost reduction (or minimization of waste) is the basis of the JIT philosophy and the scheduling techniques implemented in this environment.

There are several potential forms of waste in the order-fulfillment process including:

1. Quality-related waste – a defective part represents a waste of material and labor invested in it. A continuous effort to increase quality at the source, i.e., to eliminate the waste associated with the manufacture of defective parts is a key to JIT.
2. Inventory-related waste – the money tied up in inventories, as well as the space used for storage and the cost of operating and maintaining the inventory system are all forms of waste that should be eliminated.
3. Waste of space – this form of waste is related to inventory-related waste; storage is a waste of space, and so is the inefficient layout of machines that leaves empty space between them.

4. Material handling waste – this is the cost of moving material and parts around the factory due to poor layout.

The concentration on waste and its elimination leads to the distinction between value-added operations in the order-fulfillment process as opposed to non-value-added operations. The idea is that every operation in the order-fulfillment process should add value to the customer. Operations that do not have a value added should be studied and if possible eliminated. Thus, if material handling on the shop floor does not add any value, a layout that minimizes or eliminates material handling should be investigated. Similarly since inventory does not add any value to the customer it should be eliminated.

Scheduling in the JIT environment is a continuous effort to eliminate waste. Key steps in this effort are:

1. To minimize in-process inventories created by batches awaiting processing in different work centers, small batch sizes are scheduled for production. When a batch is processed in a work center, and the entire batch is transferred simultaneously from one work center to the next, every unit in the batch waits for the entire batch to be completed. To reduce this waiting time, the batch size should be reduced and units should be transferred between work centers as soon as they are finished, i.e., both the processing batch and the transfer batch should be as small as possible. Since smaller batch sizes imply more setups between batches of different products, the key to smaller processing batches is to reduce machine setup time by carefully planning setup operations and by modifying the machines to enable fast setups that take a few minutes to perform.

2. To further reduce work-in-process inventories, work in process accumulated between consecutive machines is limited either by the scheduling system or by limiting the space available for in-process inventories. Limited in-process inventories can cause blocking of machines when the succeeding machine fails; and starvation when the preceding machine fails or when its output is defective and not suitable for further processing. To minimize blockage and starvation, preventative maintenance efforts and an effort to minimize defects by improving quality at the source are essential in the JIT system.

3. To minimize the inventories of raw materials and supplies, the order cost associated with ordering from suppliers is reduced by purchasing from local sources, and by signing long-term contracts with suppliers. The simple EOQ model tells us that a smaller order cost implies smaller batch sizes and a smaller inventory level.

Reducing inventories in an effort to eliminate waste reduces the buffering and decoupling effects of inventories that were discussed in Chap. 5. Thus the order-fulfillment process becomes sensitive to scheduling and planning mistakes, quality problems and machine breakdowns. Each of these can cause a delay in the process. To succeed in the elimination of waste while keeping the competitive
edge in time-based competition, the order-fulfillment process in the JIT system is synchronized and controlled by a special system. One way to implement the synchronization system is by a device called Kanban. The Kanban is a card containing information that serves several purposes. It is a production order, a purchase order, and an inventory control device. To understand the Kanban concept, consider two adjacent work centers A and C in a flow shop setting in which jobs move from A to C through a buffer inventory B between the two centers. Two types of Kanbans are used to schedule the two work centers: a production Kanban that functions as a work order for A and a withdrawal Kanban that functions as an order to ship material from B to C. The batch size is fixed (ideally at one).

In this simple, two-station example, parts move from A via B to C and Kanban cards move from C to B and from B to A. In each of the three locations there is room for a predetermined, limited number of part canisters and a limited number of Kanbans. Each part canister is accompanied by a Kanban so that the number of canisters is never larger than the number of Kanbans and the in-process inventory is thus limited. The Kanbans that move between A and B are called production Kanbans while the Kanbans that move between B and C are called withdrawal Kanbans. The worker at each work center watches the number of Kanbans; when the number of withdrawal Kanbans at C reaches a predetermined level, the worker takes the cards to B, removes the production Kanbans from the part canisters in the buffer inventory and attaches the withdrawal Kanbans to the canisters. The production Kanbans at B that are not attached to canisters now serve as an order to the worker at A to produce more units. Canisters with units produced at A are transported to buffer B with the production Kanbans attached to them. The worker at A stops production when there are no more free production Kanbans, thus waiting for the worker at C to withdraw canisters from B and free production Kanbans.

This simple two work center example demonstrates the principles of a scheduling system that can be extended to any number of stations manufacturing a variety of different parts, as long as each Kanban is related to a specific part, i.e., each Kanban has a part number on it.

This scheduling system is integrated since all work centers are connected to each other by the flow of cards. It is dynamic since the production rate at the centers with excess capacity is controlled by the centers with limited capacity, as in-process inventories are limited to the number of Kanbans in the system. Monden (1983) suggested the following approach for computing the number of Kanbans in the system:

$$Y = \frac{(DL - W)}{A}$$

where

- $Y$ is the number of Kanbans
- $D$ is the expected demand rate (demand in units per unit of time)
- $L$ is the lead time
- $W$ is a variable that controls the size of the buffer stock
- $A$ is the capacity of a canister
By reducing the value of the control variable \( W \), the in-process inventory is reduced, thus eliminating the waste associated with inventories but also reducing the decoupling and buffering effects of in-process, finished goods and raw material inventories.

Just-In-Time is a form of Synchronous Production – a system in which the entire order-fulfillment process is synchronized (i.e., works in harmony) to achieve its multidimensional goals (in the dimensions of time, cost, flexibility and quality). The synchronizing device – the Kanban card – provides the tight connection between work centers.

Other forms of Synchronous Production exist as well. As an example, consider the Constant Work in Process (CONWIP) system. In its simplest form this system is implemented by a fixed number of containers or pallets on which work in process is transported and processed. The limited number of containers implies a limited number of product units in the system. Unlike the Kanban-based system, where the limit is on the inventory in each stage of the process, in a CONWIP system the limit is on the total work in process inventory in the system.

7.4 The Dynamic Shop: Expediting and Changing Priorities

In the JIT approach, work orders are generated by actual consumption of parts and material at succeeding, downstream work centers. Since in-process inventories are limited and production is authorized only when upstream demand consumes some of the limited in-process inventories, quality problems as well as machine breakdown cause shortages and idle time at upstream work centers. When demand is stable over time, it is possible to adjust the in-process inventories (or the number of Kanbans) to the demand rate to minimize shortages at upstream work centers and to ensure a fast order-fulfillment process. However, when the demand rate fluctuates over time, the adjustment of the in-process inventories may be too slow, causing delays and late deliveries. One way to cope with the problem is to adopt a make-to-stock policy, buffering against demand uncertainty by inventories of end products. This approach is wasteful according to the JIT philosophy, as buffers of finished goods represent waste. Another approach is to freeze the MPS, thus stabilizing demand over the freeze period. This approach reduces the flexibility to react to the changing needs of the market. Since the flexibility of the order-fulfillment process provides a competitive edge, freezing of the MPS for the planning horizon may not be a viable alternative. A third approach is to monitor each job as it moves in the shop and change the priorities of work orders according to the changing demand. By watching the situation on the shop floor, comparing the current status of each order to its promised due date, and expediting late orders, management may try to cope with the changing demand and the impact of uncertainties such as machine breakdown, absenteeism and late deliveries by suppliers. However this is easier said than done. Expediting in a real shop is an attempt to
solve a very complex combinatorial problem by focusing on the exceptions – those orders that are late. By doing so, other orders are delayed and so become late, and the list of late orders tends to increase over time making the problem intractable. Thus, along with the technology for automatically monitoring the progress of each work order on the shop floor, which is available in today’s bar code readers and Radio-Frequency IDentification (RFID) systems, a systematic approach to analyze the data and to support decisionmaking is needed.

A possible approach is to focus on the problematic work centers and on the late customer orders simultaneously, assuming that orders are late due to limited capacity of some work centers. The argument is that management should focus on work centers with limited capacity, and should derive the whole schedule for the shop from the schedule of these work centers. To apply this approach, the monitoring system should alert management to potentially late orders as well as to overloaded resources. By focusing on the overloaded resources, management can utilize available capacity in the best way, i.e., scheduling these resources in order that potentially late orders are processed first. Furthermore, in the long range, management may want to expand the capacity of resources that are continuously overloaded by outsourcing (using subcontractors), using extra shifts or by acquiring more of these resources. The basics of this approach, presented by Goldratt in his book, *The Goal*, are to identify the “bottleneck” resources and to schedule the whole shop to ensure that these bottlenecks are used effectively and efficiently, i.e., doing what is most important in the best way possible as explained in the next section.

### 7.5 The Drum Buffer Rope Approach

The scheduling techniques discussed so far – priority rules for work centers in a job shop, and the Kanban-based technique for the JIT environment – represent two extremes in the level of integration between operations in the order-fulfillment process. Priority rules are designed to schedule a single work center based on the situation in the queue of jobs in front of that work center and based on the center’s local objectives. In JIT all work centers are connected to each other by the Kanban system, and production and ordering decisions are based on global objectives (minimization of waste). Information about the consumption at upper stream work centers and the predetermined work in process between the work centers are used as a basis for scheduling decisions.

In the following discussion a third method is presented. Developed by Goldratt and Fox (1986), it is based on a global set of objectives supported by appropriate performance measures and global information about the load on the shop floor. Here, the schedule of all work centers is driven by the schedule of the critical work centers – those with insufficient capacity.

In Chap. 3, three performance measures suggested by Goldratt and Fox (*The Race* 1986) were introduced:
• Throughput (T) – The rate at which the system generates money through sales. It is the difference between the dollar sales for the period and the expenses generated by these sales (the expenses that would not occur if the sales were canceled).

• Inventory (I) – The entire amount of money the system invests in purchasing items the system intends to sell. This is the original purchase cost of raw materials, parts and components stored in the system.

• Operating Expenses (OE) – The entire amount of money the system spends in turning inventory into throughput, which is not directly dependent on the level of sales (i.e., not included in the throughput calculations).

The objective is to maximize T while minimizing I and OE. Every decision regarding the order-fulfillment process is judged based on its effect on the three measures. For example, make-to-stock does not increase T, although it increases I and OE. Hence, based on these performance measures, make-to-stock should be avoided (unless it increases T or decreases OE).

Using these measures, priority on the shop floor is given to firm orders due in the near future that can translate immediately into throughput. An effort is encouraged to minimize all types of inventories in the system (I) and to eliminate costs not directly related to sales (OE). The basic argument that drives the management of the delivery system is that throughput is bounded only if there are one or more constraints that limit sales or production. The constraints can be internal to the system, i.e., a machine, a work center or a worker that has limited capacity. The constraint could also be external to the system, such as a shortage of raw material on the market or a limited market for the end products. The whole system should focus on the constraint, as it is the weakest link in the chain of the order-fulfillment process.

To explain the Drum Buffer Rope (DBR) logic, Goldratt and Fox suggested a model of a group of marching kids. Assuming that the group’s output is measured by the distance the kids cover, in-process inventory is measured by the distance between the first kid in the group and the last one. Naturally, the pace of some kids is faster than that of other kids in the group and it is subject to random variations. Even if, on the average, all the kids march at the same pace, when a faster kid slows down for a while due to random variation and then hurries up to close the gap, slower kids following him cannot close the gap that fast. Consequently the “in-process inventory” – the distance between the first and the last kid in the group increases. There are several ways to keep the group together despite the random variations and the differences in pace:

1. To select kids with exactly the same deterministic (no random variation) pace.
2. To arrange the kids in the group in order of their marching speed. The slower kids first and the faster kids last. Thus, when random variations occur, the faster kids at the end can catch up and reduce in-process inventory.
3. To use a signal like a drumbeat so that all the kids march at the same pace according to the signal. The pace of the signal should be the same as the pace of the slowest kid in the group.
In this model each kid corresponds to a work center. The first solution is implemented in automatic production and assembly systems where a group of dedicated machines, all with the same production rate, is used for the mass production of a product.

The second solution is difficult to implement on the shop floor as the order of processing (the routing) is determined by the product processing requirements and usually the routing cannot be rearranged according to individual work center’s processing speed. In some cases, however, it is possible to implement this solution in a flow shop by selecting faster machines (with higher capacity) for operations performed at the end of the process.

The third solution is the basis of JIT. The drum is the MPS driving the last work center in the process. All other work centers are marching to the same beat as they are connected by the Kanban system.

Goldratt and Fox (1986) suggest a fourth approach. Instead of using the drumbeat as a signal for all the kids, use it to signal the first kid in the group. The slowest kid determines the drumbeat pace. The analogy is to use the slowest work center (the bottleneck) to signal the pace of the first work center in the process – the one that receives raw material from the storage (the gating operation). By linking the bottleneck to the gating operation, release of raw material is synchronized with the capacity of the bottleneck and in-process inventories are controlled. This approach is depicted in Fig. 7.4.

The problem with this approach is that without in-process inventory, there is no buffer to protect the bottleneck from random failures of preceding machines and to decouple it to avoid blocking and starvation. Thus, a predetermined buffer is allowed in front of the bottleneck to protect it. This scheduling approach is known as the Drum Buffer Rope (DBR) where the bottleneck is the “drum” connected by a “rope” to the gating operation, allowing a “buffer” to protect the bottleneck.

![Fig. 7.4 The drum buffer rope approach](image-url)
The buffer in the DBR system can be managed by input-output control. This control system is based on monitoring the in-process inventory buffer in front of the bottleneck. Since the capacity of the bottleneck is known, the lead time for a new order entering this buffer is the ratio between the size of the buffer measured in terms of work hours and the capacity of the work center. Thus, if for example, the work orders in the buffer require 24 h on the bottleneck to finish, and the bottleneck operates 8 h a day, the lead time is 3 days. Based on the current size of the buffer, a signal to the gating operation to release new work orders is transmitted when the buffer level gets below its predetermined size. Assuming a known capacity of the bottleneck, the momentary level of the buffer indicates the lead time of the bottleneck operation.

The first step in implementing DBR is to identify the system constraint. An internal constraint that is due to limited capacity is a bottleneck. Comparing the planned load on each work center to its actual capacity can identify bottlenecks. If the planned load is equal to or higher than the available capacity, that resource is a bottleneck. A rough estimate of the load is given by the total processing time required for all jobs scheduled for a work center. The difference between the total processing time and the work center’s available time (the scheduled operational time minus expected breakdown time) is the time available for setups. If the minimum required setup time is about the same as the time available for setups, the work center is a bottleneck. Otherwise, the extra time can be utilized for additional setups (reducing batch size and in-process inventory) or it is idle time. Since the objective is to minimize $I$ while maximizing $T$, idle time should not be used for building up in-process inventories, i.e., it is acceptable for a non-bottleneck to be idle.

To demonstrate this point, consider the daily load for the three work centers example in Table 7.6.

<table>
<thead>
<tr>
<th>Job number/ (# of units)</th>
<th>I (25 units)</th>
<th>II (50 units)</th>
<th>III (10 units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing and setup time</td>
<td>Processing time per unit</td>
<td>Setup time</td>
<td>Processing time per unit</td>
</tr>
<tr>
<td>Work center A</td>
<td>2 min</td>
<td>50 min</td>
<td>2 min</td>
</tr>
<tr>
<td>Work center B</td>
<td>1 min</td>
<td>50 min</td>
<td>1 min</td>
</tr>
<tr>
<td>Work center C</td>
<td>3 min</td>
<td>50 min</td>
<td>2 min</td>
</tr>
</tbody>
</table>

Assuming that each work center operates 8 h or a total of 480 min per day, the processing and setup time for each work center is:

- A’s total processing time: $2 \times 25 + 2 \times 50 + 10 \times 10 = 250$ min
- Minimum setup time: $50 + 100 + 50 = 200$ min
- Time left for additional setups: $480 – 250 – 200 = 30$ min
Problems

1. What are the scheduling objectives in a fast food restaurant and in the emergency room of a hospital. Explain the differences and the resulting policies.
2. Discuss the priority rules suitable for an emergency room in a hospital.
3. Under what conditions is each of the following priority rules: FIFO, EDD, SPT, CR and STR most appropriate?
4. Explain how Just-in-Time can be implemented in a fast food facility and discuss the pros and cons of implementing this policy.
5. Explain how input output analysis is used by department stores for adjusting the number of open checkouts.
6. What is the relationship between the capacity of a resource, its cost and the demand rate? Explain how deviation of actual demand from the forecast may affect the lead time of the order-fulfillment process.
7. Using the information on available work in front of each machine in a job shop, explain how the expected lead time of the order-fulfillment process can be estimated.
8. What in your opinion is the bottleneck in most highways? How can we use this information in order to improve the system?

9. When a new facility is designed, where should the bottleneck be placed? For example, in a new hospital, which resources should have excess capacity and which resources should have limited capacity roughly equal to the forecasted demand?

10. Explain the relationship between outsourcing decisions and scheduling decisions. If a subcontractor is available with unlimited capacity under what conditions would you recommend subcontracting?
8 Design of Business Processes

8.1 Process Design and Process Modeling

A business process design is a description of a business process expressed in terms of the components constituting the process and its operational environment, their attributes, and values for these attributes. It comprises two key aspects: a design concept and a detailed design (Karni and Arciszewski 1997):

- A conceptual design is a qualitative description of a process and its operational environment in terms of its functionally essential components, characterized as nominal components with qualitative values. The components are connected by general relations: taxonomies, categories and flows.
- A detailed design is a quantitative description of a process and its operational environment in terms of its functionally essential components, characterized as concrete components with quantitative values. The components are connected by specific relations: functional or operational.

Business process design specifies “which people must perform what tasks, in what order, in what location, under what circumstances, with what information and to what degree of precision” (Hammer 2007).

In this book we deal with designing a process concept – i.e., defining a set of elements or components which constitute the process and its operational environment, and the relationships between them. Detailed design – such as specifying the content and layout of forms, the structure of the databases and knowledge bases, the linkages to IT systems and process control (ERP and SCM), and the linkages between processes (triggering) – is the topic of more specialized texts.

A business process model concerns one aspect of design – a flowchart representation of the activities comprising the process and the flows between them.

8.2 Process Perspectives (Process Viewpoints)

To accommodate the goals and objectives of process design, a design specification must be capable of providing various elements of information to its users. Such elements include, for example, what activities constitute the process, who performs these activities, when and where the activities are performed, how and why they are executed, and what data elements they manipulate. To provide this
information, a modeling technique should be capable of representing one or more process “perspectives” or “viewpoints” (cf. Curtis et al. 1992; AMICE 1993; Giaglis 2001; Becker et al. 2003). We specify the process in terms of six perspectives:

- **Function perspective** – where the process is located within the enterprise process model and process suite. It provides a macro and micro positioning of the process: macro – the business functions and sub-functions under which the process is classified; micro – the immediate environment in which the process is intended to operate.

- **Activity perspective** – what process activities are being performed, when they are performed (for example, sequencing) as well as aspects of how they are performed through feedback loops, iteration, decision-making conditions, entry and exit criteria, and so on. It encompasses the process flowchart, incorporating triggers, actions and decisions.

- **Deliverable perspective** – business object(s) created or modified by the process. It defines the inputs to be transformed and the outputs to be generated.

- **Organization perspective** – where and by whom activities are performed. It encompasses the organizational chart (e.g., purchasing department), positions within each department (e.g., purchasing manager) and specific employees (e.g., Mr. Jones) together with their areas of responsibility regarding the process.

- **Information perspective** – the informational entities (data and knowledge) required, produced or manipulated by a process and their interrelationships. It encompasses interfaces between the process and the data or knowledge; and a structural model of master data (e.g., customers, vendors, materials) and transactional data (e.g., sales orders, purchase orders, invoices).

- **Contingency perspective** – the reaction required should some process resource become unavailable. It encompasses three types of response: a fallback process if IT-based data/knowledge is inaccessible; a rollback process if the transaction has to be retracted; and a backup process if the IT resource fails during process execution.

The amalgamation of perspectives enables the designer to grasp the wider system picture: function modeling to indicate where the process fits into the general scheme of business activity; activity modeling to provide the detail of individual tasks and to identify how individual tasks interact with each other to produce the whole process; delivery specification to ensure that the process achieves its business goal; organizational modeling to examine user roles within the process; information modeling to present the details of information systems and bases to support process execution; and contingency modeling to ensure that, as far as possible, the process will be executed even if key resources are unavailable.

The combination of process goals and objectives with the above perspectives provides a framework for designing and analyzing business processes. In our scheme, the activity perspective is provided by the process flowchart; the remaining perspectives are represented in two tables: a perspective table and an activity table.
8.3 Business Process Design Procedure

Our business process design procedure is carried out in eight steps:

(a) Provide an initial perspective specification using the perspective table (pre-design)
(b) Design the process flowchart
(c) Verify the process flowchart
(d) Draw up an activity table
(e) Add organizational and data/knowledge attributes to the activity table
(f) Complete the perspective specification using the perspective table (post-design)
(g) Evaluate the process design
(h) Analyze the process usage

These steps are explained in detail in this section, and applied to an illustrative process in the following sections.

(a) Provide an initial perspective specification using the perspective table (pre-design)

Defining requirements to establish specifications is the first step in the development of any system (Gause and Weinberg 1989) – in our case, the development of a business process. Requirements correspond to the objectives the process is intended to achieve, and the conditions under which it is intended to operate. It is necessary that requirements be established systematically in order to generate an accurate and agreed-upon process. They constitute the input to the detailed design phase, and also form part of the process specification. Requirements are provided by the process owner and supplemented by designer intent (Hybs and Gero 1992) – the underlying rationale on which the process design will be based. Specifications lay out how the process is to be executed. They constitute the output of the design process – the process flowchart – and are provided by the designer. In QFD terminology, requirements correspond to the “voice of the customer”; specifications correspond to the “response of the engineer” (Akao 1990).

Table 8.1 delineates a list of elements describing the operational environment of the process. Some factors will be identified before process design; others may only be finalized after an initial or final process flowchart has been designed (step (f)). The perspectives are as follows:

- **Function (macro)**: process position within the enterprise function suite (items 1 through 7)
- **Deliverable**: main (and possible ancillary) business object (items 8 through 13)
- **Function (micro)**: environment in which the process operates (items 14 through 29)
- **Organization**: personnel involved with the enactment of the process (items 30 through 42)
- **Information**: data, knowledge and decision support required (items 43 through 47)
- **Contingency**: response should a process resource become unavailable (items 48 through 51)
(b) Design the process flowchart

“Business people are very comfortable with visualizing business processes in a flow-chart format. There are thousands of business analysts studying the way companies work and defining business processes with simple flow charts” (BPMI, 2003). Moreover, the advantages of flowcharts center on their ability to show the overall structure of a system; to trace the flow of information and work; and to highlight key processing and decision points (Giaglis 2001). We thus employ the flowcharting approach in this book. We use a minimal amount of flowcharting symbols: actions, decisions, flows, start event end event (“play”, “stop”).

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Item</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action</td>
<td><img src="image" alt="Action Symbol" /></td>
<td>Start event (trigger)</td>
<td><img src="image" alt="Start Event Symbol" /></td>
</tr>
<tr>
<td>Decision</td>
<td><img src="image" alt="Decision Symbol" /></td>
<td>End event (terminus)</td>
<td><img src="image" alt="End Event Symbol" /></td>
</tr>
<tr>
<td>Flow</td>
<td><img src="image" alt="Flow Symbol" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The rules for flowcharting are reflected in the process verification checklist (Table 8.2) and refer to flowchart syntax, conventions, functionality, descriptions, and begin/end states.

We provide some hints for process design. They are not flowcharting techniques, for which more specialized texts are available, but concentrate on the business aspect of the design.

- Paths through the process (note that decision activities lead to alternative paths)
  - First flowchart the “ideal” or “straight-line” path, assuming that all decision outcomes are those favorable or preferable.
  - Then add further paths, allowing for the various decision outcomes.
  - If the process can have a favorable or unfavorable outcome, ensure that both “success” paths and “failure” paths exist.

- Communication with the process environment
  - Analyze the trigger and determine a first (and possibly a subsequent) action to respond to the trigger.
– Analyze the expected successor processes (success, failure) and ensure that the process provides all requirements of these subsequent processes.
– Analyze the expected successor processes and ensure that a transfer action is provided if the business object is to be transferred to one or more of these processes.

• Communication and coordination between process roles
  – Ensure that activity sequences correctly reflect the entry of external agents (customer, supplier, applicant, advisor) into the process and exit from the process.
  – Ensure that activity sequences correctly reflect the entry of internal agents (authorizer, supervisor) into the process and exit from the process.
  – Ensure that scripts are provided when needed to regularize interactions with internal or external agents.
  – Ensure that all roles are properly empowered as presumed by the process.

• Business object progress
  – Ensure that the input to the process is properly and fully utilized.
  – Ensure that the data and knowledge required by the process is properly and fully utilized.
  – Ensure that the output from the process is correctly created and complete.

• Granularity
  – Consider defining an activity as a sub-process if it is complex or knowledge intensive.

• Design tools
  – Ensure consistency and completeness between the process flowchart and the process perspective (Table 8.1).
  – Ensure consistency and completeness between the process flowchart and the design criteria (Table 8.3).
  – Beware of turning a process flowchart into a data flow diagram (DFD). Data flow diagramming (DFD) is a technique for graphically depicting the flow of data among external entities, internal processing steps, and data storage elements in a business process. In that respect, DFDs are comparable to flowcharts, differing from them basically in the focus of analysis (DFDs focus on data instead of activities and control). They focus exclusively (or at least primarily) on data and provide no modeling constructs on which to base representation of workflow, people, events, and other business process elements. Further, they provide no information on decisions and event sequences. Finally, DFDs have no beginning or endpoints, nor execution paths.

(c) Verify the process flowchart

After flowcharting the process, each action, decision and flow is examined against the process verification checklist (Table 8.2) and corrected where necessary.
<table>
<thead>
<tr>
<th>#</th>
<th>Factor</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Function perspective (macro)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Process identifier</td>
<td>Identification of the process within the process repository</td>
</tr>
<tr>
<td>2</td>
<td>Version identifier</td>
<td>Identification of the process version</td>
</tr>
<tr>
<td>3</td>
<td>Version date</td>
<td>Identification of the date on which the version was released</td>
</tr>
<tr>
<td>4</td>
<td>Descriptor</td>
<td>Process title</td>
</tr>
<tr>
<td>5</td>
<td>Owner</td>
<td>Person or department responsible for the process</td>
</tr>
<tr>
<td>6</td>
<td>Major functionality</td>
<td>Major business functionality from the enterprise model</td>
</tr>
<tr>
<td>7</td>
<td>Main functionality</td>
<td>Main business functionality from the enterprise model</td>
</tr>
<tr>
<td></td>
<td>Deliverable perspective</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Main business object</td>
<td>Main entity or “thing” created or modified by the process</td>
</tr>
<tr>
<td>9</td>
<td>Key action on main business object</td>
<td>Basic action – create or modify or delete/destroy object</td>
</tr>
<tr>
<td>10</td>
<td>Ancillary business object</td>
<td>Additional entity or “thing” created or modified by the process</td>
</tr>
<tr>
<td>11</td>
<td>Key action on ancillary business object</td>
<td>Basic action – create or modify or delete/destroy object</td>
</tr>
<tr>
<td>12</td>
<td>Objective (local and global)</td>
<td>Business aim(s) of the process</td>
</tr>
<tr>
<td>13</td>
<td>Process strategy (local and global)</td>
<td>Tactics underlying how the process is structured to achieve its aim(s)</td>
</tr>
<tr>
<td></td>
<td>Function perspective (micro)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Beneficiary (customer)</td>
<td>Person or department benefiting from the process</td>
</tr>
<tr>
<td>15</td>
<td>Input</td>
<td>Data, information, signal or a physical object entering the process</td>
</tr>
<tr>
<td>16</td>
<td>Output</td>
<td>Data, information, signal or a physical object leaving the process</td>
</tr>
<tr>
<td>17</td>
<td>Previous preparation required</td>
<td>Preparatory work required to be ready for process</td>
</tr>
<tr>
<td>18</td>
<td>Trigger – antecedent process</td>
<td>Preceding process initiating this process</td>
</tr>
<tr>
<td>19</td>
<td>Trigger – parent process</td>
<td>Process within which this process is a sub-process</td>
</tr>
<tr>
<td>20</td>
<td>Trigger – event</td>
<td>Preceding event which activates the process</td>
</tr>
<tr>
<td>21</td>
<td>Trigger – timer (date, cycle)</td>
<td>Clock or calendar value which activates the process when reached</td>
</tr>
<tr>
<td>22</td>
<td>Trigger – business rule</td>
<td>Business rule which activates the process if fired</td>
</tr>
<tr>
<td>23</td>
<td>Outcome event (general)</td>
<td>General process outcome vis-à-vis the trigger</td>
</tr>
<tr>
<td>24</td>
<td>Outcome event (success)</td>
<td>Process outcome if the process succeeds from a business point of view</td>
</tr>
<tr>
<td>25</td>
<td>Outcome event (failure)</td>
<td>Process outcome if the process fails from a business point of perspective</td>
</tr>
<tr>
<td>26</td>
<td>Successor process(es) (success)</td>
<td>Subsequent action if the process succeeds from a business point of view</td>
</tr>
<tr>
<td>27</td>
<td>Successor process(es) (failure)</td>
<td>Subsequent action if the process fails from a business point of perspective</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>28</td>
<td>External agent</td>
<td>Actor outside the boundaries of the enterprise involved in the process</td>
</tr>
<tr>
<td>29</td>
<td>Transfer (control)</td>
<td>Activity which relocates an object to a subsequent or parallel process</td>
</tr>
<tr>
<td><strong>Organization perspective</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Performer (regular)</td>
<td>Person executing the process</td>
</tr>
<tr>
<td>31</td>
<td>Performer qualifications (professional)</td>
<td>Competence or proficiency or experience needed</td>
</tr>
<tr>
<td>32</td>
<td>Performer eligibility (administrative)</td>
<td>Position or rank within the organization</td>
</tr>
<tr>
<td>33</td>
<td>Performer empowerment</td>
<td>Special authority given to performer for this process</td>
</tr>
<tr>
<td>34</td>
<td>Output authorizer</td>
<td>Person authorizing the business object</td>
</tr>
<tr>
<td>35</td>
<td>Authorizer qualifications (professional)</td>
<td>Competence or proficiency or experience needed</td>
</tr>
<tr>
<td>36</td>
<td>Authorizer eligibility (administrative)</td>
<td>Position or rank within the organization</td>
</tr>
<tr>
<td>37</td>
<td>Authorizer empowerment</td>
<td>Special authority given to authorizer for this process</td>
</tr>
<tr>
<td>38</td>
<td>Escalation</td>
<td>Channel to be provided for escalation</td>
</tr>
<tr>
<td>39</td>
<td>Supervisor</td>
<td>Person responding to escalated actions or transactions</td>
</tr>
<tr>
<td>40</td>
<td>Supervisor qualifications (professional)</td>
<td>Competence or proficiency or experience needed</td>
</tr>
<tr>
<td>41</td>
<td>Supervisor eligibility (administrative)</td>
<td>Position or rank within the organization</td>
</tr>
<tr>
<td>42</td>
<td>Supervisor empowerment</td>
<td>Special authority given to supervisor for this process</td>
</tr>
<tr>
<td><strong>Data perspective</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Data required</td>
<td>Data retrieved from database during process execution</td>
</tr>
<tr>
<td>44</td>
<td>Knowledge required</td>
<td>Knowledge retrieved from knowledge base during process execution</td>
</tr>
<tr>
<td>45</td>
<td>Script requirements</td>
<td>Scripts needed to regularize interactions with internal or external agents</td>
</tr>
<tr>
<td>46</td>
<td>Business rules</td>
<td>Business rule(s) activated during process execution</td>
</tr>
<tr>
<td>47</td>
<td>Decisions to be made</td>
<td>Decisions leading to alternative paths through the process</td>
</tr>
<tr>
<td><strong>Contingency perspective</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Fallback performer</td>
<td>Substitute performer if regular performer unavailable for process execution</td>
</tr>
<tr>
<td>49</td>
<td>Fallback process (no IT)</td>
<td>Alternative process if IT support inaccessible for process execution</td>
</tr>
<tr>
<td>50</td>
<td>Process abortion</td>
<td>Action if IT support fails during process execution</td>
</tr>
<tr>
<td>51</td>
<td>Process rollback</td>
<td>Action if beneficiary wishes to retract the process transaction</td>
</tr>
</tbody>
</table>
Table 8.2 Process modeling rules and checklist

<table>
<thead>
<tr>
<th>Check</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Syntax</strong></td>
<td></td>
</tr>
<tr>
<td>✔ Only one begin (start) block present</td>
<td></td>
</tr>
<tr>
<td>✔ Only one end (stop) block present</td>
<td></td>
</tr>
<tr>
<td>✔ Begin (start) state (trigger) defined</td>
<td></td>
</tr>
<tr>
<td>✔ End (stop) state (outcome) defined</td>
<td></td>
</tr>
<tr>
<td>✔ Only basic building blocks used (play, stop, action, decision, flowline)</td>
<td></td>
</tr>
<tr>
<td>✔ Branch states defined after decision block</td>
<td></td>
</tr>
<tr>
<td>✔ Decision block preceded by an action (test/check/query) block</td>
<td></td>
</tr>
<tr>
<td><strong>Process flowlines</strong></td>
<td></td>
</tr>
<tr>
<td>✔ All flowlines connected at each end (exit, entry)</td>
<td></td>
</tr>
<tr>
<td>✔ Begin block: no entry flowlines; only one exit flowline</td>
<td></td>
</tr>
<tr>
<td>✔ End block: no exit flowlines; only one entry flowline</td>
<td></td>
</tr>
<tr>
<td>✔ Action block: one or more entry flowlines; only one exit flowline</td>
<td></td>
</tr>
<tr>
<td>✔ Decision block: only one entry flowline; at least two exit flowlines</td>
<td></td>
</tr>
<tr>
<td><strong>Descriptors</strong></td>
<td></td>
</tr>
<tr>
<td>✔ All blocks have descriptors</td>
<td></td>
</tr>
<tr>
<td>✔ Format of action descriptor is &lt;verb&gt; (predicate) &lt;noun&gt; (object)</td>
<td></td>
</tr>
<tr>
<td>✔ Format of decision descriptor is &lt;noun&gt; (“object type”) &lt;adjective&gt; (“status”) ?</td>
<td></td>
</tr>
<tr>
<td>✔ Format of begin state descriptor is &lt;noun&gt; (“business object”) to be &lt;verb&gt; (“intent”)</td>
<td></td>
</tr>
<tr>
<td>✔ Format of end state descriptor is &lt;noun&gt; (“business object”) &lt;verb&gt; (“realization(s)”)</td>
<td></td>
</tr>
<tr>
<td><strong>Activity resource attributes</strong></td>
<td></td>
</tr>
<tr>
<td>✔ Resource attributes are attached to all blocks</td>
<td></td>
</tr>
<tr>
<td>✔ Only valid attribute codes are used (H, S, D, K, P, A)</td>
<td></td>
</tr>
<tr>
<td>✔ Only valid attribute code modifiers are used (U, R)</td>
<td></td>
</tr>
<tr>
<td><strong>Nested processes</strong></td>
<td></td>
</tr>
<tr>
<td>✔ All nested processes modeled</td>
<td></td>
</tr>
<tr>
<td>✔ All begin and end blocks coordinated with action block in super-process</td>
<td></td>
</tr>
<tr>
<td>Autonomy: process execution independent of extraneous constraints or other processes</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td>• Input: minimization of external data/information required</td>
<td></td>
</tr>
<tr>
<td>• Information exchange: minimization of data/information exchange between the process and other processes</td>
<td></td>
</tr>
<tr>
<td>• Material exchange: minimization of material exchange between the process and other processes</td>
<td></td>
</tr>
<tr>
<td>• Control: minimization of control between the process and other processes such as external decision making or authorizations</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Focus: concentration as far as possible on manipulating a single business object</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Convergence: complete handling of a single business object</td>
</tr>
<tr>
<td>• Divergence: elimination or minimization of the handling of other business objects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Streamlining: the process is designed to execute efficiently</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process economy: minimizing the number of activities (not at the expense of completeness!); minimizing the number of time-intensive activities; minimizing the time required to execute activities</td>
</tr>
<tr>
<td>• Role economy: minimizing the number of roles participation in process execution – the process should preferably be executed by one person or one group (enactment, authorization, escalation)</td>
</tr>
<tr>
<td>• Flexibility: providing some possibility of divergence from the process flow without negatively impacting the process validity</td>
</tr>
<tr>
<td>• Alignment: ensuring that the process input, output and scheduling are harmonized with other business processes</td>
</tr>
<tr>
<td>• Coordination: ensuring that data and knowledge sources (retrieval) are available when required; ensuring that data and knowledge sinks (entry) are available when required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Role balancing: roles are correctly delineated in terms of scope and authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Flexibility: delineating and bounding roles and authority (enactment, authorization, escalation)</td>
</tr>
<tr>
<td>• Empowerment: giving power to the process performer/authorizer/supervisor to make decisions</td>
</tr>
<tr>
<td>• Escalation: determination of activities which may require escalation if performer empowerment fails</td>
</tr>
<tr>
<td>• Ownership: certification of the process owner</td>
</tr>
<tr>
<td>• Customer: designation of the “internal” or “external” customer of the process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Robustness: the ability to ensure that the process achieves its aim (in a range of circumstances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Validity: incorporation of all activities required to handle the business object(s) – creation, modification, finalization, authorization, transfer, confirmation, control</td>
</tr>
<tr>
<td>• Fulfillment: provision of a path from begin to end if process succeeds in a business sense</td>
</tr>
<tr>
<td>• Non-fulfillment: provision of a path from begin to end if process fails in a business sense</td>
</tr>
<tr>
<td>• Interruption: provision of “escape routes” if process needs to be aborted</td>
</tr>
<tr>
<td>• Granularity: detailing of all operational actions required; detailing of all operational decisions required</td>
</tr>
<tr>
<td>• Clarity: action and decision descriptors provided in a language understandable to process performers; help facilities for process performers</td>
</tr>
</tbody>
</table>
Table 8.3 Process design evaluation (continued)

<table>
<thead>
<tr>
<th>Improvement: the ability to enable the performer himself/herself to continuously improve the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Self-monitoring: facilitating the capability of the process performer to judge the quality and effectiveness of each process step or process section</td>
</tr>
<tr>
<td>• Productivity: facilitating the capability of the process performer to judge the effect of his/her actions and be motivated to improve process steps and the overall process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Automation: reliance on IT support as far as possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Compass: maximization of IT-supported activities; maximization of template-related (input or display) activities; provision of scripted guidance for complex person-to-person interactions</td>
</tr>
<tr>
<td>• Links: maximization of automation in exchanging materials and information; maximization of help in transferring materials and information</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SWOT: strengths, weaknesses, opportunities and threats in attaining the process (business) goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Strengths: process mechanisms that maximize successful attainment of the process goal</td>
</tr>
<tr>
<td>• Weaknesses: process mechanisms that may result in non-attainment of the process goal</td>
</tr>
<tr>
<td>• Opportunities: process mechanisms that may provide a means of enlarging the process goal</td>
</tr>
<tr>
<td>• Threats: factors external to the process that may thwart the attainment of the process goal</td>
</tr>
</tbody>
</table>

(d) Draw up an activity table

The verified flowchart is converted to tabular form (analogous to a linear bill of materials created from a product tree). A row is provided for each action and each decision. Control ("go to") can be added if desired. This enables detailed organizational and data attributes to be specified for each action or decision (step (e)).

(e) Add organizational and data/knowledge attributes to the activity table

- Organizational attributes

These attributes specify the personnel within the organization responsible for carrying out the action or making the decision. Personnel can be identified at the departmental level (e.g., “purchasing department”), role (e.g., “purchasing agent”) or personal level (e.g., “Mr. Jones”).

- Data/knowledge attributes

These attributes pinpoint the nature of the linkages between the activities and data and knowledge sources and sinks required.

- Action attributes: these relate to the action driver and to any information (data or knowledge) required, created or modified. Drivers are:
  - T - externally driven: a trigger initiates the process through an antecedent process (A), a parent process (P), an event (E), a timer (M) or a business rule (B)
  - H - human-driven: no resources are required by the performer
  - S - script-driven: a script is presented to the performer (by the IT system or otherwise)
  - D - data-driven: data is provided to the performer (D/R) (by the IT system or otherwise) or entered by the performer (D/U) (into the IT system or otherwise)
8.3 Business Process Design Procedure

- **K** - knowledge-driven: knowledge provided to the performer (K/R) (by the IT system or otherwise) or entered by the performer (K/U) (into the IT system or otherwise)
- **P** - sub-process-driven: the action is decomposable into a sub-process
- **A** – automatic or system-driven: the action is executed automatically by the IT system

- Decision attributes: these relate to the previous check or test action, which requires a consequent decision, and the nature of the branches emanating from the decision. They are of three types:
  - a bifurcation (“yes”, “no”) in the process flow as a result of a check action (H, S, D, K, P)
  - a multi-path branch in the process flow as a result of a check action (H, S, D, K, P)
  - a decision made within a knowledge-driven action or sub-process (K)

(f) Complete the perspective specification using the perspective table (post-design)

The elements or factors in the perspective table (Table 8.1) may need to be completed or modified as a result of the detailed process design.

(g) Evaluate process design

Evaluation encompasses two aspects of design: accuracy of the design from a technical point of view, and quality of design from a business point of view.

Table 8.3 details eight criteria for design evaluation from a business point of view:

- **autonomy**: the process can be executed independently without being constrained by other processes or by the necessity to exchange information or materials between processes
- **focus**: the process concentrates as far as possible on manipulating a single business object
- **streamlining**: the process is designed to execute efficiently
- **role balancing**: roles are correctly delineated in terms of scope and authority
- **robustness**: the process operates correctly in a business sense, in a range of circumstances, both when it succeeds, or does not succeed, in achieving its aims (it is not always possible to predict the course of a process, especially when a customer is involved)
- **improvement**: the ability to enable the process performer himself/herself to continuously improve the process
- **automation**: the process relies on IT support as far as possible
- **SWOT**: the process is effective from a SWOT (strengths, weaknesses, opportunities, threats) perspective

These are further decomposed into 30 associated qualitative measures, which can be used directly to assess the design.
(h) Analyze process usage

We are interested in how the process model can help represent, understand, integrate, manage and improve the way work gets done and results get produced in complex enterprises. Hence, the process model is intended to become the foundation of and provide the framework for a company’s process-oriented management efforts (Browning 2002). To operationalize this, Table 8.8 (Browning 2002) details eight criteria to determine the way the process must be used within the organization over and above its use to represent the workflow of how “work gets done”:

• **program planning**: determining and evaluating the process and systems engineering master/management plan
• **program execution**: coordinating and monitoring the process and systems engineering master/management plan
• **baseline for continuous improvement**: analyzing potential process improvements and isolating root causes of problems
• **knowledge retention and learning**: capturing lessons learned when the process does not work as expected
• **process visualization**: helping people visualize where they are in a process and what they need and must produce and when
• **training**: helping newly hired employees to become oriented and see what they need to do and why
• **framework for metrics**: serving as a framework for organizing low-level measures that tie to business goals
• **compliance/audits/assessments**: providing a baseline to measure process compliance with assessments and to demonstrate knowledge of what work to do and how to do it efficiently

### 8.4 Business Process Design Example

The process design procedure is exemplified using a (simplified) business process: transacting (or losing) a sale as a result of a customer call made to a wholesale enterprise (telesales). We suppose the following scenario regarding the present situation, as told by the sales manager of a wholesale organization:

“One of our core processes is telesales – selling to customers via our call center”. The sales agent receives a call and ascertains whether the caller is a regular customer or a new contact. New contacts have to be accredited before an order can be placed. We use various strategies to fill the order. These include (in order of preference): to sell from ATP stock; to sell from stock currently on order from a supplier; to offer and sell a substitute item. If the item (or its substitute) can be provided, we inform the customer of the order price and delivery date. Unfortunately, some customers are not satisfied; and we need to convince them that the quality of our products justifies the price asked and/or the wait for delivery. We stand firm on price (as the discount for regular customers is already incorporated into the price). Regarding delivery: if we feel that the customer is important enough,
we may pre-empt another customer order in order to meet the date required.
Regrettably, we do not have statistics on how the strategies were used to effect a
sale; nor do we have statistics on why sales were lost.

“Currently, we have the following problems with the process:

– Ideally, sales agents have to have knowledge in selling techniques and
  handling customer relationships; in our products and possible substitutes; in
  accrediting new connections; in pre-empting orders if the circumstances
  justify it; and in working with the customer order management system. This
  means that training is very expensive.
– The process takes too long. Agents have to be in touch with purchasing
  (clarifying purchase orders); with the expeditor (pre-empting another order);
  and with marketing (determining customer credit limits). This leads to hold-
  ups in dealing with the customer.
– As a result, our agents complain that the process is clumsy and prone to
  errors; and that customers become irritable and angry when delays occur. As
  a result, many agents leave the company – and all our investment in their
  training goes with them.
– Our activities are supported by four computer systems: customer orders,
  purchase orders, inventory control and credit management. Each is under the
  control of the corresponding departments. We are hoping that our new ERP
  system will boost these systems and integrate them; and also improve
  cooperation between the departments in the organization”.

8.5 New Process Design

Design of the new process proceeds as follows:

(a) Define initial process requirements and features (pre-design)

These are detailed in Table 8.4.

(b) Design process flowchart

The flowchart of the illustrative process is detailed in Fig. 8.1. Forty-two
activities are required – 28 actions and 14 (yes/no) decisions. Decision making –
simple (activity 11: “acceptable to customer?”) or complex (activity 9: “item price
exceeds customer credit limit?”) – is a typical component of business processes. Table 8.5 portrays the process in tabular form, which is sometimes easier to
understand in complex cases.

(c) Verify process flowchart

The flowchart is reviewed and any corrections made where necessary. For
example (not illustrated in Fig. 8.1), an initial draft of the process had separate
exits for successful and unsuccessful transactions – activity # 18 terminated a sale,
whilst activity # 24 terminated a lost sale. “This contradicts the requirement
(Table 8.2) that only one end (stop) block can be present”. To correct this, a single termination activity #42, “end call with customer”, was added to the final flowchart. (From a business point of view, it also makes sense to end a call, profitable or not, in a standard way.)

(d) Create process activity table (PAT)

The PAT for the illustrative process is set out in Table 8.5.

(e) Add organizational and data/knowledge attributes to PAT

Attributes for the 42 activities are appended in Table 8.5. (They could be added to the flowchart if preferred.) A representative analysis of each type of attribute is given in Table 8.6. The process is enacted by a single role – the sales agent. This is interpreted that any accredited sales agent can operate the process: enactment is not restricted to a specific person.

(f) Define additional process features (post-design)

These are detailed in Table 8.4.

(g) Evaluate process design

The process design is reviewed in terms of the 30 measures (Table 8.7).

(h) Perform process usage analysis

As our scenario is limited to a specific telesales process, we give a partial example of the analysis of the uses of the process (cf. Table 8.8):

- **planning**: telesales is a component of the overall CRM (customer relationship management) strategy and functionality of the enterprise. The process definition helps to determine the division of functionality into sub-functionalities and the corresponding qualifications required of workers in these areas.
- **continuous improvement**: the process primarily deals with direct telesales. However, the design analysis has indicated that some marketing aspects (creating incentives, cross-selling) could be incorporated to maximize the benefit of the contact with a customer.
- **training**: the process flowchart serves as the basis for training new sales agents, but also as a medium for explaining enterprise policy with regard to interactive contacts with customers.
- **metrics**: the process model incorporates a large number of alternative routes through which a sale is effected or lost. These enable the enterprise to formulate measures for the success or failure of selling procedures and sales efforts – the primary business goal – and to indicate strengths and weaknesses of these procedures and their implementation.
- **assessments**: the existence of a standardized telesales process helps convince a customer that the sales agents know what to do and how to do it efficiently.
8.5 New Process Design

Customer Call

1. Greet caller
2. Identify caller
3. Regular customer?
   - Yes
   - No
   19. Register new customer
   20. Check standard credit limit for new customer
5. Check on-hand inventory (ATP)
6. Enough to cover order?
   - Yes
   - No
7. Check order price
8. Check if exceeds customer credit limit
9. Less than credit limit?
   - Yes
   - No
10. Quote order price
11. Acceptable to customer?
12. Check delivery date
13. Quote delivery date
14. Acceptable to customer?
15. Review order with customer
16. Confirm order with customer
17. Authorize order for execution
18. Thank customer for order
25. Check if item from order from supplier
26. On order from supplier?
   - Yes
   - No
27. Check total inventory
28. Total inventory enough?
29. Check for substitute item
30. Substitute found?
   - Yes
   - No
31. Check on-hand inventory (ATP)
32. Enough to cover order?
33. Offer substitute to customer
34. Substitute acceptable to customer?
35. Try to convince customer to accept price
36. Price acceptable to customer?
   - Yes
   - No
37. Try to convince customer to accept date
38. Date acceptable to customer?
   - Yes
   - No
39. Check feasibility of preemption
40. Preemption feasible?
   - Yes
   - No
41. Preempt another customer order
42. End call with customer
24. Register lost business and cause
23. Express regret that cannot help
22. Acceptable to customer?
   - Yes
   - No
21. Inform customer of credit limit
20. Check standard credit limit for new customer
19. Register new customer
18. Thank customer for order
17. Authorize order for execution
16. Confirm order with customer
15. Review order with customer
14. Acceptable to customer?
13. Quote delivery date
12. Check delivery date
11. Acceptable to customer?
10. Quote order price
9. Less than credit limit?
   - Yes
   - No
8. Check if exceeds customer credit limit
7. Check order price
6. Enough to cover order?
5. Check on-hand inventory (ATP)
4. Record order
3. Regular customer?
   - Yes
   - No
2. Identify caller
1. Greet caller

Figure 8-1: Telesales process
### Table 8.4 Process perspectives – example

<table>
<thead>
<tr>
<th>#</th>
<th>Factor</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Process identifier</td>
<td>SM-2008</td>
</tr>
<tr>
<td>2</td>
<td>Version identifier</td>
<td>Version 1.0</td>
</tr>
<tr>
<td>3</td>
<td>Version date</td>
<td>15th May 2007</td>
</tr>
<tr>
<td>4</td>
<td>Descriptor</td>
<td>Obtain customer order via telephone</td>
</tr>
<tr>
<td>5</td>
<td>Owner</td>
<td>Sales department</td>
</tr>
<tr>
<td>6</td>
<td>Major functionality</td>
<td>Sales and marketing</td>
</tr>
<tr>
<td>7</td>
<td>Main functionality</td>
<td>Telesales</td>
</tr>
<tr>
<td>8</td>
<td>Main business object</td>
<td>Customer order</td>
</tr>
<tr>
<td>9</td>
<td>Key action on main business object</td>
<td>Create customer order</td>
</tr>
<tr>
<td>10</td>
<td>Ancillary business object</td>
<td>New customer registration</td>
</tr>
<tr>
<td>11</td>
<td>Key action on ancillary business object</td>
<td>Create new customer record</td>
</tr>
<tr>
<td>12</td>
<td>Objective</td>
<td>Close a sale</td>
</tr>
<tr>
<td>13</td>
<td>Process strategy</td>
<td>Use persuasion to overcome customer resistance</td>
</tr>
<tr>
<td>14</td>
<td>Beneficiary (customer)</td>
<td>External customer</td>
</tr>
<tr>
<td>15</td>
<td>Input</td>
<td>Customer requirement (single item)</td>
</tr>
<tr>
<td>16</td>
<td>Output</td>
<td>Customer order (transferred for execution)</td>
</tr>
<tr>
<td>17</td>
<td>Previous preparation required</td>
<td>None</td>
</tr>
<tr>
<td>18</td>
<td>Trigger – antecedent process</td>
<td>None</td>
</tr>
<tr>
<td>19</td>
<td>Trigger – parent process</td>
<td>None</td>
</tr>
<tr>
<td>20</td>
<td>Trigger – event</td>
<td>Customer call</td>
</tr>
<tr>
<td>21</td>
<td>Trigger – timer (date, cycle)</td>
<td>None</td>
</tr>
<tr>
<td>22</td>
<td>Trigger – business rule</td>
<td>None</td>
</tr>
<tr>
<td>23</td>
<td>Outcome event (general)</td>
<td>Customer call handled</td>
</tr>
<tr>
<td>24</td>
<td>Outcome event (success)</td>
<td>Customer order obtained</td>
</tr>
<tr>
<td></td>
<td>Outcome event (failure)</td>
<td>Customer business lost</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>26</td>
<td>Successor process(es) (success)</td>
<td>Execute order; issue invoice; reschedule preempted order</td>
</tr>
<tr>
<td>27</td>
<td>Successor process(es) (failure)</td>
<td>Analyze reasons for lost business</td>
</tr>
<tr>
<td>28</td>
<td>External agent</td>
<td>External customer</td>
</tr>
<tr>
<td>29</td>
<td>Transfer (control)</td>
<td>Transfer order for execution</td>
</tr>
<tr>
<td></td>
<td><strong>Organization perspective</strong></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Performer</td>
<td>Sales representative</td>
</tr>
<tr>
<td>31</td>
<td>Performer qualifications (professional)</td>
<td>Accredited sales agent</td>
</tr>
<tr>
<td>32</td>
<td>Performer eligibility (administrative)</td>
<td>Sales representative</td>
</tr>
<tr>
<td>33</td>
<td>Performer empowerment</td>
<td>Set credit limit for new customer; preempt another customer order</td>
</tr>
<tr>
<td>34</td>
<td>Output authorizer</td>
<td>Sales representative (“own authorizer”)</td>
</tr>
<tr>
<td>35</td>
<td>Authorizer qualifications (professional)</td>
<td>Accredited sales agent</td>
</tr>
<tr>
<td>36</td>
<td>Authorizer eligibility (administrative)</td>
<td>Sales representative</td>
</tr>
<tr>
<td>37</td>
<td>Authorizer empowerment</td>
<td>Consent to order conditions agreed with customer</td>
</tr>
<tr>
<td>38</td>
<td>Escalation</td>
<td>No escalation channel required</td>
</tr>
<tr>
<td>39</td>
<td>Supervisor</td>
<td>None required</td>
</tr>
<tr>
<td>40</td>
<td>Supervisor qualifications (professional)</td>
<td>None required</td>
</tr>
<tr>
<td>41</td>
<td>Supervisor eligibility (administrative)</td>
<td>None required</td>
</tr>
<tr>
<td>42</td>
<td>Supervisor empowerment</td>
<td>None required</td>
</tr>
<tr>
<td></td>
<td><strong>Data perspective</strong></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Data required</td>
<td>Customer details; item inventory; item, substitutes</td>
</tr>
<tr>
<td>44</td>
<td>Knowledge required</td>
<td>Criteria for credit allocation; criteria for order preemption</td>
</tr>
<tr>
<td>45</td>
<td>Script requirements</td>
<td>Begin call; end call; thank caller; regret order failure</td>
</tr>
<tr>
<td>46</td>
<td>Business rules</td>
<td>Only built-in discounts; preemption allowed if feasible</td>
</tr>
<tr>
<td>47</td>
<td>Decisions to be made</td>
<td>Set delivery date; select substitute item; preemption feasible</td>
</tr>
<tr>
<td></td>
<td><strong>Contingency perspective</strong></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Fallback performer</td>
<td>Sales manager</td>
</tr>
<tr>
<td>49</td>
<td>Fallback process (no IT)</td>
<td>Manually record customer/order details and later call back</td>
</tr>
<tr>
<td>50</td>
<td>Process abortion</td>
<td>Order recorded only when final confirmation given</td>
</tr>
<tr>
<td>51</td>
<td>Process rollback</td>
<td>Order cancellation process required</td>
</tr>
<tr>
<td>Step</td>
<td>Action/decision</td>
<td>Descriptor</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td>0 (Trigger)</td>
<td>Caller contacts sales agent</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Greet caller</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>Identify caller</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Caller identified (regular customer)? (Y go to 4; N go to 19)</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>Record order (single item)</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>Check on-hand inventory (ATP)</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Enough to cover order? (Y go to 7; N go to 25)</td>
</tr>
<tr>
<td>7</td>
<td>A</td>
<td>Check item price</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>Check if exceeds existing customer credit limit</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Greater than limit? (Y go to 23; N go to 10)</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>Quote order price</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Acceptable to customer? (Y go to 12; N go to 35)</td>
</tr>
<tr>
<td>12</td>
<td>A</td>
<td>Check delivery date</td>
</tr>
<tr>
<td>13</td>
<td>A</td>
<td>Quote delivery date</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
<td>Acceptable to customer? (Y go to 15; N go to 37)</td>
</tr>
<tr>
<td>15</td>
<td>A</td>
<td>Review order with customer</td>
</tr>
<tr>
<td>16</td>
<td>A</td>
<td>Confirm order with customer</td>
</tr>
<tr>
<td>17</td>
<td>A</td>
<td>Authorize order for execution</td>
</tr>
<tr>
<td>18</td>
<td>A</td>
<td>Thank customer for order (Go to 42)</td>
</tr>
<tr>
<td>19</td>
<td>A</td>
<td>Register new customer</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>Check standard credit limit for new customer</td>
</tr>
<tr>
<td>21</td>
<td>A</td>
<td>Inform customer of credit limit</td>
</tr>
<tr>
<td>22</td>
<td>D</td>
<td>Acceptable to customer? (Y go to 4; N go to 23)</td>
</tr>
<tr>
<td>23</td>
<td>A</td>
<td>Express regret that cannot help customer</td>
</tr>
<tr>
<td>24</td>
<td>A</td>
<td>Record “lost business” and cause (Go to 42)</td>
</tr>
<tr>
<td>25</td>
<td>A</td>
<td>Check if item on order from supplier</td>
</tr>
<tr>
<td>26</td>
<td>D</td>
<td>On order from supplier? (Y go to 27; N go to 29)</td>
</tr>
<tr>
<td>27</td>
<td>A</td>
<td>Check total inventory</td>
</tr>
<tr>
<td>28</td>
<td>D</td>
<td>Enough to cover order? (Y go to 7; N go to 29)</td>
</tr>
<tr>
<td>29</td>
<td>A</td>
<td>Check for substitute item</td>
</tr>
<tr>
<td>30</td>
<td>D</td>
<td>Substitute found? (Y go to 31; N go to 23)</td>
</tr>
<tr>
<td>31</td>
<td>A</td>
<td>Check on-hand inventory (ATP)</td>
</tr>
<tr>
<td>32</td>
<td>D</td>
<td>Enough to cover order? (Y go to 33; N go to 29)</td>
</tr>
<tr>
<td>33</td>
<td>A</td>
<td>Offer substitute to customer</td>
</tr>
<tr>
<td>34</td>
<td>D</td>
<td>Acceptable to customer? (Y go to 4; N go to 23)</td>
</tr>
<tr>
<td>35</td>
<td>A</td>
<td>Try to convince customer to accept price</td>
</tr>
<tr>
<td>36</td>
<td>D</td>
<td>Price acceptable to customer? (Y go to 12; N go to 23)</td>
</tr>
</tbody>
</table>
### Table 8.5 Telephonic sales process activity table (continued)

<table>
<thead>
<tr>
<th>Step</th>
<th>Action/decision</th>
<th>Driver</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>Action</td>
<td>S</td>
<td>Try to convince customer to accept date</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sales agent S</td>
</tr>
<tr>
<td>38</td>
<td>Date acceptable to customer? (Y go to 15; N go to 39)</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Check feasibility of preemption</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Preemption feasible? (Y go to 41; N go to 23)</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Preempt another customer order (Go to 15)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>End call</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Process termination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8.6 Representative analysis of activity drivers

<table>
<thead>
<tr>
<th>Step</th>
<th>Action/decision</th>
<th>Driver</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Action</td>
<td>H</td>
<td>Greet caller</td>
</tr>
<tr>
<td></td>
<td>T (E) Caller contact</td>
<td></td>
<td><em>A (potential) customer call triggers the process</em></td>
</tr>
<tr>
<td>37</td>
<td>Action</td>
<td>S</td>
<td>Try to convince customer to accept date</td>
</tr>
<tr>
<td></td>
<td>H (E) The performer does not need direction on how to greet a caller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Action</td>
<td>D (R)</td>
<td>Identify caller</td>
</tr>
<tr>
<td></td>
<td>The performer retrieves caller data from the customer database</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Action</td>
<td>D (U)</td>
<td>Register order (single item)</td>
</tr>
<tr>
<td></td>
<td>The performer fills in the customer order template</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Action</td>
<td>K (R)</td>
<td>Check feasibility of preemption</td>
</tr>
<tr>
<td></td>
<td>The performer retrieves order and priority data for this item – over all customer orders – from the sales database</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Action</td>
<td>K (U)</td>
<td>Record lost business</td>
</tr>
<tr>
<td></td>
<td>The performer records that the sale has been lost, the reason, and suggests possibilities for improvement which will be transferred to the departments involved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Action</td>
<td>P</td>
<td>Check standard credit limit for customer</td>
</tr>
<tr>
<td></td>
<td>The performer enters customer parameters and the knowledge sub-process computes the credit limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Decision</td>
<td>S</td>
<td>Price acceptable to customer?</td>
</tr>
<tr>
<td></td>
<td>The performer makes a decision on the basis of a response to a scripted action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Decision</td>
<td>D (R)</td>
<td>Caller identified (regular customer)?</td>
</tr>
<tr>
<td></td>
<td>The performer makes a decision on the basis of retrieved data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Decision</td>
<td>K (R)</td>
<td>Preemption possible?</td>
</tr>
<tr>
<td></td>
<td>The performer makes a decision on the basis of retrieved knowledge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8.7 Process design evaluation – telesales example

<table>
<thead>
<tr>
<th>Autonomy: process execution independent of extraneous constraints or other processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Input: provided by customer who triggers the process</td>
</tr>
<tr>
<td>• Information exchange: none</td>
</tr>
<tr>
<td>• Material exchange: none</td>
</tr>
<tr>
<td>• Control: sub-processes and/or rules for credit assignment, item substitution, order prioritization</td>
</tr>
<tr>
<td>• Flexibility: various mechanisms provided to maximize success – convincing customers, substituting items, order preemption</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Focus: concentration as far as possible on manipulating a single business object</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Convergence: main object – sales order</td>
</tr>
<tr>
<td>• Divergence: secondary object – new customer; tertiary object – prioritized order</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Streamlining: the process is designed to execute efficiently</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process economy: knowledge management facilitates credit assessment and order prioritization</td>
</tr>
<tr>
<td>• Role economy: correct empowerment necessitates one role only to execute process</td>
</tr>
<tr>
<td>• Flexibility: performer provided with alternatives to try to effect sale</td>
</tr>
<tr>
<td>• Alignment: no confirmation from warehouse management re order execution</td>
</tr>
<tr>
<td>• Coordination: process relies on customer, credit and inventory databases which are maintained by the corresponding functionalities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Role balancing: roles are correctly delineated in terms of scope and authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Flexibility: process restricted to regular selling – no marketing is included</td>
</tr>
<tr>
<td>• Empowerment: performer empowered to set credit limit and to preempt orders</td>
</tr>
<tr>
<td>• Escalation: may be required to overcome customer objections</td>
</tr>
<tr>
<td>• Ownership: sales functionality; call center sub-functionality</td>
</tr>
<tr>
<td>• Customer: external – customer; internal – warehouse management</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Robustness: the ability to ensure that the process achieves its aim (in a range of circumstances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Validity: includes actions for creating/modifyng/finalizing/ authorizing/transferring the sales order; no confirmation from warehouse management included</td>
</tr>
<tr>
<td>• Fulfillment: provides several paths through which a sale may be effected</td>
</tr>
<tr>
<td>• Non-fulfillment: provides several paths to handle lost business, based on customer balk or inability to supply the ordered items</td>
</tr>
<tr>
<td>• Interruption: the order is only registered when the performer authorizes it at the end of the process</td>
</tr>
<tr>
<td>• Granularity: all primary actions and decisions detailed; credit assessment and order prioritization denoted as sub-processes</td>
</tr>
<tr>
<td>• Clarity: only conventional sales language used</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Improvement: the ability to enable the performer himself/herself to continuously improve the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Self-monitoring: the performer can evaluate whether the “convincing” scripts and other stratagems are effective when the customer balks</td>
</tr>
<tr>
<td>• Productivity: the performer can suggest refinements such as improved scripts, additional methods (e.g., customer incentives) to increase the likelihood of closing a sale, or the incorporation of cross-sales</td>
</tr>
</tbody>
</table>
8.5 New Process Design

Table 8.7 Process design evaluation – telesales example (continued)

<table>
<thead>
<tr>
<th><strong>Automation:</strong> reliance on IT support as far as possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ Compass: templates for customer, order</td>
</tr>
<tr>
<td>✔️ Links: final authorization transfers order to warehousing; access provided to multiple databases (customer, inventory, customer orders)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SWOT:</strong> strengths, weaknesses, opportunities, threats in attaining the process goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ Strengths: mechanisms provided to close a sale – convincing customers, substituting items, preempting orders</td>
</tr>
<tr>
<td>✔️ Weaknesses: no mechanisms to provide order and due date confirmation from warehouse management</td>
</tr>
<tr>
<td>✔️ Opportunities: improve scripts, add methods (e.g., customer incentives) to increase the likelihood of closing a sale, or incorporate cross-sales</td>
</tr>
<tr>
<td>✔️ Threats: alternative suppliers may offer better conditions (e.g., credit limits)</td>
</tr>
</tbody>
</table>

Table 8.8 Uses of a process model (Browning 2002)

<table>
<thead>
<tr>
<th><strong>Program Planning:</strong> A process model helps determine the statement of work (SOW), the work breakdown structure (WBS), the integrated master plan (IMP) and schedule (IMS), and therefore the systems engineering master/management plan (SEMP). It also helps to estimate cost, schedule, effort, resources and risk. It is therefore useful for proposal preparation.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Execution:</strong> A process model helps identify the critical path, determine what to work on this week, evaluate progress, coordinate deliverables, analyze the impacts of changes and the value of options, and replan the remainder of a program.</td>
</tr>
<tr>
<td><strong>Baseline for Continuous Improvement:</strong> A process model helps analyze potential process changes in terms of net value (investment costs vs. value added benefits) and helps isolate root causes of problems.</td>
</tr>
<tr>
<td><strong>Knowledge Retention and Learning:</strong> A process model captures lessons learned when the process does not work as expected. The model can account for “system-level” knowledge about the interactions between areas of work. Importantly, the model also serves as the basis for a common vocabulary of activities and work products.</td>
</tr>
<tr>
<td><strong>Process Visualization:</strong> A process model helps people visualize where they are in a process and what they need and must produce and when. It provides the basis for focused, committed, and accountable collaboration between organizations, teams, individuals, and even companies.</td>
</tr>
<tr>
<td><strong>Training:</strong> A process model can help new hires get oriented, see what they need to do and why and see where to go for more information.</td>
</tr>
</tbody>
</table>
8.6 Comparison of the Current and New Processes

Throughout this book we emphasize the four dimensions or cornerstones of competitiveness leading to organizational success: time, cost, quality and flexibility. These impinge on all aspects of the organization: integrated production and order management (Sect. 1.3), order fulfillment (Sect. 2.3), purchasing and outsourcing (Sect. 6.2), and manufacturing policy (Chap. 5). In Sect. 13.3 (b) we detail their application to business process improvement. Here we use them to compare the current process and the new design. We note that the design is based upon the centralized database afforded by the ERP system; and by the introduction of a policy that all authorized employees have free access to those parts of the database needed by them.

- **Time**
  - Current process: the agent has to contact various departments to obtain information needed for the sales transaction. This results in both queue and wait time.
  - New process: the agent has direct and guided access to all data required.

- **Cost**
  - Current process: knowledge and experience required of the sales agents comes at a cost, both in basic training, lost investment when workers leave the organization, and the slowness of the process.
  - New process: the ERP system, incorporating a central database, scripts and improved input forms, enables the process to be carried out faster, and thus at less cost. The guidance provided by the scripts and forms offsets some of the costs involved in training workers. Hopefully, it also increases job satisfaction, and thus decreases turnover.
• **Quality**
  - Current process: the process shows bad operability and reliability – “clumsy and prone to errors” – and bad fitness – “customers become irritable and angry when delays occur”. All this detracts from the quality of customer relationships.
  - New process: IT support provides smoother operation; direct access to data minimizes errors occurring when data and information is obtained indirectly; and smoother operation reduces or eliminates delays. All this enhances the quality of customer relationships.

• **Flexibility**
  - Current process: several strategies are in place to maximize the possibility of closing a sale.
  - New process: the strategies are reinforced in the new process through scripting and the ability to access the full range of data and information required to execute these strategies.

### 8.7 Context-Dependent Processes

We ask the question: can all business processes be modeled? Many of the processes in an enterprise can be rigorously formalized. These processes are well understood and are performed repeatedly. However, other activities lack the rigorous repeatability required for a predefined process, yet have elements of process – such as actions and decisions. Work is seen as a collection of activities, some of which are enabled at the current time. However, there are parts of the process that must be changed or otherwise accommodated for a specific situation. We cannot expect a perfect arrangement that will fit all situations. The term “situated action” underscores the view that every course of action depends in essential ways upon its material and social circumstances. Such processes:

• Depend upon the people involved (performer, authorizer, supervisor, internal customer, external customer).
• Often involve an external agent (usually a customer) and assume that the agent interacts or behaves according to plan (e.g., the customer in the case of the telesales process).
• Depend upon the specifics of the task instance (e.g., a customer may make an unusual stipulation in order to be willing to place an order).
• Depend upon the state of knowledge or information at the time the process is to be executed (e.g., a production routing will depend upon the expected up time of certain machines whose current state of repair is not clear).
• Change when situation changes (e.g., if a customer requires an urgent order, certain formalities may have to be bypassed to gain time).
1. Review production order
2. Check material availability
3. Material available?
   - Yes: Go to 4. Check current shop flow capacity
   - No: Go to 13. Check for substitute materials
4. Check current shop flow capacity
   - Sufficient: Go to 6. Create final shop floor control
   - Not sufficient: Go to 23. Check possibility of rescheduling
5. Current shop flow capacity sufficient?
   - Yes: Go to 6. Create final shop floor control
   - No: Go to 25. Reschedule shop floor order
6. Create final shop floor control
7. Collect all necessary documents
8. Authorize shop floor order
9. Release shop floor order for execution
10. Check impact on due date
11. Check impact on due date
12. Inform marketing of due date delay
13. Check for substitute materials
   - Substitute materials possible?:
     - Yes: Go to 14. Check for external purchase
     - No: Go to 15. Check material availability
   - No: Go to 16. Material available?
     - Yes: Go to 17. Revise production order
     - No: Go to 20. Create urgent purchase request
14. Substitute materials possible?
15. Check material availability
16. Material available?
17. Revise production order
18. Check for external purchase
   - External purchase possible?:
     - Yes: Go to 19. External purchase possible?
     - No: Go to 21. Transfer purchase request to purchasing
19. External purchase possible?
20. Create urgent purchase request
21. Transfer purchase request to purchasing
22. Put production order on hold
23. Check possibility of rescheduling
24. Rescheduling possible?
25. Reschedule shop floor order
26. Check possibility of adding an extra shift
27. Extra shift possible?
28. Schedule an extra shift
29. Check possibility of rerouting
30. Rerouting possible?
31. Reroute shop floor order
32. Inform production of order status
33. Production order handled

Figure 8-2: Shop floor order creation process
• May need to change in response to competitive pressures (e.g., if a customer requires an urgent order, certain formalities may have to be bypassed if the customer threatens to place the order elsewhere).

• May need to change in response to a context-dependent business goal (e.g., if a customer places a complex multi-product order, certain formalities may have to be bypassed if all parts of the order are to be completed at the same time).

• Cannot afford to be fixed into a uniform format (e.g., if an organization has a lack of production capacity, there may be many ways in which the problem can be solved, depending on a variety of factors such as the type of production order, the importance of the customer, the complexity of the skills and equipment required, and so on).

There are several approaches to modeling a context-dependent process when activities are highly diversified or unanticipated:

• Develop multiple versions of the process, reducing or eliminating standardization.

• Start the process with a triage action-decision area that determines the appropriate path.

• Model only the principle action and decisions, using a high level of granularity.

• Develop a chart of actions and decisions without flow paths (precedences).

Problems

1. Figure 8.2 details a process for determining how to release an order to the shop floor while taking into account complications, which may necessitate putting the production order on hold. Perform a design analysis on this process.

2. Use literature and Internet sources to find process flowcharts (e.g., RosettaNet (2007), SCOR (Supply Chain Council 2007), OAGIS (OAGi 2007), Metters et al. (2003)). Perform design analyses on these processes and comment on their validity and completeness.

3. We have described six perspectives of business processes (Sect. 8.2). Summarize the contribution of each perspective to a comprehensive definition of a business process.

4. Discuss the following questions: Can all business processes be modeled? Can all individual actions be modeled (i.e., specified)? Can the logic leading to a decision be specified?

5. Discuss the following questions: Need all business processes be modeled? Need all individual actions be modeled (i.e., specified)? What would be the criteria for modeling or not modeling a business process?

6. Our convention for identifying a business process (where it begins and where it ends) is that it deals with a single business object as far as possible. Discuss this principle as the basis for delimiting a business process.

7. Our convention for identifying a business process (where it begins and where it ends) is that it involves a single performer as far as possible. Discuss this
principle as the basis for segmenting the processing of a business object into several processes (e.g., creation, modification, authorization, escalation, monitoring, transferring, receiving, utilizing).

8. Escalation is defined as passing a call to a supervisor when a situation is outside the performer’s authority; or when a situation becomes too complex for the performer to deal with; or when an external agent asks (or demands) to speak to someone more senior. Discuss whether the action of escalating and the ensuing actions should be part of the current process (a kind of “interruption”) or whether the current process terminates at this stage.

9. A customized process is defined as a process, which has been designed to meet the specific needs of the enterprise; or a general process which has been modified for the same purpose. Discuss the generality or specificity of the Telesales process (Fig. 8.1) or the Shop Floor Order process (Fig. 8.2).

10. Carry out your own design evaluation of the Telesales process. How does it compare with the evaluation given in Table 8.7? Who should be responsible for evaluating the design of a business process?

11. Carry out your own usage analysis of the Telesales process. How does it compare with the analysis given in Sect. 8.4 (h)? Who should be responsible for analyzing the usage of a business process?

12. Table 8.1 incorporates general contingency considerations for the inability to carry through a business process:

- fallback performer: substitute performer if regular performer unavailable for process execution
- fallback process (no IT): alternative process if IT support inaccessible for process execution
- process abortion: action if IT support fails during process execution
- process rollback: action if beneficiary wishes to retract the process transaction

Can you suggest further generalized contingency activities that may be required? Who should decide to implement contingency activities or processes? Alternatively, how would they be triggered?

13. Table 8.4 incorporates specific contingency considerations for the inability to carry through the Telesales process:

- fallback performer: sales manager
- fallback process (no IT support): manually record customer/order details and later call back
- process abortion: order recorded only when final confirmation given
- process rollback: order cancellation process required

Can you suggest further specialized contingency activities that may be required in this case? Who should decide to implement contingency activities or processes? Alternatively, how would they be triggered?
14. A process flowchart often gives explicit expression to an organizational strategy. In the case of the Telesales process flowchart (Fig. 8.1), it is necessary that the customer agree both on delivery date and order price. If the customer accepts the one, it may be easier to persuade him to accept the other if there is a disagreement. Therefore a sales strategy must be formulated: to quote price before or after delivery date? Note that the delivery date may be changed by preemption; the price cannot be changed (any “built-in” discount will be seized upon by all customers). Is the strategy realized in the flowchart preferable (price (activity 10) before delivery date (activity 13))? Should the sales representative be given discretion to decide which quotation comes first?
9 The Integrated Order-Fulfillment Process Using MRP

9.1 Operations Management Frameworks

In this book we describe and utilize three central frameworks for ERP and operations management: business functions, business processes and IT support:

- **Business functions** relate to centers of professionalism or expertise within the organization, and usually, but not necessarily, coincide with organizational units (e.g., purchasing, manufacturing, inventory, sales).
- **Business processes** relate to activities – actions and decisions – carried out by employees within the organization in order to create value for the organization.
- **IT support** relates to the computerization of data-based and knowledge-based activities and transactions, and the maintenance of organizational data and knowledge repositories, in order to facilitate and empower the performance of such activities and transactions.

Over time, these frameworks have evolved with the realization that:

- The process-oriented enterprise: the realization that
  - all business operations, and not just manufacturing, involve processes; and all processes are vital to business success and business improvement
  - processes often cross functional boundaries – i.e., they are carried out by roles associated with different functions
- The IT-oriented enterprise: the understanding that
  - IT must provide support to all business processes that require it
  - IT must be aligned to the processes it supports
  - all data and knowledge must be centralized in a single repository
- The integrated enterprise: the recognition, implied by process- and IT-oriented management, that functions, processes and IT systems must be integrated, coordinated and aligned across the enterprise (and even along the supply chain) and must be viewed and managed “as a whole.”
9.2 Evolution of Computer-based Operations Management Strategies

In particular, with regard to manufacturing, IT-supported operations management strategy has evolved through four main stages:

- **MRP (material requirements planning – 1970–1980):** is a material-centric, IT-supported, internal operations management strategy based on the concept of production activity expressed in terms of material-related processes. These encompass (a) manufacturing activities (fabrication, assembly, inventory); purchasing activities; and (b) delivery activities (from suppliers and to customers). MRP is supported by product (bill of materials, (BOMs)) and inventory data bases.

- **MRP II (manufacturing resource planning – 1980–1990):** is a manufacturing-centric, IT-supported, internal operations management strategy based on the concept of manufacturing activity expressed in terms of those enterprise functionalities and enterprise processes which comprise all aspects of manufacturing. These encompass (a) demand management activities (sales forecasting, sales order processing); (b) resource planning activities (master production scheduling, capacity requirements planning, material requirements planning); (c) production control activities (purchase order processing, production order processing, shop floor control, inventory control, distribution management); and (d) cost management activities (standard costing, cost control). MRP II is supported by several data bases in these four areas.

- **ERP (enterprise resource planning – 1990–2000):** is an enterprise-centric, industry-specific, IT-supported, internal operations management strategy based upon the concept of enterprise activity expressed in terms of intra-enterprise functionality and enterprise processes. These encompass (a) commercial activities (buying and selling); (b) financial, human relations and administrative activities; and (c) industrial activities dedicated to the production of goods and services. ERP is further based on the concept of a single data base which supports an operations management strategy based on the concept of integrated cross-enterprise processes and unrestricted access to operational data across functional borders.

- **ERP II (extended enterprise resource planning – 2000 onwards):** is a partnership-centric, domain-specific, IT-supported, internal and external operations management strategy based upon the concept of enterprise activity expressed in terms of intra- and inter-enterprise functionality and intra- and inter-enterprise processes and interfaces. These encompass (a) commercial activities (buying and selling); (b) financial, human relations and administrative activities; (c) industrial activities dedicated to the production of goods and services; and (d) co-production and collaborative activities performed in conjunction with suppliers, customers and other business partners. ERP II is thus based on the concept of positioning the enterprise in the supply chain; incorporating consumer relationship management (CRM), supply chain management (SCM) and product lifecycle management (PLM); and internet-based communication between the enterprise and suppliers, customers and other business partners.
In this and the following chapter we apply the MRP and ERP concepts to the integrated order-fulfillment process.

9.3 The Material Requirements Planning Concept

The discussion so far has presented general concepts of Management Information Systems and the role of the marketing, purchasing and production functions in the order-fulfillment process. A typical MIS for marketing supports applications like demand forecasting and the management of customer orders. The MIS for purchasing supports the management of suppliers and the management of purchase orders while a typical MIS for production provides information like the routing of each part and the resources required for its manufacturing. In the order-fulfillment process, two or more functional areas frequently need the same information. For example, information on current inventories and open production and purchasing orders is used simultaneously by marketing, production and purchasing personnel:

- Marketing personnel use this information to determine quantities of products that can be supplied off the shelf, and to decide when to place new orders for end products.
- Production personnel use information on inventories to check that all material required for a work order will be available when the order is scheduled for production.
- Purchasing personnel need inventory information to decide when to order parts and materials and how much to order.

Thus in the order-fulfillment process (as well as in other processes) the same information should be available to all the participants in the process. Furthermore, transactions performed by one functional area should update the information used by the other functional areas and sometimes shared with suppliers, customers, etc. who are part of the supply chain. For example, if a production order is delayed by the production people due to a machine breakdown, the marketing people should know about it and adjust the promised delivery dates to customers accordingly; in some applications the customers whose order is delayed are updated automatically by the information system. The ability of dedicated information systems, designed for one functional area (legacy systems), to support the whole dynamic, integrated order-fulfillment process is limited. In addition, problems like duplicated data entry (the same data is used in different systems and has to be input several times) motivated efforts to develop integrated Management Information Systems to support the order-fulfillment process. Ideally, these systems serve not only to support the decisionmaking processes but also as a means of communication between the members of the team managing the order-fulfillment process. However, experience shows that without proper training and education, the communication capabilities of these systems are not fully utilized to support group decisionmaking and teamwork.
Material Requirement Planning (MRP) is an early attempt to develop an integrated MIS for the order-fulfillment process. The concept of an integrated system is a significant change from the legacy systems discussed so far:

- By combining information on the demand for products purchased by the customers (known as independent demand items or end items) with information on the structure of these products (subassemblies and components required to make each independent demand item which are known as dependent demand items), the required quantities of dependent demand items do not have to be forecasted – they can be calculated as explained later. Thus the uncertainty associated with forecasting errors is reduced.

- By integrating the inventory management information into the system, the requirements for dependent demand items, as well as those for independent demand items, can be balanced against existing inventories on hand, in-process inventories and pipeline inventories (items ordered from suppliers but not delivered yet) so that only the net requirements need to be ordered.

- By introducing lead time information for purchased items and for manufactured items, manufacturing and purchasing orders can be time-phased to ensure delivery exactly when needed.

The result of using an integrated information system is a reduction in the total inventory (as demand forecasts are more accurate) coupled with an increase in the service level (percentage of orders supplied on time) and a reduction in the lead time.

The original MRP systems (known as MRP I systems) transformed marketing information into a Master Production Schedule (MPS) with information on current inventory levels and standing manufacturing and purchasing orders, with technological information about the structure of each product and its manufacturing processes. The output included recommendations on how many units of each product, component, parts or raw material to purchase, to manufacture or to assemble and when to issue the production or purchase order.

Over the years new capabilities were added to these systems, including capacity planning modules that reveal capacity shortages, and shop floor control modules that utilize limited capacity efficiently. MRP systems that deal with resource capacities are known as MRP II (or Manufacturing Resource Planning) systems. More recent developments in this area produced the ERP or Enterprise Resource Planning systems designed to support the order-fulfillment process of an enterprise operating several warehouses in different factories and an integrated logistic system that shares information with customers and suppliers – a complex known as the supply chain.

### 9.4 The Product (Engineering) Data: The Bill of Material

The basic MRP (or MRP I) logic is illustrated in Fig. 9.1. The MPS serves as a driver, combining information on actual orders with forecasts of anticipated demand for independent demand items for each period throughout the planning
Fig. 9.1 The basic MRP system

horizon. This information is compared on an item-by-item basis to the current inventory on hand, and to scheduled deliveries from the shop floor. Issuing new shop orders for independent demand items fills gaps between the requirements generated by the MPS and current and planned availability. Using information on the product structure (the Bill of Material or BOM) the system calculates the net demand for dependent demand items (taking into account existing inventories of these items) required to assemble or manufacture the independent demand items. Finally, all orders are time-phased by the anticipated lead time of the shop floor (for manufactured items) or the lead time of vendors (for purchased items).

The basic MRP logic as explained above is straightforward; however its implementation requires the ability to store, retrieve and process a large amount of data. Therefore, only in the seventies, when the required computer power became available and economical, did industry implement MRP logic on a wide scale. The last thirty years of experience show that understanding the logic on a personal level is not sufficient and many MRP installations did not fulfill expectations to improve the order-fulfillment process. There are several reasons for the failure of MRP systems: the system is data intensive; and if the quality of the input data is poor (see discussion on quality of information), the system output is useless (GIGO-Garbage In Garbage Out). Thus, each person who generates data for the system should understand the importance of data accuracy even if he is not a user of the system’s output. Also, the whole order-fulfillment team should develop a mutual understanding on how to use the MRP system concurrently and define the role of each team member in the dynamic integrated process. Otherwise the system is not effective in supporting an integrated order-fulfillment process.
The input to the MRP system consists of information from Marketing, Purchasing and Production. In modern MRP systems, the data is stored in databases. In the early days of MRP systems, dedicated files were used to store the data, as database technology was not yet available.

- **The Bill of Material** – The Bill of Material or BOM is the source of information about the structure of each independent demand item. Through the BOM it is possible to coordinate the requirements for independent demand items with the requirements for subassemblies, components and raw materials as explained later. This is achieved by assigning an identification number to each component part, raw material, subassembly or product. By consistently using the same numbers (known as part number) throughout the MRP system, unique identification is possible. Two common BOM formats are the single level BOM and the indented BOM.

The single level BOM shows only immediately required components of each part number. These relationships are known as father-son or parent-child connections. Information about the components of components, etc. is maintained by linking the single level BOMs of different part numbers.

The indented BOM shows all the required components for each independent demand item including components of components and raw materials. To explain the difference, consider independent demand item A, which is made of two units of X and one unit of Y. While X is a raw material and has no BOM of its own, Y is made of three units of the raw material Z.

The indented BOM of A is as follows:

- A (independent demand item)
  - X – (2 units required)
  - Y – (1 unit required)
  - Z – (3 units required)

A graphical presentation of the BOM of A is depicted in Fig. 9.2.

Although the BOM is usually constructed by engineers, its main users are the Production people who “explode the BOM” to calculate the requirements of each subassembly, component part and raw material based on the requirements for independent demand items. Assuming that three units of A are required for week two, then six units of X and three units of Y are required. Furthermore, the demand for three units of Y translates into a demand for nine units of Z.

In addition to the father-son relationship depicted in the BOM, information on the processing required to manufacture each part number (which is not purchased from outside vendors) is needed as well. This information is stored in the routing file that shows the sequence of operations required for each manufactured part, the machines used to perform these operations, the setup time per batch and processing time per unit. The routing file is the basis of capacity planning and scheduling decisions.
9.5 Logistic (Order) Data: The Master Production Schedule and Inventory Data

The Master Production Schedule (MPS) – The MPS is the anticipated build schedule for selected (independent demand) items by quantity per planning period. These selected items are products or product options that are demanded by the market (as opposed to components and parts used to assemble the independent demand items). The MPS combines two types of requirements for independent demand items – requirements based on firm customer orders and requirements based on forecasts. Since the MPS drives the material requirement process, it represents the management’s commitment and its authorization to order from vendors and to manufacture. The management of the MPS is very important: it includes the trade-off between make-to-stock and make-to-order, the use of inventories to level production when demand is seasonal or random and the order-promising process to customers. In its simplest form, the MPS is an anticipated built schedule as depicted in Table 9.1.

Table 9.1 A 9-week MPS

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>6</td>
<td></td>
</tr>
<tr>
<td>Product B</td>
<td>4</td>
<td>2</td>
<td>5</td>
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<td>8</td>
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</table>
In Table 9.1, there are two independent demand items A and B. The smallest planning time periods are weeks and the planning horizon is 9 weeks. This basic form of the MPS corresponds to the built schedule for independent demand items only. Other forms of the MPS include additional information, such as on hand inventories, Projected Available Balance (PAB) of inventory items, firm customer orders and the number of product units not dedicated to specific customers (Available To Promise – ATP). This information is important for the order-promising process in which customer orders are assigned delivery dates.

The MPS integrates firm customer orders and demand forecasts. At this level the question is not only when to promise delivery to a customer but also whether to accept a potential customer order or not. Constrained by capacity limitations and the availability of materials, the order-fulfillment process management team needs marketing, manufacturing, purchasing and cost information to develop an MPS that serves the process best:

- Marketing information on actual customer orders and forecasts of future demand. This information is the basis of the MPS, which is translated into the production master plan.
- Manufacturing information on the current load on the shop floor and the ability to supply additional customer orders during each period in the planning horizon. This information is an important input for setting delivery promise dates to customers.
- Purchasing information on supplier lead times and the availability of purchased parts and materials in inventory and in the pipeline. This information is important for setting delivery promise dates to customers as it introduces the effect of supplier lead time into the process.
- Cost information on the cost of manufacturing each independent demand item. When facing with the need to negotiate a price with a customer or to consider discounts to customers this information is very important for the order-fulfillment team.

Based on the above information, the order-fulfillment process management team has to construct and to maintain the MPS. In fact, Master Production Scheduling is an excellent example for the need to integrate the different aspects of the order-fulfillment process. Although the task of developing and maintaining the MPS may be assigned to a specific person (known as the Master Production Scheduler), this person should be a team player and should understand the relationship between his role and the role of all other players in the order-fulfillment process.

The time frame used for the MPS is also important. The minimum planning time period, known as a time bucket, specifies the accuracy of the planning process; a time bucket of 1 week is typical, but shorter or longer time buckets are used as well. The number of time periods that the MPS spans specifies the length of the planning horizon. The minimum length of the planning horizon should be equal to the total time required to purchase raw materials and component parts, to manufacture and assemble the independent demand item with the longest lead time, and to provide enough time for the order-fulfillment process to supply this
An important part of the order-fulfillment process is Master Production Scheduling modification or change management. Frequent changes in the MPS create changes in the production and purchasing plans that result in nervousness of the system and in low efficiencies, excess inventories and an unstable order-fulfillment process. Change management applies different criteria for approving changes in the MPS. By dividing the planning horizon into several time frames (separated by "Time Fences"), it is possible to apply appropriate criteria to change requests.

In the short range, changes are rarely approved as the work may already have begun on some orders, materials may already be on the shop floor and machines may be set up for these orders. Some organizations even use the term freezing of the MPS or FIRM MPS, which means no changes are allowed in the short range.

It is easier to make changes in the MPS if the change affects plans for the far future. In this case, change management may be handled automatically by the computer to insure correct implementation. An intermediate planning period known as the "Slushy period" may also be defined. In this period the Master Scheduler should concentrate on proper validation of proposed changes, evaluate changes and closely monitor their implementation.

The MPS is updated continuously. When the current time period is over, the next period becomes the current one and a new period enters the planning horizon. This process, known as the rolling planning horizon, is designed to keep the MPS current and updated.

• **Inventory Records** – To function properly, the MRP system compares the gross requirements for each part number to its current inventory. Only if the gross requirements exceed the current inventory should an order for that part number be issued. The current inventory includes inventories in the stock rooms, in-process inventories and inventories of parts and material already ordered from suppliers but not yet delivered (known as pipeline inventories). Inventory records contain (for each part number) information on stock on hand, in-process and pipeline inventories and the anticipated arrival dates to the factory. The date that in-process and pipeline inventories are scheduled to arrive and be ready for use is the basis of the calculation of time-phased net requirements as explained later.

### 9.6 Gross to Net and Time-phasing – MRP Logic

Material Requirement Planning (MRP) systems are designed to support the material management function in the order-fulfillment process. The basic idea is that the same logic can be used for ordering purchased materials or parts, manufactured components and assembled products. The MPS is the source of information on gross requirements for independent demand items. The basic MRP logic makes use of this information as input and translates it into time-phased net
requirements. The first and second lines in the MRP record of independent demand items are based on the MPS, as illustrated in Table 9.2 for the case of product A.

Table 9.2 The basic MRP record for product A

<table>
<thead>
<tr>
<th>Week</th>
<th>0</th>
<th>1</th>
<th>2</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross requirements</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Scheduled receipts</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>6</td>
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<tr>
<td>Projected available balance</td>
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<td>Planned order release</td>
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</table>

Table 9.2 represents the logic of the basic MRP record. The first row indicates the planning time periods (weeks in the example). The second row summarizes the gross requirements. For independent demand items, these requirements are taken from the MPS record. This is the case for product A since it is an independent demand item (see Table 9.1). Gross requirements for dependent demand items are based on the planned order release information in the MRP records of their parents in the BOM as explained later.

The Scheduled receipt information in the third row is related to pipeline and in-process inventories. These are inventories for which a work order or a purchase order was issued. The quantity scheduled to be supplied is indicated in this row in the column that corresponds to the scheduled supply period.

The first entry in the Projected available balance row is the inventory on hand for that part number. This entry indicates the current inventory level. The other entries in this row are estimates of future on hand inventories. These estimates are calculated based on a very simple model; first the projected available balance is calculated:

Projected available balance \((t + 1)\) = Projected available balance \((t)\) + Scheduled receipt \((t + 1)\) – Gross requirements \((t+1)\)

Based on the calculated projected available balance, a decision to issue work orders or purchase orders is made. A simple decision rule known as Lot for Lot (LFL) follows:

As long as the calculated projected available balance is nonnegative, no order is issued. However, when the calculated projected available balance is negative, an order is issued and released so that it will arrive (taking the lead time into account) exactly at the first time period when the calculated projected available balance is negative. The Planned order release field is updated accordingly and the calculated negative projected available balance is increased by the order size.

Assuming that the policy is to keep minimum inventories, the order size is set equal to the calculated negative projected available balance. By adjusting the order size in this way, the value of the projected available balance is set to zero. This “Lot For Lot” lot sizing policy is one of several possible policies that will be discussed later.
Assuming that the on hand inventory of A is 5 units and its lead time is 1 week, the complete MRP record is depicted in Table 9.3.

**Table 9.3** The MRP record for part A

<table>
<thead>
<tr>
<th>Week</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
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<tbody>
<tr>
<td>Gross requirements</td>
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<td></td>
</tr>
<tr>
<td>Projected available balance</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
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The same MRP record is used for the analysis of requirements for dependent demand items as well. The only difference, as explained earlier, is that the Gross requirements are calculated based on the planned order releases of the parents in the BOM. For example, consider the MRP record of part X. Two units of X are needed for each unit of A and the gross requirements for X are 10 units in period 2, 20 units in period 4, 16 units in period 6, and 12 units in period 8. These are derived from the bottom row in the MRP record for part A (Table 9.3). Assuming that there are 35 units of X on hand, 10 units are scheduled to arrive on week 5 and the lead time of X is 3 weeks, the complete MRP record is depicted in Table 9.4.

**Table 9.4** MRP record of part X

<table>
<thead>
<tr>
<th>Week</th>
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<th>2</th>
<th>3</th>
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<th>5</th>
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</tbody>
</table>

In a similar way the MRP record is used for each part number. The MPS is used as the source of gross requirements for independent demand items. Planned order releases for parent items are used as the source of gross requirements for dependent demand items.

This basic MRP logic is modified to accommodate special situations. A common modification is in the lot sizing policy. The lot-for-lot (LFL) lot-sizing logic discussed earlier does not take setup or order cost into account. When these costs are relatively high, a minimum batch size is calculated and each time an order is placed, its size is set equal to or larger than the minimum batch size. The Economic Order Quantity (EOQ) logic discussed in Chap. 5 is frequently used to calculate this minimum order size. The same logic applies to purchased parts when economy-to-scale is available, i.e., the cost per unit decreases as the order size increases. Other modifications in the lot sizing policy are based on the idea that each order should cover a minimum period of demand. This approach is known as the Periodic Order Quantity (POQ). To demonstrate the minimum order size and the POQ logic, consider the MRP record of part A. Assuming that the minimum batch size is 10 units of A (based on the EOQ model), the MRP record is modified as illustrated in Table 9.5.
Table 9.5 EOQ based lot sizing

<table>
<thead>
<tr>
<th>Week</th>
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</thead>
<tbody>
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</table>

Assuming that the POQ model is used and each order covers the demand of the following four periods Table 9.6, the MRP record for part A changes as follows:

Table 9.6 POQ based lot sizing

<table>
<thead>
<tr>
<th>Week</th>
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<th>3</th>
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<td>Gross requirements</td>
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<tr>
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</tr>
<tr>
<td>Projected available balance</td>
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<td>5</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned order release</td>
<td>15</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unlike the LFL logic, both EOQ and POQ generate inventories. The number of orders, however, is reduced – and setup time or order costs are saved.

Another modification of the basic MRP logic is to buffer against uncertainty. Two types of buffers are commonly used:

**Buffer Stock** – in this case a minimum inventory level target is set. This value is used in the gross-to-net computation as follows: The Projected available balance is calculated as explained earlier and an order is placed whenever the Projected available balance is lower than this minimum inventory target. By setting the minimum inventory target to a level that covers the expected fluctuations in the demand for a part number (e.g., fluctuations due to the loss of parts in the assembly process), a buffer against uncertainty is created.

**Buffer Lead Time** – this method is designed to protect the system from fluctuations in supply lead time. It is based on increasing the lead time of a part number by a predetermined amount to protect the system against uncertainty (fluctuations) in actual delivery dates. The result is that on the average shipments arrive earlier than needed and the average inventory in the system increases but the probability of shortages that delay assembly, production or delivery to customers is reduced.

9.7 Capacity Considerations

The MRP logic of Gross-to-Net and Time-Phasing derives the material requirements from the Master Production Schedule. This logic does not check the availability of production resources needed to accomplish the required work on time. This availability of production resources is known as capacity. Capacity refers to each of the available resources (different machines, material-handling equipment, cutting tools and fixtures, storage space and most importantly, workers
specializing in different operations). Early applications of the MRP logic focused on material requirements, assuming that enough capacity is available in the system to execute all the work orders generated. The problem with this assumption is that, in an operation that uses many types of resources, the probability that enough capacity of all the different resources will always be available is usually small.

To coordinate resource availability with resource requirements, capacity considerations need to be added to the basic MRP system. The simplest analysis of capacity is based on comparing the resource requirements with resource availability. One way of doing that is known as Rough Cut Capacity Planning (RCCP). Another approach is known as Capacity Requirement Planning (CRP).

Rough cut capacity planning is performed at the MPS level. Its major inputs are the MPS and information about the processing time per unit product on each machine or work center. The logic used for Rough Cut Capacity Planning varies in its complexity and in the accuracy of the capacity requirements forecasts generated. A simple approach to rough cut capacity planning is illustrated in the following four-machine four-product example.

Table 9.7 summarizes the per-unit processing time in minutes for each of the four products (A, B, C, D) on the four machines. In addition, the last column of Table 9.7 presents the MPS information for the next period. The last row in Table 9.7 is a simple estimate of required capacity, which is the product of the per-unit processing time and the MPS quantity of that product type summed over all product types.

Thus the load on machine 1 is calculated as follows:

$130 \times 5 + 110 \times 7 + 60 \times 3 + 160 \times 4 = 2240$.

<table>
<thead>
<tr>
<th>Product</th>
<th>Machine 1</th>
<th>Machine 2</th>
<th>Machine 3</th>
<th>Machine 4</th>
<th>Total MPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>130</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>160</td>
</tr>
<tr>
<td>Load (min)</td>
<td>2,240</td>
<td>1,300</td>
<td>1,300</td>
<td>1,410</td>
<td></td>
</tr>
</tbody>
</table>

Assuming that each machine is available 5 days a week, 8 h a day, the available capacity of each machine is $8 \times 5 \times 60 = 2400$ min. Since we did not include setup time in the calculations, machine 1 may be short on capacity. At most, only $2400 - 2240 = 160$ min are available for setups. If we assume that the setup time for this machine is 20 min per setup, then a total of $160 / 20 = 8$ setups can be scheduled for the period, assuming no machine breakdowns and no idle time.

Total setup times as well as machine breakdown times are difficult to estimate. A simple solution is to forecast these times based on historical data, using a forecasting technique similar to the techniques discussed in Chap. 3. Suppose, for example, that using exponential smoothing on last year’s data, the forecasted setup time of machine 1 is 10% of its processing time, while machine 1 forecasted breakdown time is 5% of its processing time. Given these forecasts, the expected
load on machine 1 is \(2,240 \times (100\% + 10\% + 5\%) = 2,576\) min. The expected load on machine 1 exceeds its available capacity of 2,400 min. Management can solve the problem by reducing the load, i.e., delaying some of the MPS lots to future periods, or reducing the size of some of the planned lots if the customers agree to partial deliveries. Management can also try to increase the available capacity of machine 1 by operating it on a second shift, by using overtime or by subcontracting some of its load.

Rough Cut Capacity planning is an important tool for the management of the MPS. The decision to accept a new customer order is traditionally based on cost accounting considerations, i.e., the comparison between the cost of manufacturing an order and its dollar sale value. The cost of capacity, however, is not a simple component in this equation. There is a difference between the cost of an hour of a resource that has idle capacity and the cost of an hour on a resource that is short of capacity. The reason is that for many resources the cost per period is fixed up to a given level of capacity utilization. Additional capacity adds to the cost. A good example is the fixed labor cost of employees on the payroll. As long as these workers are working up to an agreed number of hours (say 8 h a day), labor cost is fixed. Additional capacity, say overtime or extra shifts as well as subcontracting, adds to this fixed cost (Feldman and Shtub 2006).

Rough cut capacity planning is also the basis for setting priorities in monitoring and controlling the shop floor. Since an hour lost on a resource that has excess capacity is not as significant as an hour lost on heavily loaded resources, it is very important to closely watch the resources that (according to the rough cut capacity planning) have very little slack capacity, i.e., to apply tighter control.

The above logic is the basis of the work of Goldratt and Fox (1986) which is an effort to identify the few resources that are short of capacity and to schedule the whole operation in such a way that these resources will be used efficiently and effectively (i.e., they will perform the operations that they do best, in the best way possible). The assumption is that in a complex system, capacity is never perfectly balanced and therefore only a few of the resources will serve as constraints on the production schedule. Goldratt explains this logic in his book *The Goal* and he uses the term “bottlenecks” for these constrained resources. Goldratt’s logic is translated into the following steps:

1. Identify the system’s constraints (the bottlenecks) – this step can be based on rough estimates of the load on each resource compared to its available capacity (i.e., rough cut capacity planning as discussed earlier in this section).
2. Develop a detailed schedule for the bottlenecks – using simple techniques such as a Gantt chart as illustrated in Figs. 9.3 and 9.4 creates a detailed schedule for each bottleneck.
3. Derive the schedule for all non-bottleneck resources from the schedule developed for the bottlenecks. Since the nonconstrained resources have excess capacity, the assumption is that it is possible to schedule these resources to support the schedule of the bottlenecks (i.e., to guarantee that the bottleneck will not be idle due to the lack of material on which to work).
4. Repeat the process – Since bottlenecks may change over time as the product mix changes or due to changes in resource capacity, it is necessary to identify the system’s constraints repetitively every period and to watch the actual utilization of the bottleneck to avoid idle time.

This logic is aimed at maximizing the throughput of the system in the short range. In the long range, management should consider possible ways to add capacity to the bottleneck resource by operating it on a second shift, by using overtime or by subcontracting some of its load.

By integrating rough cut capacity planning logic with the above steps a detailed schedule for the heavily loaded resources and supporting schedules for all other resources can be created. A continuous effort to monitor the load on the resources, especially the known bottlenecks, can alert the team to overload resources that may cause problems in the order-fulfillment process.

The use of the MPS as a basis for rough cut capacity planning may lead to substantial errors in estimating the resource requirements. One reason is that some of the resource requirements for any given time period on the MPS may have been fulfilled in earlier periods. This capacity is stored in the form of in-process inventories that represent past investment in material and capacity. Furthermore, in any given time period, the actual load on resources is generated by the MPS requirements for that period but also by the time-phased work orders generated by the MRP for dependent demand items as a result of requirements in future periods.

To overcome these difficulties, a more detailed approach for capacity planning is used. This approach known as CRP or Capacity Requirements Planning is based on an effort to treat the requirements for resources by logic similar to the logic used for material planning. This logic is based on the output of the MRP – work orders generated by the Gross-to-Net and the Time-Phasing logic. A resource requirement database is constructed in which the estimated processing time required for each part number on each machine or work center is stored along with the setup time required to prepare each resource for each type of operation. Based on the orders released by the MRP logic, the required periodical capacity of each resource is calculated. Since these work orders are time-phased already, the timing of capacity requirements is more accurate than those of the rough cut capacity planning logic. Furthermore, since the MRP logic that generates work orders takes existing in-process inventories into account in its gross-to-net analysis the capacity requirements are more accurate.

Fig. 9.3 The combined routing and BOM
Both CRP and RCCP are tools for testing the feasibility of the plans developed by the MIS. RCCP tests the feasibility of the MPS, while the CRP tests the feasibility of the MRP plans. Both tools are based on estimates of available capacity and forecasts of expected loads and therefore do not provide perfect accuracy. To support the order-fulfillment team in its resource management tasks, a module called Shop Floor Control (SFC) is incorporated in the MRP II system. This module implements logic known as Input-Output analysis. In its simplest form, this logic is based on monitoring the actual queue of work orders in front of each work center. By measuring the length of the queue in terms of the number of hours required to complete all the work orders waiting for processing in front of a work center and comparing this load to the available capacity of the work center, the time required to complete the current queue can be estimated. This calculated time can serve as an estimate of the lead time for that work center. The name “Input-Output analysis” comes from the analogy between the queue in front of a work center and a reservoir. The input rate to the reservoir is analog to the input of work orders to the queue generated by the MRP logic, while the output rate is analog to the rate at which work orders are executed (the capacity of the work center). By controlling the input rate (rate of incoming work orders) the order-fulfillment team can control the level of the reservoir (or the in-process inventory) of the system. The complete MRP II system consists of the basic MRP I modules plus the RCCP, CRP and SFC modules. The relationship between these modules is depicted in Fig. 9.5.

Fig. 9.4 A Gantt chart for the example
Fig. 9.5 The modules of MPR II system

Problems

1. Explain how MRP logic can be implemented in the following contexts:
   - a fashionable restaurant
   - a fast-food eatery
   - a chemical product
   - a food product

2. Discuss the differences between the EOQ model and the MRP logic. Under what conditions, in your opinion, does the EOQ model outperform the MRP logic?

3. Explain the difference between the MRP concept and the ERP concept.

4. How does an increase in quantity in the MPS gross requirements affect the MRP output? Use the gross-to-net and time-phasing logic in your explanation.

5. How does an increase in the MPS gross requirements affect the available-to-promise quantity?
6. Explain the difference between a regenerative MRP system and a net change MRP system.

7. Under what conditions do the estimates produced by rough cut capacity planning equal those produced by the Capacity Requirement Planning logic?

8. Suggest a methodology for rough cut capacity planning in a hospital.

9. How would you define and measure the throughput and capacity of the following:
   - a bakery?
   - a restaurant?
   - a fast food eatery?
   - an airliner?
   - a call center?
   - a parking lot?
   - a highway?
   - an elevator?
   - a print shop?

10. Are throughput and capacity for the above contexts definable? Do these definitions have any common characteristics? If so, what are they? If not, why?
10 The Integrated Order-Fulfillment Process Using ERP

10.1 Cross-Enterprise Processes in the Integrated Order-Fulfillment Process

The integrated order-fulfillment process provides an outstanding archetype of the evolutionary approach to cross-enterprise operations management. We describe this process in detail in the following sections. However, in order to position it in relation to the ERP paradigm, we first provide an overview of the whole process, and its cross-functional nature, through the use of a focused reference model (Table 10.1). The model itemizes the various processes involved in the integrated order-fulfillment process and portrays the progression from the basic MRP processes (*) through the enterprise-wide involvement of several functionalities at the ERP (*** ) and ERP II (****) levels. It highlights the nature of the cooperation and coordination required – as well as the multi-functional knowledge required of the order-fulfillment team.

10.2 The Role of Management in the Integrated Order-Fulfillment Process

Management is the art and science of getting things done through other people. Traditionally, organizational structures are used as a framework that supports the management process. Organizational structures establish clear relationships and communication lines between managers and subordinates; within these structures the lines of authority and responsibility are defined and maintained.

The selection of an appropriate structure for today’s highly competitive environment is not a simple task. In particular, the traditional functional organizational structure, which is based on the principles of division of labor and specialization, may not provide adequate support for the management of modern business processes due to the following problems:

1. Each functional organizational unit tends to focus on its local goals and objectives. The local optimum of each organizational unit does not necessarily lead to a global optimum for the whole organization. For example, a common goal for purchasing and material supply is to increase the service level provided,
measured as the proportion of requests for material which is supplied on time. One way to achieve this goal is to keep high levels of inventories of purchased items and materials (using inventories to buffer the process against uncertainty). Inventories improve the service level but are costly and wasteful. Another way is to promise the customers long lead times (using lead times to buffer the process against uncertainty), which hurt the time-based competition ability of the whole organization. In a similar way, marketing is measured on its ability to increase sales. Thus, in a market dominated by time-based competition, marketing tends to promise short lead times to the customers, which may cause impossible schedules for the shop floor. Manufacturing is frequently evaluated on its efficiencies, which can be increased by running large batches avoiding setup time. However, large batches may translate into building stocks and thereby reducing the flexibility to respond to changing customers’ orders, thus hurting the time-based competition ability of the organization. Although the communication within each organizational unit in a functional organization may be easy to maintain, communication between different units may not flow properly. This results from the conflicting goals discussed earlier; it is also due to differences in the background of people in different functional units, and even due to geographical distances between members of different functional units that are geographically separated.

2. In a functional organization, many processes that cross the functional organizational lines do not have a clear owner responsible for the process performances from start to finish. Each organizational unit involved is responsible for part of the process, but the whole process does not have a single owner with overall responsibility for setting global goals, the authority to advance these goals and accountability for the results.

To overcome these problems of the traditional functional structure in the product development process, a new approach was adopted. This approach, known as Concurrent Engineering is based on a team of experts in the areas of product development, manufacturing and logistics support. Members of the team study customer needs and evaluate the method of operating the new product. Application of this new approach improved communication between the participants in the development process and resulted in a shorter development cycle. In a similar way, a team responsible for the whole order-fulfillment process can solve the problems of the functional organizational structure. A team that has global responsibility for the whole process, is located together, shares the same information and has a common goal. Team building is a challenging managerial task, consisting of organizing, staffing, motivating and leading people.

The responsibility of the order-fulfillment team is to plan, direct and control the activities of the resources used to perform the order-fulfillment process. These activities are related to all four aspects that interact in the process, namely: marketing and the interface to the customers, purchasing and the interface with the suppliers, the utilization of resources used for the production of goods and services, and distribution and the interface to the customers – i.e., traditional Operations Management.
### Table 10.1 Reference model for the integrated order-fulfillment process

1 **Strategic planning and control**
- Establish order-fulfillment goal plan (***)
- Specify order-fulfillment performance measures (***)
- Establish generic (repetitive) action policies (***)
- Establish special (contingent) action policies (***)
- Monitor order-fulfillment goal performance (***)

2 **Sales cycle management**
- Forecast sales (***)
- Forecast demand (**)
- Establish sales plan (***)
- Configure product for quotation (**)
- Process quotation (***)
- Configure product for manufacture (**)
- Schedule sales order and promise delivery schedule (**)
- Process sales order (**)
- Monitor sales performance (***)
- Monitor customer behavior (****)
- Monitor customer delivery schedules (****)

3 **Purchasing/procurement cycle management**
- Establish supply network plan (****)
- Establish procurement plan (**)
- Establish scheduling agreements with suppliers (*)
- Process purchase order (*)
- Process sub-contracting order (*)
- Monitor supplier/sub-contractor delivery schedules (****)
- Monitor supplier/sub-contractor quality (****)
- Receive and inspect goods (***)

4 **Operations cycle management**
- Establish production master plan (MPS) (*)
- Plan safety stock (*)
- Plan material requirements (MRP) (*)
- Plan capacity requirements (CRP) (**)
- Schedule and sequence orders for release to the shop floor (*)
- Schedule shop floor (*)
- Process production orders (*)
- Monitor shop floor scheduling (**)
- Monitor shop floor loading (**)
- Monitor process performance (****)
- Monitor process quality (****)
- Monitor product quality (****)
- Perform input-output analysis (***)

5 **Item and inventory cycle management**
- Manage product configuration (BOM) (*)
- Manage inventory (*)
The basics of marketing, purchasing and operations management discussed in the previous chapters represent the common knowledge that should be shared by all the members of the order-fulfillment team. This common knowledge provides the ability to communicate, to set common goals and to develop an integrated plan that can be controlled and directed efficiently by the team. Each team member should specialize in one or more of these aspects, but the common knowledge and the understanding that the whole team shares the responsibility for the entire order-fulfillment process is the cornerstone of a successful ERP implementation.

Planning starts with the definition of goals for the whole order-fulfillment process and the agreement on the time frame to reach these goals. A combination of long and short-term goals is needed. For example, a short-term goal may be to supply a customer’s order ahead of its promised due date when a preferred customer asks for it. An example of a long-term goal is to become a leader in the market and to capture a market share of 50% or more within 2 years. Each goal is a description of a “destination” that the order-fulfillment team agrees on and wants to reach within a given time frame.

The development of a plan or a road map that details the steps needed to reach the goal is the next step in the management process. The plan provides each team member with exact information on what he is supposed to do and when. The plan integrates and coordinates the efforts of individuals involved in the process and facilitates teamwork. It serves like musicians’ notes that facilitate the integration of the efforts of individual players in an orchestra into a concert. When part of the order-fulfillment process is repetitive, the plan can be translated into procedures representing a policy that applies as long as the team agrees to perform the process again and again in the same way.

A “compass” that provides updated information as to exactly where the team is with respect to its goals is essential. Deviations from the original plan are likely, due to uncertainty such as engineering changes, customer order modifications, machine breakdowns, late deliveries from suppliers, etc. A set of performance measures corresponding to the goals set by the team; and the resulting road map or the plan developed serves as a compass. By monitoring the value of the performance measures, deviations from the original plans can be traced early on and attended to. Special actions, as opposed to long-lasting policies, are needed when deviations are detected. Detection of deviations and the development of answers to questions, such as when to take an action and which action is most appropriate for a given situation, is part of the management process.
Learning and practicing the art and science of planning, controlling and directing the order-fulfillment process, combined with team building, is the key to success. Developing a management information system that supports the order-fulfillment team is the second key to success. The ERP concept of a single information system that supports all the processes in the organization by providing an integrated database and a comprehensive model base is therefore essential for successful implementation. Learning how to use the ERP, how to work in a team, and how to lead in a dynamic, integrated environment is equally important.

10.3 The Hierarchy of Goals and the Road Map to the Goal

In *Alice in Wonderland*, Alice asks the cat for directions: should she turn right or left? The cat asks her where she wants to go and she explains that it does not matter. The cat then replies that in this case she can go either way. In business as in the story, unless we set clear goals (or define where we want to be in the future), we do not know our destination and therefore we cannot develop a plan that will lead us there. Frequently, the goal for profit-making organizations is to make a profit in the short range and in the long range. To achieve this goal, the order-fulfillment process must provide customers with the products or services they want, on time, and at a cost low enough to ensure the desired profit, given the market price.

This global goal is translated into several lower level goals such as:

- **Time related goals:**
  1. Deliver in a short lead time, be compatible with the lead time required by customers to guarantee a competitive edge in the market.
  2. Deliver on time to the customers; actual delivery date should not deviate from the promised delivery date.

- **Cost related goals:**
  1. Deliver at the minimum cost possible – a cost low enough to provide the required profit given the competitive market price, i.e., maximizing the *throughput* of the process.
  2. Minimize the *operating costs* of the process.
  3. Minimize inventories to minimize the *inventory-related costs*.

- **Service related goals:**
  1. Deliver the service at the minimum cost possible – a cost low enough to provide the required profit given the competitive market price, i.e., maximizing the throughput of the process.
  2. Maximize the flexibility and variety of services.
  3. Minimize waiting time.
• Quality related goals:

1. Deliver a product that fits its intended use.
2. Deliver a product or service that satisfies customer requirements

In this example the upper level goal is translated into lower level goals. Based on these goals, a destination as well as a set of performance measures can be defined and used to indicate whether the process is moving toward its specified goals. The next task of the order-fulfillment team is to develop a plan that will lead the organization toward its goal.

To reach its goals, the order-fulfillment team needs a plan that specifies what should be done by whom and when – a plan that coordinates the efforts of the team members. Coordination is easier in a repetitive environment where the same hierarchy of goals is valid over a long period of time and the same plan may be applied repeatedly to reach these goals. For example, in a make-to-stock environment, an intermediate goal is to keep the desired inventory level of the make-to-stock products. The MRP logic described in Chap. 7 can be set to automatically develop a plan of action for this environment by using Gross-to-Net and Time Phasing logic. As long as the goal does not change, the MRP logic is implemented correctly and uncertainty does not intervene; the automatic planning process should yield the desired results, i.e., bring the organization closer to its goal. In this environment the task of management is to set the correct goals (e.g., the desired inventory levels for finished goods), to select the policy, to adjust the MRP logic (e.g., to set the batch sizes and lead times correctly) and to monitor the performance of the order-fulfillment process so as to detect problems caused by uncertainty and to take care of such problems.

In a nonrepetitive environment, this level of automatic planning may not be feasible. In this case, each delivery to a customer is a project: a one-of-a-kind endeavor, and new plans have to be developed on a continuous basis. A major task of the order-fulfillment team is, therefore, to identify the repetitive part of the order-fulfillment process and to develop appropriate plans that can be implemented continuously. This process of developing policies that govern the order-fulfillment process results in a generic plan of action that is valid as long as the environment and the goals do not change.

In addition to developing policies, the order-fulfillment team should take actions to deal with the nonrepetitive aspects of the process. The need to take some of these actions may be obvious; for example, when a customer calls in and asks for a special delivery (a shorter lead time, a modified product, etc.), it is clear that special action is needed.

In other cases, special action is needed because the current policy does not yield the expected results (for example, a supplier that did not deliver on the promised due date and caused a delay of a customer order). In these situations, management may not be aware of the need to take action; a special system is needed to bring this need to management’s attention. A control system may be used to monitor the performance of the order-fulfillment process and to alert management whenever actual performance deviates from the plan and special action may be
required. The order-fulfillment team has to define what to monitor, how to measure deviations (or irregularities) and when to take an action.

Policy actions and control systems can all be supported by the MIS used by the order-fulfillment team. The MRP logic, for example, supports a variety of policies such as lot sizing and the use of buffer inventories. Special actions can be taken by issuing a manual work order, or subcontracting a lot that is usually made in-house. Monitoring and control in the MRP environment is provided by logic such as input-output analysis that monitors the load on work centers. Easy access to the MRP database provides current information on the status of the order-fulfillment process.

The task of the order-fulfillment team is to decide which part of the order-fulfillment process is repetitive enough to warrant the development of policies to manage it. The team has to develop the policies that will lead the organization toward its goals, to establish an adequate control system that detects situations that should be brought to management attention and to take the correct action when needed.

10.4 Establishing Control: Identifying Problems

In a certain world where perfect updated information about the past, present and future is continuously available, the management’s task is fairly simple: to establish the order-fulfillment team, to develop a proper hierarchy of goals and to select a plan leading to that goal. However, our world is far from being certain – updated, accurate information is not always available: we do not know the future values of many variables that at best can be estimated, and sometimes we do not even know the past or the current values of some variables. Therefore, our plans do not always capture the best way to reach our goals and sometimes our plans turn out to be impossible to implement, due to unforeseen developments. To reduce the effect of uncertainty, management tries to establish systems that identify problems in implementing its plans as early as possible. These monitoring systems are part of a control mechanism that continuously monitors the situation, identifies problems preventing the organization from reaching its desired goals and takes actions to correct these problems. Continuous control systems are common in many engineering and organizational applications. For example, the control of a room’s temperature: the thermostat of the system is set to a desired room temperature (the goal) and detects (monitors) deviations between the actual temperature and the desired one. This control system is automatic as no human decisionmaking is involved in the actions taken by the system when a deviation is detected; the air-conditioning system (or the heating system) is automatically activated and changes the room temperature in the desired direction. In this example, deciding on the desired temperature is equivalent to selecting a goal. Setting the thermostat to the desired temperature is equivalent to setting a policy and the control system takes action by turning the air-conditioning system (or the heating system) on and off. Human involvement is thus reduced to selecting goals,
setting policies and monitoring the environment to check if there is a need to change the goals, the policies, or both, and to detect any malfunction of the system.

The control of the order-fulfillment process is based on the same principles, but more human decisionmaking is required when the process is not repetitive. In this case, a computerized monitoring system can detect problems or deviations, but the team managing the process has to decide what to do when a problem is detected, since the decision may be difficult to automate. However, the designer of the order-fulfillment process should strive to automate its repetitive parts as much as possible so that the order-fulfillment team can devote its time to the selection of proper goals and the development of policies. The development of monitoring systems is therefore an important task of the team managing the order-fulfillment process. A good control system facilitates more automatic decisionmaking so that problems can be detected early on and taken care of.

In the design of a control system, there are several alternatives. Monitoring the value of the performance measures is one way to go. Assuming that the performance measures are derived from the goals defined for the order-fulfillment process, the value of these measures and the trends in these values indicate whether the process is moving in the right direction. The problem with a monitoring system based on performance measures is that it detects problems fairly late – after influencing the values of the performance measures. If possible, it is desired to detect problems before they affect the performance measures. For example, if due date performance is an important measure, it is preferable to detect problems on the shop floor that might cause a delay in a customer order, or to detect late deliveries from suppliers and to fix these problems before the due date performance level is affected. Thus, a system that monitors the load on each work center can send early warning signals when the load exceeds a predetermined value (say 2 weeks of work). Although the load on work centers may not be a performance measure, its value may be a good indication of the future values of some performance measures (like due date performances).

All four aspects of the order-fulfillment process should be monitored continuously: the interface with the customers (the demand rate, due date performance, etc.), the interface with the suppliers (delivery on time, quality of goods delivered, etc.), the performance of the shop floor (load on work centers, actual lead times, etc.) and the further interface with the customers (delivery on time, quality of goods delivered, etc.). The monitoring system can operate continuously, i.e., whenever a transaction takes place the values of the relevant parameters are updated; or intermittently, i.e., the parameters are updated periodically. The first approach fits net change MRP systems, where each transaction performed is recorded and updates the system files. The second approach fits regenerative MRP systems, where transactions are collected and processed as a batch to update the master files of the MRP system.

The monitoring system can present the value of the parameters selected continuously (like a fuel gauge in a car), or it can operate in an on/off alarm mode (like the hot engine light in a car that lights up when the temperature reaches a certain level). The values presented can be momentary values (like the current temperature of the engine or the current load on a work center), or cumulative (like the total distance traveled so far or total sales for the month). The design of
the monitoring system is part of the policy development process as the values monitored are those that affect policy performance and its ability to reach the desired goal. It is the responsibility of the order-fulfillment team to develop a proper monitoring system and to learn how to use it efficiently to support the selected policies.

In addition to the continuous control system, periodic control should be implemented. Management should take a good look at the process from time to time and evaluate the goals, policies and actions taken in the past in order to improve the process and to adjust it to the ever-changing environment. Periodic control or process design reviews are an opportunity to learn from past mistakes and to continuously improve the process (see Chap. 13). Research has shown that, even at the individual level, the ability to review past decisions is an important factor enhancing the learning process (Parush et al. 2002).

A proper combination of continuous and periodic control is essential for a successful, flexible process. The design of the control system is an important part of any ERP implementation project.

10.5 Taking Actions: Solving Problems

The monitoring system alerts the order-fulfillment team to problems in the process. To solve these problems, the team must take proper action. Furthermore, the team has to analyze the source of problems and decide whether there is a need to change the current policy in order to avoid the occurrence of similar problems in the future. Thus the management of the order-fulfillment process is a continuous effort to design, refine and monitor the process, to look for problems and to solve them. This effort includes the establishment of goals, the development of appropriate performance measures, the establishment of a policy leading toward the goals, the installation of a monitoring system to identify problems and finally taking corrective actions and the modification of goals, policies and the control system when needed.

Problem solving is tricky due to the integrated, dynamic nature of the process and the uncertain environment. Management may take an action related to one facet of the process which may cause other problems – leading to a ripple effect over time impacting the original facet and/or other facets. These system behaviors can be difficult to grasp and even more difficult to predict. Actions are taken under time pressure by learning how to use the capabilities of the ERP system to support group decisionmaking. The team managing the order-fulfillment process can improve its problem solving skills.

The first step in solving problems is to recognize that there is a problem and to define it clearly. Problem identification is easier with the support of a monitoring and control system. The sensitivity of the control system should be adjusted so that minor deviations between the plans and actual performances will not cause a “false alarm.” Thus the definition of a significant problem that should be brought to management’s attention is important. Consider, for example, a control system
that monitors the actual delivery of goods from suppliers and compares it to the promised delivery date. A shipment delayed 1 day may not be a problem if the buffer lead time used in the system is a couple of days. However, a delay of 2 or more days should be brought to management’s attention as it might cause poor due date performances of the whole process.

Once a problem is detected, the next step is to define it in clear terms. The performance measures used to evaluate the process are the basis for problem definition. Thus, a possible reduction in due date performance or increases in the cost of the order-fulfillment process are both well-defined problems.

Problem definition is the basis for the next step – problem analysis. This step is aimed at understanding the cause of the problem and its possible effects. It is good practice to use the question “why” repeatedly in the analysis. Thus, in the previous example, the problem is a reduction in due date performances. The answer to the question why, is that a supplier delivery is late. Asking why again may lead to the answer that this supplier is always late, i.e., this is an unreliable supplier (as opposed to the case where something special happened this time that caused the late delivery). If the team asks why we order from a supplier that is always late, the root of the problem may be identified, i.e., that we try to save money.

The third step in the process is to generate alternative solutions to the problem. Two types of solutions are needed: immediate solutions for the current problem and long-term solutions to avoid the occurrence of the same problem in the future. The first type of solution leads to an action that solves the current problem, while the second type leads to a change in policy that eliminates this type of problem in the future. Since more than one solution may be generated, the alternative solutions should be evaluated based on their effect on the performance measures and the goals of the order-fulfillment process. The alternatives expected to yield the best results are selected and implemented in the process.

This problem solving approach can be summarized as follows:

- Identify the problem
- Define the problem in terms of the process performance measures
- Analyze the problem to find its roots
- Generate alternative short- and long-range solutions
- Evaluate the solutions with respect to their effect on the performance measures
- Select the best solutions
- Implement the selected solutions

The successful application of this approach by a team requires that the team members understand the details of the process they are dealing with, the goals and performance measures used in managing the process and the monitoring and control system. Furthermore, the team members have to understand and practice the concept of group decisionmaking and the tools available to support it within the ERP system.
Problems

1. Explain the difference between policies and actions.
2. Suggest one or more goals and performance measures, and develop a set of managerial policies based on the goals and performance measures, for:
   - The call center of a mobile phone provider
   - The emergency room in a hospital
   - A fast food establishment
   - The purchasing function in a manufacturing enterprise
   - The production function in a manufacturing enterprise
   - The marketing function in a manufacturing enterprise
   - The distribution function in a manufacturing enterprise.
3. Suggest a goal and performance measures for the emergency room in a hospital and develop a set of managerial policies based on the goal and performance measures.
4. Explain the decisionmaking process that should be applied in a business school when a new student is considered.
5. Suggest a policy and a control system for an emergency call center (e.g., 911 in the USA).
6. What kind of monitoring and control system is used in a supermarket to support the decision on the number of open checkouts?
7. Explain what kind of control is needed in:
   - The purchasing function in a manufacturing enterprise
   - The production function in a manufacturing enterprise
   - The marketing function in a manufacturing enterprise
   - The distribution function in a manufacturing enterprise
8. What are the relationships between input/output analysis and CRP?
9. Use the problem solving methodology discussed in this chapter to solve the problem of finding the best way to teach operations in a business school setting. Explain each step in the process and the results of your analysis.
10. Develop the ten most important steps in implementing ERP in an organization.
11 Teaching and Training Integrated Production and Order Management

11.1 Individual Learning and Organizational Learning

The essence of Integrated Production and Order Management is teamwork – a process-based organization in which a team is responsible for each process. To ensure a competitive process, each member of the team has to understand the team’s task, its objectives, constraints and the performance measures used to evaluate the team. Furthermore, each individual has to learn the concepts of process and cross-functional process, information systems, the use of information, and the support provided by ERP-type systems. This knowledge of individual team members is the basis of coordination and teamwork. It provides the necessary communication channel for group decisions regarding the design of the process and its implementation. In addition to individual learning, team building and team training are major issues in the implementation of IPOM.

The discussion so far has focused on the knowledge each individual participating in the order-fulfillment process must have. The following discussion focuses on teams, specifically the building teaching and training of the group of people responsible for the design implementation and control of the order-fulfillment process.

In a functional organization, people are grouped according to the function they perform, and are trained to focus on their part of the order-fulfillment process. Based on the principles of division of labor, the functional organization tries to divide the process among the people participating in it so that different steps in the process are performed by different people in such a way that these steps are independent (or de-coupled) as much as possible. Furthermore, it is assumed that it is sufficient that each individual performs his part of the process correctly to ensure that the whole process achieves a high level of performance. As a result, in a functional organization, each individual is trained to concentrate on his part of the process while not being required to understand the whole picture. Training individuals to perform their tasks effectively and efficiently is the main effort in functional organizations when trying to achieve a desired level of performance.

IPOM is based on an integrated approach to the order-fulfillment process (integration as the opposite of de-coupling). The assumption is that de-coupling is impossible in a competitive, fast changing business environment. In the IPOM environment, each member of the team has to understand the whole process, including the role of every other team member, as all team members participate in
decision making. In this environment the team is responsible for the whole process. Consequently teaching IPOM requires a special teaching approach in which individual learning and team learning are combined.

The teaching of IPOM at the individual level starts with the basic concepts of information and its use, by basic training in marketing, purchasing, scheduling, Material Requirement Planning (MRP) and the concepts of business processes and Enterprise Resource Planning (ERP). The teaching at the individual level provides the foundation. The next step is to build a team and to teach it how to work as a team: how to develop policies, how to implement those policies, how to monitor the process and how to deal with problems, i.e., to take corrective actions when needed. This phase of the training process is similar to the training of a basketball or a football team. Each individual must learn how to play the game and how to excel in it. However, a group of good players selected at random does not constitute a good team. Building the team, and training it to play together as a team, is very important. Each player has to understand his role and to excel in it. Coordination between the players is an important part of training a basketball or a football team. The high degree of dependency among the players and the dynamic, stochastic environment requires team building and team learning.

11.2 The Individual Learning Curve

The functional organization is based on division of labor and de-coupling of activities. The underlying assumption is that if each individual is an expert in his task the integration of individual expertise by a well-planned organizational structure provides the organization’s competitive edge. The expertise of individuals is developed by proper education, training and on the job learning process.

Individual learning can take many forms including the learning of verbal knowledge, intellectual skills, cognitive strategies and attitudes. The learning mechanism can also take many forms including learning by the imitation of other people or learning by repetition of the same process. An early attempt to study the learning by repetition phenomena resulted in the learning curve model of Wright (1936). This model is presented next using the following notation:

\[ X \quad \text{repetition number} \]
\[ T(1) \quad \text{time taken to perform the first repetition} \]
\[ T(x) \quad \text{time taken to perform repetition number } x \]
\[ b \quad \text{learning coefficient} \]

The learning curve model follows:

\[ T(x) = T(1)x^{-b} \]

The shape of the learning curve is illustrated in Fig. 11.1.
In this model the value of the parameter $b$, known as the learning factor, controls the rate of learning. It is easy to see that whenever the number of repetitions doubles, the performance time is reduced by the same rate, i.e.,

$$\frac{T(2x)}{T(x)} = 2^{-b}$$

Since the introduction of this model by Wright, several other learning models have been published. An extensive review of learning curve models is presented in Yelle (1979).

The learning curve model is widely used for planning purposes, such as estimating the time and cost to complete an order consisting of several units of the same product. It is known that individual learning is enhanced by proper training and by individual incentives.

Group learning in its simplest form is an aggregation of individual learning. Assuming that the direct labor cost of individuals decreases as experience is gained, it is logical to assume that the direct labor cost of a product or service that represents the aggregate effort of a group of individuals should decrease as a result of individual learning. There are three problems with the extension of the individual learning curve to group learning: first, the learning coefficients of individuals in a group are not necessarily the same. Second, absenteeism, turnover and job rotation make the organizational learning curve difficult to predict, as each person in the organization may be on a different point on his individual learning curve (i.e., having a different level of experience). In this case those with the lowest experience may be the bottlenecks of the whole process. The third problem relates to synergy in teams. The whole in this case is not necessarily equal to the sum of its components – a good team can perform much better than a group of individuals that divide the
work content among them. However, a poor team may perform much worse than the prediction of the individual learning curves due to poor coordination between operations performed by different group members. Thus, when integration or teamwork is required and tasks are not completely independent and repetitive, the individual learning curve may not be an appropriate model for team learning.

11.3 Team Building and the Team Performance Curve

The ability of groups to improve performance, and the differences between group learning and individual learning, motivated research into this area. One research avenue resulted in the team performance curve model. This model developed by Katzenbach and Smith (1993) relates the type of group and its performance impact as illustrated in Fig. 11.2.

In this model five types of groups are defined:

1. The working group: the members of the group interact primarily to share information and best practices. They try to make decisions to help each individual perform best within his or her area of responsibility. Working groups rely on “the sum of individual bests” for their performances – their members do not commit to a common purpose and a unified set of goals that leads to mutual accountability. Working groups are common in functional organizations where members from different organizational units cooperate in performing processes that cut across functional lines. Members of effective working groups constructively compete with one another in their pursuit of individual performance targets.

2. The Pseudo-team: In this case, members of the group claim that they are a team but they do not really believe in the stated common goals; they do not have a genuine interest in shaping a common purpose and mutual accountability. In some cases, the members of the group do not trust each other and cannot develop a real commitment to the group. This is the case where the sum of the whole is less than the potential of the individual members.

3. The Potential team: This is a group that recognizes that there is a real need or opportunity for a significant incremental performance and is really trying to achieve it. It has not yet established collective accountability and it requires more clarity about purpose, goals and the common working approach.

4. Real team: This is a group of people who are really committed to a common purpose, goals and a working approach for which the members of the group hold themselves mutually accountable.

5. High-performance team: This is a group that meets all the conditions of a real team and has members who are deeply committed to each other’s success. The high performance team utilizes synergy to achieve team performance levels far better than the sum of individual performances.
The Katzenbach and Smith (1993) model explains how important it is to combine individual learning with team building in order to succeed in implementing Integrated Production and Order Management. An attempt to implement IPOM without building a real team or even better, a high performance team, may result in the deterioration of performances and a failure.

There are several barriers that a new team must overcome. Thamhain and Wilemon (1979) list the following:

- Unclear objectives – the cornerstone of a real team is a clear definition and agreement on the group’s objectives. If the objectives are not clear, conflicts, ambiguities and power struggles are highly likely.
- Differing outlooks, priorities and interests – a real team must have a common interest in order to translate the objectives into established common goals and performance measures, otherwise a pseudo-team will be created.
- Role conflicts – team members should clarify who does what and practice individual roles as well as teamwork to eliminate any ambiguity.
- Personnel selection – the selection of individual members of the team should be based on their commitment to the common goals, professional ability and willingness to work in a team.
Team learning has been defined as a process in which a team takes action, obtains and reflects upon feedback, and makes changes to adapt or improve (Akgun et al. 2006; Edmondson 1999; Sarin and McDermott 2003). A team is defined as two or more people who interact dynamically, interdependently and adaptively and who share at least some common goals or purpose. Team knowledge is more than the collection of knowledge of individual team members; team knowledge is a result of interactions among team members (Klimoski and Mohammed 1994).

Problem-based learning is the learning that results from the process of working toward the understanding or resolution of a problem. The learning occurs in small groups, while problems are the vehicle for the development of problem-solving skills. New information is acquired through self-directed learning. One training technology that has the potential for establishing effective learning environments for the enhancement of team problem solving expertise is simulation (Cannon-Bowers and Bell 1997). The characteristics of effective problem solvers are delineated (i.e., flexibility, quickness, resilience, adaptability, risk-taking, accuracy) and provide an end state for training.

The three key insights that frame the experiential approach to team learning are:

1. A pivotal role of reflective conversation
2. The theory of functional role leadership
3. The experiential learning process as the key to team development (Lewin 1948)

The Kolb Team Learning Experience (KTLE) is a structured way to help a team to develop the essential competencies necessary for team learning. The KTLE provides a comprehensive tool to help teams learn to solve problems and work together to arrive at effective solutions (Kayes et al. 2005).

Day et al. (2005) examined how team composition affects the learning and performance of a complex skill at both team and individual levels, taking into account that a team’s performance is largely determined by the competency of its individual members and that intelligence is a key determinant of individual learning and team performance.

One benefit of a team is that many gaps in individual knowledge can be compensated for by the knowledge of other team members. Because team members can interact with one another, knowledge and skill gathered by one team member can be transferred to the teammates (Stasser et al. 2000), which can affect the efficiency and effectiveness of the team’s collective learning process (Hinsz et al. 1997). Team knowledge is central to a number of theoretical explanations of team performance ranging from team decisionmaking to team situation awareness (Cooke and Salas 2000). Although team knowledge and related constructs have been assumed to be critical aspects of team performance, there has been minimal empirical work to support this claim.

Collaborative learning is a process of knowledge construction during which students actively search for information, engage in critical discussion, ask questions, discuss answers, make proposals and reply to other proposals (Alavi 1994).

The patterns and conditions for team learning have been found to be similar to those for individual learning (Lynn et al. 2000). There are various methods to
Organizational Learning in the IPOM Environment

11.4 Organizational Learning in the IPOM Environment

facilitate team learning. One of those methods is project learning logs. Recording
the problems, alternative solutions, and major learning and then reviewing and
discussing that information within the team can improve team learning.

Team building is not an easy task and there is no guaranteed “how to” recipe
for building teams. Furthermore, the team building process is risky as it involves
conflicts regarding trust, interdependence and hard work. Katzenbach and Smith
(1993) list several hints that can help in the process of team building:

1. Establish urgency and direction – all team members need to believe the team
has urgent and worthwhile purposes. The more urgent and meaningful the
rationale, the more likely it is that a real team will emerge.
2. Select members based on skill and skill potential, not personalities. Teams must
have the complementary skills needed to do the job. Three categories of skills
are relevant: technical and functional, problem solving and interpersonal. It is
important to strike the right balance between members who already possess the
needed skill levels versus developing the skill levels after the team gets started.
3. Pay particular attention to first meetings and actions. Initial impressions always
mean a great deal. The team leader is introduced in this meeting and the
acceptance of his leadership is extremely important.
4. Set some clear rules of behavior. Rules regarding attendance, discussion,
confidentiality and contributions are very important and help the team perform
its tasks in the early stages. Other rules of conduct are typically developed by
the team to help its members achieve the team’s goals.
5. Set and seize upon a few immediate performance-oriented tasks and goals. By
establishing a few challenging yet achievable goals, members of the team can
start working together right away – a process that forges them together.
6. Challenge the group regularly with fresh facts and information. New information
helps the team shape a common purpose and set clearer goals.
7. Spend lots of time together. Creative insights as well as personal bonding are
created early on if the team members spend time together.
8. Exploit the power of positive feedback, recognition and reward. Positive or
reinforcing feedback helps the process of team building and accelerates it.

Promoting and nurturing individual learning, team building and organizational
learning are key elements in the implementation of IPOM. Many organizations
take the wrong attitude – assuming that the installation of a new ERP-type
Information System can change performance and provide the competitive edge in
today’s global markets. Experience shows that implementation of new Information
Systems fails whenever proper training and team building is missing.

11.4 Organizational Learning in the IPOM Environment

Individual learning and team building are necessary steps in the implementation of
IPOM. In most cases, these steps are the start of the process of organizational or
team learning. Team learning is a process traditionally promoted by organizations
facing high levels of uncertainty where processes are composed of highly dependent tasks. As discussed earlier, a football or a basketball team relies neither on the ability of each player to play as an individual nor on the common goal of the players to win the game. The players must learn how to coordinate efforts in an uncertain environment where “division of labor” is important but the process is far from being completely repeatable; players are dependent on each other as the situation changes rapidly in an unpredictable way. Thus in many areas in sports, team learning is considered a fundamental process that complements individual learning and team building. Members of the team learn how to coordinate their efforts by discussing the role of each individual, by developing “policies” and by playing together in a simulated competition where part of the team represents the opponent and the cost of mistakes is negligible. Similarly, in many armies the training of a soldier starts at the individual level. The next step is to build small groups of soldiers who learn how to work as a team. Next a whole company or a whole battalion are trained together and learn how to coordinate efforts. As in sports, armies are using simulation games, where the “enemy” is represented by some of the soldiers or by a computer simulation.

Organizational or group learning is the process of developing the ability of a group of individuals to improve its performance working as a team to achieve a common goal. Argyris and Schon (1978) define two levels of organizational learning: “Organizational learning involves the detection and correction of error. When the error detected and corrected permits the organization to carry on its present policies or achieve its present objectives, then the error detection and correction process is single-loop learning. Double-loop learning occurs when an error is detected and corrected in ways that involve the modification of an organization’s underlying norms, policies and objectives.” This definition fits very well with the concepts of IPOM. The idea that members of a team should develop policies together (policies that can frequently be implemented by the ERP system) and monitor the process to take actions and to change the policies when needed is a fundamental idea in IPOM. However, in the same article, the authors report that most organizations that do quite well in single-loop learning are having great difficulties in double-loop learning. Their general contention is that organizations ordinarily fail to learn on a higher level. Organizations tend to create learning systems that inhibit double-loop learning, calling into question their norms, objectives and basic policies.

Based on this study, successful implementation of IPOM depends on the ability of the organization to create an environment that encourages single- and double-loop learning. Detecting and solving problems is not enough – a continuous process of questioning current norms, objectives, basic policies and processes in an effort to eliminate the root of the problem and not only its symptoms is necessary.

Group learning is based on several mechanisms, one of which is repetition – the very same mechanism that drives the individual learning curve. Other mechanisms include:
1. The ability to collect and share knowledge so that members of the group can learn from each other’s experience.
2. The ability to learn from the experience of other groups or organizations.
3. The development of an efficient group decisionmaking process.
4. The ability to share and use information in real time.

A special training environment is needed to teach IPOM – an environment that facilitates individual learning, team building, group decisionmaking and the sharing of information; an environment that promotes both single-loop and double-loop organizational learning, i.e., the detection and solution of problems; and the analysis of current processes and policies and the generation of new policies based on timely information and new knowledge.

**Problems**

1. Discuss two mechanisms for individual learning.
2. Explain the effect of repetition on quality. Is this a learning effect?
3. Explain the difference between on the job training and other forms of training; discuss the pros and cons of each form.
4. Compare the teaching methodology in elementary schools and the methodology used in universities. Discuss the applicability of each to the training of new employees in your organization.
5. Explain the difference between a group of individuals and a team. Give an example of each and discuss the transition process between the two.
6. Develop a training program for a new individual hired as a waiter in a restaurant. Is there a need for team building and team learning in this case?
7. Explain the role of simulation in team building. Discuss two examples.
8. What is the difference between individual learning and team learning in a class learning how to use e-mail?
9. Discuss the role of computers in individual and organizational learning.
10. “Learning is a never-ending process.” Discuss the implications for individuals and organizations.
12 Business Process Management

12.1 Motivation

The best description of our approach to the management of business processes is described by Maddern et al. (2004): At the heart of practitioner understanding is the idea that all businesses have processes. Businesses provide goods and services to customers; processes are the means through which those goods and services are delivered. Critical to this perspective, is the idea that processes are universal. Given the universal nature of processes, process management, in some form, is not optional. Practitioners recognize the hierarchical nature of the process concept, and the associated terms used to describe different levels of process granularity, such as subprocesses, activities, tasks and so on. However, activity at these lower levels is not, in itself, evidence of conscious process management. Moreover, most companies establish, control and, potentially, try to improve individual processes and subprocesses under the banner of “business process management” (BPM) as part of traditional operational practice. A critical feature of the management of business processes is process management on an end-to-end basis. Such activity does not constitute conscious process management. Conscious process management involves addressing processes as a whole rather than in isolation or in fragments; to understand the totality of processes, their boundaries and interrelationships; to actively manage the totality of an organization’s processes, on an “end-to-end” basis. As such, it is a management philosophy, which requires initiating intervention aimed at the delivery of a sustained capability to understand, manage and improve processes. Further, businesses manage within business silos: functional business models continue to dominate. Identification and management of end-to-end processes is needed to enable companies to overcome functional barriers, typically leading to reduced costs and improved service.

The “classical” definition of business process management (BPM) is as follows:

BPM is a field of knowledge at the intersection between management and information technology, encompassing methods, techniques and tools to design, enact, control, and analyze operational business processes involving humans, organizations, applications, documents and other sources of information. The activities which constitute business process management can be grouped into three categories: design, execution and monitoring (Wikipedia 2007).
Our definition, based upon the approach of Wensley (2003), Maddern et al. (2004) and Raisinghani (2004) is as follows:

Business process management is the identification, comprehension and management of business processes that interact with people and systems both within and across organizations. Conscious process management involves addressing processes as a whole, rather than in isolation, by seeking to understand the totality of processes, their boundaries and interrelationships. Identification and management of end-to-end processes are needed to enable companies to overcome functional barriers, typically leading to reduced costs and improved service. We therefore need to develop and apply appropriate conceptual tools for integrating the visioning and provisioning of organizational strategies and process perspectives.

Specifically, our tools are aimed at the planning level of management (macro-management), rather than at the operational level (micro-management). We concentrate on three types of tools:

- Uses of the enterprise process model for planning and implementation (Sect. 12.2)
- Uses of the enterprise process model for identifying and characterizing the management attributes of groups of business processes (Sect. 12.3)
- Guidelines to business process improvement (Chap. 13)

### 12.2 Enterprise Process Master Planning

The enterprise process model (Sect. 3.6) constitutes a specification of the business process suite as required by the organization. This specification can be put to the following uses:

(a) Performing a Type II gap analysis (see Sect. 3.2 (o)) between enterprise specificity and vendor model generality to assess and decide on acquiring an ERP system for the enterprise
(b) Guiding the business process engineering and re-engineering program
(c) Guiding the scope and design of the operations of the enterprise
(d) Comparing the enterprise model ("actual") with an industry standard or some industry leader ("benchmarking")
(e) Integrating activities along the supply chain (process and information exchange interfaces)

(a) Model acquisition

The enterprise model defines the organizational requirements, whereas each vendor has an explicit or implicit model that serves as a platform for its ERP software. Enterprise and vendor models can be compared as follows:
1. Perform a focused Type II gap analysis to determine the differences between the enterprise requirements and the vendor model offering
2. Determine the degree of compatibility of the two models
3. Identify requirements for added functionality or process capability lacking in the vendor model
4. Identify functionality or process capability in the vendor model and lacking in the enterprise model which could be added to strengthen the latter
5. Highlight the possibility of combining several vendor models in order to achieve all enterprise requirements
6. Pinpoint requirements for adaptation of the enterprise model or the customization of the vendor model

1. For example, an Internet search was made for vendors offering a comprehensive Hotel Front Desk management system. Two vendors were found. A list of IT-supported processes was obtained from the vendor sites. This enables a gap-analysis table to be drawn up (Table 12.1), showing the enterprise model (from Table 3.8), the two offerings, and processes not requiring IT support (e.g., welcoming a guest or calling for a porter). Several processes offered by the vendors and not specified in the enterprise model are also listed. The following observations can be made:
2. HFD functionality coverage can be summarized as follows (number of processes in parentheses):

<table>
<thead>
<tr>
<th>Main function</th>
<th>First vendor</th>
<th>Second vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservation management (11)</td>
<td>Some support (5)</td>
<td>Good support (11)</td>
</tr>
<tr>
<td>Rate and yield management (2)</td>
<td>No support</td>
<td>Good support (2)</td>
</tr>
<tr>
<td>Check in management (7)</td>
<td>Good support (6)</td>
<td>Good support (7)</td>
</tr>
<tr>
<td>Check out management</td>
<td>Good support (7)</td>
<td>Good support (7)</td>
</tr>
<tr>
<td>Guest relationship management (11)</td>
<td>Some support (6)</td>
<td>Some support (4)</td>
</tr>
<tr>
<td>Guest infoservice management (hotel) (2)</td>
<td>Some support (1)</td>
<td>No support</td>
</tr>
<tr>
<td>Guest infoservice management (external) (6)</td>
<td>No support</td>
<td>No support</td>
</tr>
<tr>
<td>Communication management (2)</td>
<td>Good support (2)</td>
<td>No support</td>
</tr>
<tr>
<td>Service support management (6)</td>
<td>Minimal support (1)</td>
<td>No support</td>
</tr>
<tr>
<td>Gift shop management (6)</td>
<td>No support</td>
<td>No support</td>
</tr>
<tr>
<td><strong>Total support for 59 specified processes</strong></td>
<td><strong>28</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>

Both vendor models cover the “standard” functionalities: reservations, check-in, check-out, and regular guest services; the second vendor provides stronger support in this area. However, no meaningful support is provided for extended guest services or for the gift shop (as expected). In general, both vendors provide the same degree of coverage – for about half the required processes.
3. Added modules required include: guest information service management (hotel amenities), guest information service management (external amenities), service support management and gift shop management.
4. Additional processes are available in the vendor models, and can be incorporated into the enterprise model:
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<table>
<thead>
<tr>
<th>Process</th>
<th>First vendor</th>
<th>Second vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Receive payment in multiple currencies</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Remind desk clerk of actions to be taken</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Block rooms that are out of order</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Issue a detailed account of calls made by guest</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Express and record regret that a reservation cannot be made</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Maintain a register of customers on a wait list for a reservation</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Cancel a no-show reservation</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Provide dynamic information on regular and special rates</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Manage cashier reconciliation</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>• Maintain a register of prospective customers for advertising</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

5. Further vendor models which should be investigated include: guest information service management, service support management and gift shop (“small business”) management.

6. This step is outside the scope of this book, as it requires a more detailed picture of the actual processes required and provided.

**Table 12.1** Type II gap analysis for the enterprise-specific hotel front desk model

<table>
<thead>
<tr>
<th>Function and process</th>
<th>(1)*</th>
<th>(2)*</th>
<th>(3)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Reservation management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Review future room availability and status for reservation</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Search available units for specified date range and unit capacity</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Select unit for single reservation</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Verify single/multi/group reservation information prior to booking</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Create single/multi/group reservation</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Issue single/multi/group reservation confirmation letter</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Charge room at check in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Create reservation frontally</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Create reservation via telephone</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Create reservation via e-mail</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Cancel reservation via fax</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td><strong>2 Rate and yield management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provide information on regular rates</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maintain tour operator account</td>
<td></td>
<td>a</td>
<td></td>
</tr>
<tr>
<td><strong>3 Check-in management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Welcome regular guest</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Welcome VIP guest</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Review current room availability and status for occupation</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Check in guest arriving on time to reserved room</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Check in guest arriving early to reserved room</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Check in guest arriving late to reserved room</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Provide information on predefined deposit</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Provide information on alternative means of payment</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provide information on vehicle parking and parking fees</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Record customer credit card number</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>• Handle credit card invalidity</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>4 Check-out management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Check out guest leaving early</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Check out guest leaving late</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Issue check-out invoice with list of guest fees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Receive single currency (cash) payment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Receive credit card payment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Issue final receipt</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5 Guest relationship management (guest services)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Handle complaints</td>
</tr>
<tr>
<td>• Handle guest queries</td>
</tr>
<tr>
<td>• Record guest instructions or other notes on guest record</td>
</tr>
<tr>
<td>• Charge additional services to guest record</td>
</tr>
<tr>
<td>• Charge additional expenses to guest record</td>
</tr>
<tr>
<td>• Charge point of sale expenses to guest record</td>
</tr>
<tr>
<td>• Supply newspaper to guest</td>
</tr>
<tr>
<td>• Supply travel directions to guest</td>
</tr>
<tr>
<td>• Rent car for guest</td>
</tr>
<tr>
<td>• Order taxi for guest</td>
</tr>
<tr>
<td>• Coordinate guest request for wake-up call</td>
</tr>
<tr>
<td>• Issue wake-up call</td>
</tr>
<tr>
<td>• Allocate safe to guest</td>
</tr>
<tr>
<td>• Issue safe receipt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6 Guest information service mgt. (hotel amenities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide information on meal timetables</td>
</tr>
<tr>
<td>• Provide information on meal/restaurant menus</td>
</tr>
<tr>
<td>• Provide information on currency exchange rates</td>
</tr>
<tr>
<td>• Provide information on hotel facilities</td>
</tr>
<tr>
<td>• Provide information on hotel shop</td>
</tr>
<tr>
<td>• Provide information on found items</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7 Guest information service mgt. (external amenities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provide information on vehicle rental agencies</td>
</tr>
<tr>
<td>• Provide information on tourist agencies</td>
</tr>
<tr>
<td>• Provide information on restaurants</td>
</tr>
<tr>
<td>• Provide information on tourist attractions/sites</td>
</tr>
<tr>
<td>• Provide information on organized tours</td>
</tr>
<tr>
<td>• Provide information on medical services and hospitals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8 Communication management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Record and/or post messages for guest</td>
</tr>
<tr>
<td>• Deliver messages to guest</td>
</tr>
<tr>
<td>• Transfer telephone call to guest</td>
</tr>
<tr>
<td>• Enable guests to receive e-mail messages</td>
</tr>
<tr>
<td>• Enable guests to send e-mail messages</td>
</tr>
<tr>
<td>• Enable guests to receive fax messages</td>
</tr>
<tr>
<td>• Enable guests to send fax messages</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9 Service support coordination management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coordinate guest request with housekeeping</td>
</tr>
<tr>
<td>• Coordinate guest request with maintenance</td>
</tr>
<tr>
<td>• Coordinate guest request with room service</td>
</tr>
<tr>
<td>• Coordinate guest request with computing services</td>
</tr>
<tr>
<td>• Coordinate guest request with porterage</td>
</tr>
<tr>
<td>• Coordinate guest request with transportation</td>
</tr>
<tr>
<td>• Coordinate guest request with restaurant</td>
</tr>
</tbody>
</table>
### Table 12.1 Type II gap analysis for the enterprise-specific hotel front desk model (continued)

<table>
<thead>
<tr>
<th>10 Gift shop management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coordinate with purchasing on item inventories</td>
</tr>
<tr>
<td>• Coordinate with sales on item prices</td>
</tr>
<tr>
<td>• Maintain display items on shelves</td>
</tr>
<tr>
<td>• Handle guest queries</td>
</tr>
<tr>
<td>• Record item purchase on guest record</td>
</tr>
<tr>
<td>• Handle purchase payments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vendor processes not specified in enterprise model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Receive payment in multiple currencies</td>
</tr>
<tr>
<td>• Remind desk clerk of actions to be taken</td>
</tr>
<tr>
<td>• Block rooms that are out of order</td>
</tr>
<tr>
<td>• Issue a detailed account of calls made by guest</td>
</tr>
<tr>
<td>• Express and record regret that a reservation cannot be made</td>
</tr>
<tr>
<td>• Maintain a register of customers on a waiting list for a reservation</td>
</tr>
<tr>
<td>• Cancel a no-show reservation</td>
</tr>
<tr>
<td>• Provide dynamic information on regular and special rates</td>
</tr>
<tr>
<td>• Manage cashier reconciliation</td>
</tr>
<tr>
<td>• Maintain a register of prospective customers for advertising</td>
</tr>
</tbody>
</table>

*(1) IT/ERP support provided by the first vendor; (2) IT/ERP support provided by the second vendor; (3) Processes not requiring IT (ERP) support*

(b) **Business process engineering (BPE) program**

The enterprise model defines the organizational business process suite. It therefore plays a central role in a BPE program or project. (We do not deal with project management in this book. The reader is referred to books by Shtub et al. (2004), Jeston and Nelis (2006), and Becker et al. (2003) which deal with project management in general, and business process project management in particular). In particular, it supports several project management processes within the project scope management knowledge area (PMI 2004):

- **Scope planning**: it serves as a background document for setting up a preliminary project scope statement and a project scope management plan.

- **Scope definition**: it serves as a work breakdown structure (WBS) which is defined as “a fundamental project management technique for defining and organizing the total scope of a project, using a hierarchical tree structure. The levels of the WBS define a set of planned outcomes that collectively and exclusively represent the total project scope. A well-designed WBS describes planned outcomes … the desired ends of the project” (Wikipedia 2007). The business functions constitute the upper levels of the tree; the individual processes constitute the “planned outcomes” of the BPE project. In other words, it constitutes a checklist of the process suite to be modeled and implemented.

- **Scope verification**: it serves as a checklist for monitoring the scope fulfillment of the BPE project.
For example, for the HFD case study in Sect. 3.7, the enterprise model (Table 3.8) defines a list of 72 processes to be designed. The model enables hotel management to decide which processes should be designed, and on design priorities. It may decide to organize the project by function (e.g., first reservations, then check-in, then check-out, and so on); or by the type of action carried out by each process (Table 12.3 and Sect. 12.4; e.g., first creation of documents, then recording of transactions, then providing information to guests, and so on); or by the necessity to match processes to any IT support implemented in parallel with the BPE program.

(c) Scope and design of the operations of the enterprise

The operations engineer receives the model and transforms it into a multi-process service operations design problem to be solved through scheduling and other planning techniques (Chap. 7).

(d) Model benchmarking

The enterprise model can serve as a basis for comparison with other models:

- A leading vendor model in the same or similar industrial sector
- A leading enterprise model in the same or similar industrial sector
- An identical or similar business or industrial functionality or process capability demonstrated by an industrial leader (not necessarily from the same industrial sector)

Gap analysis (Type III) can indicate where the enterprise needs to augment its functionality or process capability through BPE efforts.

Continuing with our example (Sect. 12.2 (b)): if the second vendor model is accepted as an industry standard, the following new functions and associated processes need to be engineered and incorporated into the enterprise model:

<table>
<thead>
<tr>
<th>Main function</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservation mgt.</td>
<td>Express and record regret that a reservation cannot be made</td>
</tr>
<tr>
<td>Rate and yield mgt.</td>
<td>Cancel a no-show reservation</td>
</tr>
<tr>
<td>Front desk zone mgt.</td>
<td>Provide dynamic information on regular and special rates</td>
</tr>
<tr>
<td>Special databank mgt.</td>
<td>Manage cashier reconciliation</td>
</tr>
<tr>
<td></td>
<td>Maintain a register of prospective customers for advertising</td>
</tr>
<tr>
<td></td>
<td>Maintain a register of customers on a wait list for a reservation</td>
</tr>
</tbody>
</table>

(e) Model coordination

Each business partner along the supply chain has its own enterprise model. The necessity to coordinate or integrate activities places certain demands and restrictions on these models:

- Models must be understandable to other partners. The enterprise model, based on the SAP convention, provides the basis for understanding and comparing models – and, in particular, for determining whether each partner incorporates the requisite functionalities and process capabilities.
In the case of our HFD example, the front desk is one “partner” in the running of a hotel. The SAP Hospitality Industry solution (sub-industry: Hotel, Cruise and Timeshare Management) (SAP 2007a) incorporates the following functions: real estate management; sales management; reservations; spa and wellness, leisure management; guest management; billing management; restaurant management, event management, housekeeping and staffing; property maintenance; and financial accounting. The operations of the front desk and its scope of responsibility must be understandable to those dealing with sales, leisure, billing, restaurant, events, housekeeping and staffing, and property maintenance.

In the case of the Procurement/Purchasing function (Table 3.3), partners include suppliers and shippers. Each will have its own enterprise model. From these models purchasing can learn, for example, how a bid package is handled, how item quality is managed, how catalogues are updated, how shipping timetables are worked out, and how shipping notifications are issued.

- Certain processes are “interface processes”: they are concerned with the transfer and reception of information and goods between links (partners) in the chain. These processes can be identified and subsequently analyzed at the flowchart level to ensure both operational and informational compatibility and complementarity.

In the case of our HFD example, the front desk interfaces not only with the hotel functionalities listed above, but also with many external information suppliers as reflected in the “Guest information service management (external amenities)” main function (Table 12.2). As information provided to guests must be reliable and updated, processes interfacing with these external sources must ensure a dependable flow of information to the hotel through the interface.

In the case of the Procurement/Purchasing major function (Table 3.3), interface processes include, for example: accredit supplier; issue procurement contract; issue bid; issue purchase order; handle shipment notification; issue goods received note; maintain supplier prices and discounts.

- When outsourcing or utilizing vendor-managed inventory (VMI), certain functionalities or process capabilities may be transferred from one partner to another. Model harmonization helps to ensure that operational consistency and completeness is maintained.

In the case of the Procurement/Purchasing major function (Table 3.3), Catalogue Management (main function #9) may be outsourced to a company specializing in the design of technical catalogues, integrating the data from several suppliers, maintaining consistency between supplier and manufacturer catalogues (e.g., spare and substitute parts), and producing a publication which fulfils both technical and marketing goals. These activities have to accord with the remaining main functions retained in the Procurement/Purchasing major function.
Table 12.2 Hotel front desk processes – function viewpoint (Table 3.2)

1 *Reservation management*

- Review current room availability and status for reservation
- Review future room availability and status for reservation
- Search available units for specified date range and unit capacity
- Select unit for single reservation
- Select multiple units for multiple reservations
- Select multiple units for group reservations
- Specify customer group name and description
- Verify single/multi/group reservation information prior to booking
- Create single/multi/group reservation
- Issue single/multi/group reservation confirmation letter and send
- Issue single/multi/group reservation cancellation letter and send
- Charge room at time of reservation
- Charge room at check in
- Charge room at check out
- Create reservation frontally
- Create reservation via telephone
- Create reservation via fax
- Create reservation via Internet
- Create reservation via e-mail
- Cancel reservation frontally
- Cancel reservation via telephone
- Cancel reservation via fax
- Cancel reservation via Internet
- Cancel reservation via e-mail

2 *Rate and yield management*

- Provide information on regular rates
- Provide information on seasonal and weekend rates
- Provide information on special rates
- Provide information on different rate packages at time of reservation
- Offer different rate packages for different seasons
- Offer multiple rate types and rates during a single stay
- Maintain tour operator account

3 *Check-in management*

- Welcome regular guest
- Welcome VIP guest
- Check in guest arriving on time to reserved room
- Check in guest arriving early to reserved room
- Check in guest arriving late to reserved room
- Check in walk-in guest
- Search guest by key (First/Last Name, Company name, Address, Home/Work Phone, E-mail)
- Review current room availability and status for occupation
- Review future room availability and status for occupation
- Replace guest reservation with another guest
- Provide information on predefined deposit
- Provide information on alternative means of payment
- Provide information on vehicle parking and parking fees
- Record customer credit card number
- Handle credit card invalidity
- Record customer driver license number
Table 12.2 Hotel front desk processes – function viewpoint (continued)

4 Check-out management

- Check out guest leaving on time
- Check out guest leaving early
- Check out guest leaving late
- Issue check-out invoice with list of guest fees
- Adjust bill amount by providing discounts or fees
- Receive single currency (cash) payment
- Receive multiple currency (cash) payments
- Receive credit card payment
- Issue final receipt

5 Guest relationship management (guest services)

- Exchange room before or during stay
- Handle complaints
- Handle guest queries
- Handle conference guest queries
- Reserve dinner for guest
- Record guest instructions or other notes on guest record
- Charge additional services to guest record
- Charge additional expenses to guest record
- Charge point of sale expenses to guest record
- Supply newspaper to guest
- Supply travel directions to guest
- Provide information on guest policy to guest
- Rent car for guest
- Order taxi for guest
- Coordinate guest request for wake-up call
- Issue wake-up call
- Allocate safe to guest
- Issue safe receipt
- Supply (free/digital) photographs of guests
- Record outgoing ticket and flight information on guest record
- Confirm outgoing ticket and flight information for guest
- Issue special (cheap) tickets for public transportation
- Direct visitors to guest

6 Guest information service management (hotel amenities)

- Provide information on meal timetables
- Provide information on meal/restaurant menus
- Provide information on currency exchange rates
- Provide information on hotel facilities
- Provide information on hotel shop
- Provide information on conference program
- Record information on lost items
- Provide information on found items
- Provide information on babysitting services

7 Guest information service management (external amenities)

- Provide information on travel agencies
- Provide information on vehicle rental agencies
- Provide information on bicycle rental agencies
- Provide information on tourist agencies
Table 12.2 Hotel front desk processes – function viewpoint (continued)

- Provide information on restaurants
- Provide information on cultural attractions
- Provide information on entertainment attractions
- Provide information on tourist attractions and sites
- Provide information on shopping facilities
- Provide information on organized tours
- Provide information on sports facilities and events
- Provide information on public transport facilities
- Provide information on airlines and flight schedules
- Provide information on telephone numbers
- Provide information on medical services and hospitals
- Provide information on city maps and guides
- Provide information on country-wide maps and guides
- Provide information on local and country-wide weather

8 **Communication management**

- Record and/or post messages for guest
- Deliver messages to guest
- Deliver incoming mail to guest
- Transfer telephone call to guest
- Enable guests to receive e-mail messages
- Enable guests to send e-mail messages
- Enable guests to receive fax messages
- Enable guests to send fax messages

9 **Service support coordination management**

- Coordinate guest request with housekeeping
- Coordinate guest request with maintenance
- Coordinate guest request with room service
- Coordinate guest request with computing services
- Coordinate guest request with laundry and dry-cleaning facility
- Coordinate guest request with porterage
- Coordinate guest request with valet parking
- Coordinate guest request with transportation (e.g., airport, city)
- Coordinate guest request with restaurant

10 **Front desk zone management**

- Manage front desk (including flowers)
- Manage lobby
- Manage lobby billboard(s)
- Manage ambient music
- Manage cash drawer
- Manage front desk audit
- Manage night audit
- Manage clock-in and clock-out

11 **Special databank management (hotel services)**

- Maintain wait list for reservations
- Maintain historical VIP guest data
- Maintain historical guest data
- Maintain historical DNR (do not rent!) data
- Maintain historical complaint data
Table 12.3 Hotel front desk processes – action viewpoint

Provide (information)
- Provide information on airlines and flight schedules
- Provide information on alternative means of payment
- Provide information on babysitting services
- Provide information on bicycle rental agencies
- Provide information on city maps and guides
- Provide information on conference program
- Provide information on country-wide maps and guides
- Provide information on cultural attractions
- Provide information on currency exchange rates
- Provide information on different rate packages at time of reservation
- Provide information on entertainment attractions
- Provide information on found items
- Provide information on guest policy to guest
- Provide information on hotel facilities
- Provide information on hotel shop
- Provide information on local and country-wide weather
- Provide information on meal timetables
- Provide information on meal/restaurant menus
- Provide information on medical services and hospitals
- Provide information on organized tours
- Provide information on predefined deposit
- Provide information on public transport facilities
- Provide information on regular rates
- Provide information on restaurants
- Provide information on seasonal and weekend rates
- Provide information on shopping facilities
- Provide information on special rates
- Provide information on sports facilities and events
- Provide information on telephone numbers
- Provide information on touristic agencies
- Provide information on tourist attractions and sites
- Provide information on travel agencies
- Provide information on vehicle parking and parking fees
- Provide information on vehicle rental agencies

Coordinate
- Coordinate guest request for wake-up call
- Coordinate guest request with computing services
- Coordinate guest request with housekeeping
- Coordinate guest request with laundry and dry-cleaning facility
- Coordinate guest request with maintenance
- Coordinate guest request with porterage
- Coordinate guest request with restaurant
- Coordinate guest request with room service
- Coordinate guest request with transportation (e.g., airport, city)
- Coordinate guest request with valet parking

Manage
- Manage ambient music
- Manage cash drawer
- Manage clock-in and clock-out
- Manage front desk (including flowers)
Table 12.3 Hotel front desk processes – action viewpoint (continued)

- Manage front desk audit
- Manage lobby
- Manage lobby billboard(s)
- Manage night audit

**Issue**
- Issue check-out invoice with list of guest fees
- Issue final receipt
- Issue safe receipt
- Issue single/multi/group reservation cancellation letter and send
- Issue single/multi/group reservation confirmation letter and send
- Issue special (cheap) tickets for public transportation
- Issue wake-up call

**Charge**
- Charge additional expenses to guest record
- Charge additional services to guest record
- Charge point of sale expenses to guest record
- Charge room at check in
- Charge room at check out
- Charge room at time of reservation

**Create**
- Create reservation frontally
- Create reservation via telephone
- Create reservation via e-mail
- Create reservation via fax
- Create reservation via Internet
- Create single/multi/group reservation

**Maintain**
- Maintain historical complaint data
- Maintain historical DNR (do not rent!) data
- Maintain historical guest data
- Maintain historical VIP guest data
- Maintain tour operator account
- Maintain waiting list for reservations

**Record**
- Record and/or post messages for guest on guest record
- Record customer credit card number on guest record
- Record customer driver license number on guest record
- Record guest instructions or other notes on guest record
- Record information on lost items on guest record
- Record outgoing ticket and flight information on guest record

**Cancel**
- Cancel reservation frontally
- Cancel reservation via telephone
- Cancel reservation via e-mail
- Cancel reservation via fax
- Cancel reservation via Internet
Table 12.3 Hotel front desk processes – action viewpoint (continued)

**Check in**
- Check in guest arriving early to reserved room
- Check in guest arriving late to reserved room
- Check in guest arriving on time to reserved room
- Check in walk-in guest

**Enable**
- Enable guests to receive e-mail messages
- Enable guests to receive fax messages
- Enable guests to send e-mail messages
- Enable guests to send fax messages

**Handle**
- Handle complaints
- Handle conference guest queries
- Handle credit card invalidity
- Handle guest queries

**Review**
- Review current room availability and status for occupation
- Review current room availability and status for reservation
- Review future room availability and status for occupation
- Review future room availability and status for reservation

**Check out**
- Check out guest leaving early
- Check out guest leaving late
- Check out guest leaving on time

**Select**
- Select multiple units for group reservations
- Select multiple units for multi reservations
- Select unit for single reservation

**Receive**
- Receive credit card payment
- Receive multiple currency (cash) payments
- Receive single currency (cash) payment

**Supply**
- Supply (free/digital) photographs of guests
- Supply newspaper to guest
- Supply travel directions to guest

**Transfer**
- Transfer incoming mail to guest
- Transfer messages to guest
- Transfer telephone call to guest

**Offer**
- Offer different rate packages for different seasons
- Offer multiple rate types and rates during a single stay

**Search**
- Search available units for specified date range and unit capacity
- Search guest by key (First/Last Name, Company name, Address, Home/Work Phone, E-mail)
Table 12.3 Hotel front desk processes – action viewpoint (continued)

Welcome
• Welcome regular guest
• Welcome VIP guest

Adjust
• Adjust bill amount by providing discounts or fees

Allocate
• Allocate safe to guest

Confirm
• Confirm outgoing ticket and flight information for guest

Direct
• Direct visitors to guest

Exchange
• Exchange room before or during stay

Order
• Order taxi for guest

Replace
• Replace guest reservation with another guest

Rent
• Rent car for guest

Reserve
• Reserve dinner for guest

Specify
• Specify customer group name and description

Verify
• Verify single/multi/group reservation information prior to booking

12.3 Process Action Analysis

12.3.1 Introduction

One of the biggest problems in managing business processes is that there are a large number of them. This is reflected in the enterprise process model (Sect. 3.6). For example, the HFD enterprise-specific model encompasses 78 processes (Table 3.8); the complete reference model encompasses 136 processes (Table 3.2); the APQC PCF model (Sect. 3.6 (a), APQC (2008)) incorporates close to 1,000 processes and activities. A total enterprise model (e.g., a complete hotel model) may contain many more. To help grasp the totality of processes, the conventional solution is to view an enterprise through its functionalities, as evidenced by SAP’s business solutions for industrial sectors or application areas (ERP/CRM) (Sect. 3.6 (a)). A typical SAP solution contains eight major functions and 40 main functions (Tables 3.4 (a), 3.5 and 3.6). However, an enterprise model at the functional level is too abstract for process management. We wish BPM to act at the process level. How can this be done? We base ourselves on the following observation:
If we examine, for example, Table 3.3 (“Procurement/purchasing”), we find that three processes have the same verb “negotiate” in the process name: “Negotiate bids,” “Negotiate procurement contract” and “Negotiate purchase order with supplier.” If enough processes involve “negotiate,” a general negotiation protocol needs to be established – training employees how to negotiate (e.g., with customers, suppliers, sub-contractors, potential employees) and specifying the necessary authority for workers to set conditions and make decisions. This gives us an idea how to find and exploit the commonality between several processes for management purposes.

We do this by looking only at the process verb or action, rather than at the entire process name or descriptor. In the HFD case study (Table 12.2), instead of “Create reservation frontally” or “Create reservation via e-mail” we abstract “Create”. Actually, there are six processes with this verb under “Reservation management.” This enables us to collapse six processes into one action. If we look at the processes whose action is “Provide information” (“Guest information service management”) we can collapse no less than 34 processes into one action.

Using actions to characterize a set of processes provides several management perspectives:

- **Management area**: determination of to which management area the action belongs (plan/execute/control) and thus better assign management responsibility
- **Significant actions**: identification of significant actions which should be the focus of business process management and formulating procedures and standards for process quality related to these actions
- **Cross-functionality**: noting which actions occur in several functionalities and therefore require coordination between organizational units or sub-units.

### 12.3.2 Basic Concepts in Process Action Analysis

- **Process descriptor**: a verb phrase describing the content of a business process, consisting of a predicate and an object
- **Predicate**: one of the two main constituents of a process descriptor, containing an action (verb) and its qualifiers
- **Object**: the second main constituent of a process descriptor, containing an artifact (noun) that is acted upon and its qualifiers
- **Action**: something done or carried through
- **Process action analysis**: a procedure or methodology for perceiving a process suite through the actions incorporated in each process as identified in the process descriptor verb and making inferences about the characteristics and meaning of common actions realized by the processes within the context of the suite
- **Pareto analysis**: selection of a limited number of process actions that are common to a significant number of processes, based on the principle that not all process action types occur with the same frequency or with the same impact (see explanation in Sect. 6.4)
• **Pareto list**: a list of process descriptors or actions, sorted in descending order of the frequency of the action verb within the process suite

• **Pareto benefit**: process management can focus on creating and implementing procedures and standards which are common to a significant number of processes rather than developing individualized procedures and standards for each process

### 12.3.3 A Procedure for Process Action Analysis

Process action analysis (PAA) is carried out in four stages:

(a) Determine the compass of the business process suite to be analyzed and compile the relevant set of processes.

(b) Re-organize the business process suite according to the action verb (action view).

(c) Create a Pareto list of actions (verbs) extracted from the process descriptors within the suite.

(d) Carry out a set of analyses on the actions.

(a) Bring together all processes constituting the business process suite (functional view)

1. Define the process suite: the total enterprise, a major function (e.g., “Hotel front desk”) or a main function (e.g., “Reservation management”).
2. Extract the relevant process suite from the enterprise model.

This partial (or total) enterprise model, as it is prearranged by function or sub-function, constitutes the functional viewpoint of the process suite (compare Sect. 3.5).

(b) Re-organize the business process suite according to the action verb (action view)

3. Sort and group the process suite by the action verb.
4. Count the number of processes in which each verb occurs.
5. Re-order the process groups by verbs in descending count order.

This partial (or total) enterprise model, as it is now ordered by descending order of the action verb frequency, constitutes the action viewpoint of the process suite. We stress that “frequency,” in the context of action analysis, refers to the rate of occurrence of a given action within all the processes in the suite; it is unrelated to the frequency of execution of each process within the operational framework.

(c) Create a Pareto list of action verbs from the process descriptors

6. Set up a table of action verbs (verbs only – not the complete descriptor) in descending count order.
7. Divide the table of verbs into “major significance,” “minor significance” and “no significance” verbs using the Pareto principle.
(d) Carry out the following process action analyses:

8. Management area
   - Determine to which management area each action belongs (plan/execute/control). This influences factors such as the action time window, the vocabulary of the procedure or specification, and the category of both manager and worker addressed.

9. Significant actions
   - Identify significant actions to be the focus of business process management. This pinpoints areas for creating procedures and standards for process execution and quality related to the significant actions.

10. Cross-functionality
   - Note which actions occur in several functionalities. The corresponding processes will require coordination between organizational units or sub-units.

12.4 Example: Hotel Front Desk

(a) Bring together all processes constituting the business process suite (functional view)

1. Define the process suite.
   - We select the “hotel front desk” major function.

2. Select the relevant process suite from the enterprise model.
   - For this example we use the complete reference model (Table 12.2).

   The model (Table 12.2), ordered by function, constitutes the functional viewpoint of the “Hotel Front Desk” process suite.

(b) Reorganize the business process suite according to the action verb (action view)

3. Sort and group the process suite by the verb.
   - Sorting and grouping the processes in Table 12.2 by the action verb (the first word in the descriptor) creates the list in Table 12.3 (first grouping step – not shown).

4. Count the number of processes in which each verb occurs.
   - Table 12.3 reveals that there are operationally 32 distinct actions. A frequency count of these actions, in descending order, is given in Table 12.4. The ratio 136/32 indicates an average of 4.25 processes per verb.
5. Re-order the process groups by verbs in descending count order.

- Re-ordering the process groups in Table 12.3 by frequency of the action verb creates the list in Table 12.3 (final grouping step – end order).

The rearranged model (Table 12.3), ordered by descending order of action verb frequency, constitutes the action viewpoint of the process suite.

(c) Create a Pareto list of action verbs from the process descriptors

6. Set up a table of action verbs in descending count order.

- These are listed in Table 12.4.

7. Divide the table of verbs into major, minor and no significance using the Pareto principle.

- From a study of Table 12.4 we divide the actions into three categories (major: – recurrence six or more times; minor – recurrence three to five times; and insignificant – recurrence less than three times):

<table>
<thead>
<tr>
<th>Times verb recurs</th>
<th>Number of verbs</th>
<th>Percent of verbs</th>
<th>Number of processes</th>
<th>Percent of processes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>3</td>
<td>34</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>3</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>6–9</td>
<td>6</td>
<td>19</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>3–5</td>
<td>10</td>
<td>31</td>
<td>41</td>
<td>26</td>
</tr>
<tr>
<td>1–2</td>
<td>14</td>
<td>44</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>100</td>
<td>136</td>
<td>100</td>
</tr>
</tbody>
</table>

- The eight most common verbs (Table 12.4) (25%), covering 83 processes (61%), are:

<table>
<thead>
<tr>
<th>Verb</th>
<th>Occurrence (processes)</th>
<th>Percent of all processes</th>
<th>Cumulative percent of all processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide (information)</td>
<td>34</td>
<td>25.0</td>
<td>25</td>
</tr>
<tr>
<td>Coordinate</td>
<td>10</td>
<td>7.4</td>
<td>32</td>
</tr>
<tr>
<td>Manage</td>
<td>8</td>
<td>5.9</td>
<td>38</td>
</tr>
<tr>
<td>Issue</td>
<td>7</td>
<td>5.1</td>
<td>43</td>
</tr>
<tr>
<td>Charge</td>
<td>6</td>
<td>4.4</td>
<td>48</td>
</tr>
<tr>
<td>Create</td>
<td>6</td>
<td>4.4</td>
<td>52</td>
</tr>
<tr>
<td>Maintain</td>
<td>6</td>
<td>4.4</td>
<td>57</td>
</tr>
<tr>
<td>Record</td>
<td>6</td>
<td>4.4</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>
Table 12.4 Analysis of the action verbs for the “Hotel Front Desk”

<table>
<thead>
<tr>
<th>#</th>
<th>Verb</th>
<th>Cumulative percent of all verbs</th>
<th>Occurrence (processes)</th>
<th>Percent of all processes</th>
<th>Cumulative percent of all processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide (information)</td>
<td>3.1</td>
<td>34</td>
<td>25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>2</td>
<td>Coordinate</td>
<td>6.3</td>
<td>10</td>
<td>7.4</td>
<td>32.4</td>
</tr>
<tr>
<td>3</td>
<td>Manage</td>
<td>9.4</td>
<td>8</td>
<td>5.9</td>
<td>38.2</td>
</tr>
<tr>
<td>4</td>
<td>Issue</td>
<td>12.5</td>
<td>7</td>
<td>5.1</td>
<td>43.4</td>
</tr>
<tr>
<td>5</td>
<td>Charge</td>
<td>15.6</td>
<td>6</td>
<td>4.4</td>
<td>47.8</td>
</tr>
<tr>
<td>6</td>
<td>Create</td>
<td>18.8</td>
<td>6</td>
<td>4.4</td>
<td>52.2</td>
</tr>
<tr>
<td>7</td>
<td>Maintain</td>
<td>21.9</td>
<td>6</td>
<td>4.4</td>
<td>56.6</td>
</tr>
<tr>
<td>8</td>
<td>Record</td>
<td>25.0</td>
<td>6</td>
<td>4.4</td>
<td>61.0</td>
</tr>
<tr>
<td>9</td>
<td>Cancel</td>
<td>28.1</td>
<td>5</td>
<td>3.7</td>
<td>64.7</td>
</tr>
<tr>
<td>10</td>
<td>Check-in</td>
<td>31.3</td>
<td>4</td>
<td>2.9</td>
<td>67.6</td>
</tr>
<tr>
<td>11</td>
<td>Enable</td>
<td>34.4</td>
<td>4</td>
<td>2.9</td>
<td>70.6</td>
</tr>
<tr>
<td>12</td>
<td>Handle</td>
<td>37.5</td>
<td>4</td>
<td>2.9</td>
<td>73.5</td>
</tr>
<tr>
<td>13</td>
<td>Review</td>
<td>40.6</td>
<td>4</td>
<td>2.9</td>
<td>76.5</td>
</tr>
<tr>
<td>14</td>
<td>Check out</td>
<td>43.8</td>
<td>3</td>
<td>2.2</td>
<td>78.7</td>
</tr>
<tr>
<td>15</td>
<td>Select</td>
<td>46.9</td>
<td>3</td>
<td>2.2</td>
<td>80.9</td>
</tr>
<tr>
<td>16</td>
<td>Receive</td>
<td>50.0</td>
<td>3</td>
<td>2.2</td>
<td>83.1</td>
</tr>
<tr>
<td>17</td>
<td>Supply</td>
<td>53.1</td>
<td>3</td>
<td>2.2</td>
<td>85.3</td>
</tr>
<tr>
<td>18</td>
<td>Transfer</td>
<td>56.3</td>
<td>3</td>
<td>2.2</td>
<td>87.5</td>
</tr>
<tr>
<td>19</td>
<td>Offer</td>
<td>59.4</td>
<td>2</td>
<td>1.5</td>
<td>89.0</td>
</tr>
<tr>
<td>20</td>
<td>Search</td>
<td>62.5</td>
<td>2</td>
<td>1.5</td>
<td>90.4</td>
</tr>
<tr>
<td>21</td>
<td>Welcome</td>
<td>65.6</td>
<td>2</td>
<td>1.5</td>
<td>91.9</td>
</tr>
<tr>
<td>22</td>
<td>Adjust</td>
<td>68.8</td>
<td>1</td>
<td>0.7</td>
<td>92.6</td>
</tr>
<tr>
<td>23</td>
<td>Allocate</td>
<td>71.9</td>
<td>1</td>
<td>0.7</td>
<td>93.4</td>
</tr>
<tr>
<td>24</td>
<td>Confirm</td>
<td>75.0</td>
<td>1</td>
<td>0.7</td>
<td>94.1</td>
</tr>
<tr>
<td>25</td>
<td>Direct</td>
<td>78.1</td>
<td>1</td>
<td>0.7</td>
<td>94.9</td>
</tr>
<tr>
<td>26</td>
<td>Exchange</td>
<td>81.3</td>
<td>1</td>
<td>0.7</td>
<td>95.6</td>
</tr>
<tr>
<td>27</td>
<td>Order</td>
<td>84.4</td>
<td>1</td>
<td>0.7</td>
<td>96.3</td>
</tr>
<tr>
<td>28</td>
<td>Replace</td>
<td>87.5</td>
<td>1</td>
<td>0.7</td>
<td>97.1</td>
</tr>
<tr>
<td>29</td>
<td>Rent</td>
<td>90.6</td>
<td>1</td>
<td>0.7</td>
<td>97.8</td>
</tr>
<tr>
<td>30</td>
<td>Reserve</td>
<td>93.8</td>
<td>1</td>
<td>0.7</td>
<td>98.5</td>
</tr>
<tr>
<td>31</td>
<td>Specify</td>
<td>96.9</td>
<td>1</td>
<td>0.7</td>
<td>99.3</td>
</tr>
<tr>
<td>32</td>
<td>Verify</td>
<td>100.0</td>
<td>1</td>
<td>0.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Total 136 100.0
(d) Carry out the following action-based analyses on the actions of major significance

8. Pinpoint management areas.
   - The eight most frequent verbs encompass two management areas: operations (provide (information), coordinate, manage, issue, charge, create, record) and control (maintain). As expected, the HFD is operations-intensive; BPM support is required up front and must be harmonized with the activities of the front desk staff.

9. Manage most significant actions.
   - The following procedures and specifications should be established:
     - *Provide (information to guest)*
       * Specify a comprehensive database for all information to be provided to staff and guests
       * Set up a procedure to ensure continued updatedness of the data
     - *Coordinate (with other hotel departments)*
       * Set up a procedure to ensure coordination and cooperation between hotel departments
       * Set up a procedure for collaborative processes and progress reporting of the guest requests
     - *Manage (lobby)*
       * Formulate a clear guide for lobby administration
       * Set up a procedure to coordinate with other hotel departments (e.g., advertising, event hosting, maintenance)
     - *Issue*
       * Design (where possible) both computerized and hard-copy templates to provide clarity and completeness for recording, and transparency for the customer
     - *Charge (room and services)*
       * Specify charges that are unambiguous and understandable to staff and guests
       * Ensure that charge schedules are easily accessible to staff and guests set up a procedure to ensure updatedness of all charges
     - *Create (reservation)*
       * Set up a procedure to ensure that all reservation channels and methods of confirmation are consistent and coordinated
       * Set up a procedure to ensure that all reservation data is unified within the reservation database
       * Organize training for frontal or distance encounters with guests with emphasis on service and cultivating guests
– **Maintain (historical data)**
  
  * Set up a procedure to ensure data updatedness and completeness  
  * Set up an efficient system for data entry database integration  
  * Set up procedures for analysis and interpretation of historical data and feedback of lessons learned

– **Record (items on guest record)**
  
  * Design (where possible) both computerized and hard-copy templates to provide clarity and completeness for recording, and transparency for the customer  
  * Ensure that records, if not computerized, are properly legible so that all the front desk staff activities are understandable to all other department staff

10. Analyze cross-functionality.

- Table 12.5 displays a cross-functionality matrix for the hotel front desk – the number of processes within each function having a common action verb. It is obviously only meaningful for significant processes, and so encompasses the 21 processes whose verb frequency is greater than 1. From a functional viewpoint (moving up one level from the process), we see that:
  
  – **Provide (information to guest)**
    
    * Information is provided to guests by the front desk within multiple contexts (rate and yield management, check-in management, guest relationship management and guest information service management – hotel and external amenities). Management must decide whether the staff will be trained to act as generalists or specialists when advising guests.

  – **Coordinate (with other hotel departments)**
    
    * These activities mainly occur within the service support coordination management function.

  – **Manage (lobby)**
    
    * These activities only occur within the front-desk zone function.

  – **Issue**
    
    * Documents are issued to guests within multiple contexts (reservation management, check-out management and guest relationship management). Management must decide whether the staff will be trained to act as generalists or specialists when issuing documents.
12.5 Process Action Analysis: Summary

Business process content is the fundamental basis for the modeling, implementation, operation and monitoring of business processes. Action-oriented content describes what the business does ("charge," "authorize," "check") – by concentrating on the action verb as a surrogate itemization of the suite of actual business activities representing the scope of a specific function, enterprise or industrial sector. The framework formulates, formalizes and exploits process actions by: (a) extracting verbs from process descriptors; (b) concentrating on the set of actions and subjecting them to a Pareto analysis; (c) focusing on the most frequent actions as a basis for planning and implementing a limited number of common procedures that can produce a significant overall effect; and (d) mapping the relationship between functions and actions to unify the functional and action viewpoints of the enterprise. The approach enables the practitioner to understand the totality of a business suite and characterize the action profile of the organization as part of the implementation of business process management.
**Table 12.5 Cross-functionality matrix for the “Hotel Front Desk”**

<table>
<thead>
<tr>
<th>Function</th>
<th>Total number of processes</th>
<th>Reservation management</th>
<th>Rate and yield management</th>
<th>Check-in management</th>
<th>Check-out management</th>
<th>Guest relationship management</th>
<th>Guest info service mgmt (hotel amenities)</th>
<th>Guest info service mgmt (external amenities)</th>
<th>Communication management</th>
<th>Service support coordination management</th>
<th>Front desk zone management</th>
<th>Special datamBank management (hotel services)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide (information)</td>
<td>34</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td>18</td>
<td></td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordinate (departments)</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manage (lobby)</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issue</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge (room and services)</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Create (reservations)</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Maintain (historical data)</td>
<td>6</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Record (on guest record)</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Cancel (reservations)</td>
<td>5</td>
<td>5</td>
<td></td>
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<td></td>
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<tr>
<td>Check-in (guest)</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Enable (messages to guest)</td>
<td>4</td>
<td></td>
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<td></td>
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<td>4</td>
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<tr>
<td>Handle</td>
<td>4</td>
<td>1</td>
<td>3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Review (room availability)</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Check out (guest)</td>
<td>3</td>
<td>3</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Select (room, unit)</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Receive (payment)</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Supply</td>
<td>3</td>
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<tr>
<td>Transfer (messages to guest)</td>
<td>3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Offer (rates, packages)</td>
<td>2</td>
<td>2</td>
<td></td>
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<tr>
<td>Search</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Welcome (guest)</td>
<td>2</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Total processes</strong></td>
<td><strong>125</strong></td>
<td><strong>22</strong></td>
<td><strong>7</strong></td>
<td><strong>15</strong></td>
<td><strong>8</strong></td>
<td><strong>16</strong></td>
<td><strong>9</strong></td>
<td><strong>18</strong></td>
<td><strong>8</strong></td>
<td><strong>9</strong></td>
<td><strong>8</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>
Problems

1. The conventional Pareto analysis requires raw data (in our case the process suite) to be categorized as the analysis is carried out on categorized, not on raw data. We have used the action verb directly as being sufficiently powerful to “categorize” or characterize a process action. (For a detailed overview of this type of approach – using raw data decomposition rather than categorizations, see the literature on Object Role Modeling (e.g., Halpin 2007).) Our assumption is that verbs will be found to be common to a sufficient number of processes so that the Pareto approach can be applied. We notice that the Procurement/Purchasing reference model (Table 3.3) exhibits this property, as well as the APQC Process Classification Framework (Table 3.7).

   - Why should verb commonality be so prevalent?
   - Do you feel that there is probably a limited number of action verbs to describe most business activities?
   - How do the action verbs in reference models (Internet, vendor and consortium models – see Sect. 3.6 (a)) compare with the verb taxonomy of the MIT process handbook (Malone et al. 2003), which uses a limited number of verbs to synthesize business processes at the descriptor level?

2. Certain processes are “interface processes” (Sect. 12.2 (e)): they are concerned with the handing over and receipt of information and goods between links or partners in the supply chain. These processes can be identified and subsequently analyzed at the flowchart level to ensure both operational and informational compatibility and complementarity between links.

   - From an organizational perspective, what is the best way to coordinate interface processes and process interfaces?
   - From a process perspective, such coordination is itself a process. What function or organizational unit would be the owner (or co-owner) of such processes?
   - From a supply chain perspective, some links are intermediaries, such as transportation or data transfer networks. How should these intermediaries and their requirements be integrated into the B2B interfaces?

3. Three types of gap analysis have been defined (Sect. 3.2 (o)): Type I – analysis of the differences between a reference model and specific enterprise requirements; Type II – analysis of the differences between enterprise requirements and vendor model offering; and Type III – analysis of the differences between enterprise requirements and the ERP system implemented.

   - Who within the organization would be responsible for each type of gap analysis?
   - Gap analysis reflects the conflict between standardization – dictated by the industry or the vendor – and customization – required by the enterprise. What factors would be operative at each stage when seeking a balance between these two demands?
4. We have identified three action-oriented analyses (Sect. 12.3.4 (d)):

(a) Determine to which *management area* the action belongs (plan/execute/control). This influences factors such as the action time window, the vocabulary of the procedure or specification, and the category of worker addressed.

(b) Identify *significant actions* to be the focus of business process management. This pinpoints areas for creating procedures and standards for process execution and quality related to the significant actions.

(c) Note which actions occur in *several functionalities*. The corresponding processes will require coordination between organizational units or sub-units.

- Can you suggest other analyses that could be carried out on an ensemble of process descriptors?
- For example, could a specific performance feedback mechanism or report framework be associated with each action verb or a group of operationally similar action verbs? Or does each group have similar operational performance measures?
13 Business Process Improvement

13.1 Motivation

For a process-centric organization, the management and improvement of its business processes is an essential factor in organizational advancement. From the same perspective, the implementation and change of these processes has all the facets of Change Management – including managerial disputes about the nature of advancement; a socio-cultural challenge resulting from the severe organizational effects on the involved people, which may lead them to react against those changes; and a technical challenge, which is due to the difficulty in developing a business process redesign which aims towards an improvement of the current design (Reijers and Mansar 2005; Carr and Johansson 1995). To keep pace with the ever-changing environment, organizations need to be aware of their ability to adapt. Business Process Management is one approach to enhance internal efficiency and to change the way the organization functions (Forster 2006b). In effect, Business Process Management is an essential part of enterprise management. For an in-depth review of Business Process Management the reader is referred to the many books on this topic (see, for example, Jeston and Nelis 2006). Within the scope of this book, we focus on one aspect: the modification and improvement of business processes resulting from problems such as dissatisfaction with current processes, feedback from process performers and customers, changes in the modus operandi of the organization, enhancement of IT and knowledge resources, and adaptation of the enterprise to developments in the external environment.

In previous chapters we have concentrated on two levels: the enterprise process suite (Chap. 3) and the individual business process (Chap. 8). If we accept the definition by Davenport (1993) that business process improvement (BPI) is an incremental bottom-up enhancement of existing processes within functional borders, we take the opinion that “Business Process Improvement initiatives primarily have to deal with the improvement of the business process itself” (Grove and Kettinger 1998, quoted in Forster 2006b). This chapter therefore concentrates on the process redesign aspect of BPI. It provides a set of specific guidelines as to how an existing business process can be modified and thereby improved (for further reading on this topic see Reijers and Mansar 2005; Forster 2006a; Forster 2006b), how the ability of the process performer can be evaluated and improved, and how the capability of the process designer can be reinforced in order to take the lead in implementing a business process improvement.
In this chapter we therefore deal with three issues of business process improvement:

- Redesign – how is a business process improved?
- Performer capability – how is the process performer to be qualified to carry out the improved process?
- Designer capability – how is the designer to be qualified to improve the business process and integrate it into the enterprise process suite?

### 13.2 Definitions

A *business process* is an ordered set of related, structured activities, linked by precedence relationships, which express how the work is done within an organization across time and place. It has a beginning, an end, and clearly defined inputs and outputs and comprises three main components: actions, decisions and controls. The set of activities represents all the alternative methods of performing the work needed to produce a specific service or product for a particular internal or external customer and thereby to achieve some business goal (synthesized from definitions in Sect. 3.2 (c)).

A *(business)* *process performer* is a human agent who carries out the actions needed to produce a result from the process. “Carrying out the actions” is also termed “execution” or “enactment”.

*Business Process Management (BPM)* is “a matured cross-functional approach which stresses a process-centered view. It can be defined as a structured, coherent and consistent way of understanding, documenting, modeling, analyzing, simulating, executing, measuring and continuously changing end-to-end business processes and all involved resources in light of their contribution to business improvement” (Australian Business Process Management Community of Practice 2007). (A complementary definition is given in Sect. 12.1).

An *improved business process* is one that has been redesigned to achieve one or more of the following purposes:

- enhanced functionality (outputs delivered and business goals achieved)
- increased quality (conformance, operability, reliability)
- increased flexibility (adaptability to variations and compliance with future needs)
- reduced operation (cycle) time (queue, service, wait)
- reduced cost (operation, failure, preventive, appraisal)

*Business Process Improvement (BPI)* is a systematic approach to help any organization make significant changes in the way it does business (Wikipedia 2007). BPI works by:

- Defining the organization's strategic goals and purposes (who are we, what do we do, and why do we do it?)
Determining the organization’s customers (or stakeholders) (whom do we serve?)

Aligning the business processes to realize the organization’s goals (how do we do it better?)

Alternatively, BPI is a “focused change in a business process achieved by analyzing the AS-IS (existing) process … and then developing a streamlined TO-BE (future) process in which automation [and other enhancements] may be added to result in a process that is better, faster, and cheaper” (Balanced Scorecard 2007).

*A Business Process Improvement Pattern* is an “abstract form of a recurring instance of a process modification step used in a Business Process Improvement activity. Process modification steps are activities undertaken to amend the process, organization, data or object, or, in general, all Business Process related issues” (Forster 2006b). Each pattern specifies a change that can be made.

### 13.3 Redesign: Dimensions of BPI

It is important to define a framework to help the process designer in identifying the topics that should be considered and how these topics are related (Alter 1999; quoted in Reijers and Mansar 2005). The framework should identify clearly all perspectives that should be considered whenever approaching the improvement of a business process – an explicit set of ideas that helps in thinking about the business process in the context of reengineering. BPI is carried out in three main dimensions:

- What attributes of the process, its resources or its environment can be modified?
- What modifications can be made to the process itself?
- What improvement measures are we aiming for by making these modifications?

(a) Change foci: the attributes of the process, its resources or its environment that can be modified

Analysis of the structure of a business process, as implied by the above definition (Sect. 13.2), indicates that changes to the business process or its associated performers, human and informatic resources and interfacing environment can be characterized by six central perspectives as follows (Forster 2006b; Reijers and Mansar 2005):

*Process* – redesign of the process (operational and behaviour view)

- Basic question: How are things done?
- Items: Activities, decisions and events
- Focus: How can the way work is done be done better?
Object – input received and output provided

- Basic question: What is the role and content of the input and output?
- Items: Input and output data, information and knowledge
- Focus: What is the impact of input and output on the entire process; and how can their content be improved?

Organization – modifications of the human resources (performers, customers) involved in the process (organizational view; customer view)

- Basic question: Who is doing things?
- Items: Performers, authorizers, customers, organizational units
- Focus: How should resources execute or control a process step?

Informatics – adjustments to the within-process data, information and knowledge needed to support new ways of working

- Basic question: What is the role of data, information and knowledge?
- Items: Data, information and knowledge; data, information and knowledge media
- Focus: What data, information and knowledge content is required and how should it be managed?

IT application – computerized support for data, information and knowledge exchange between a process activity and an application or enterprise database

- Basic question: What activities or decisions are automated?
- Items: Data, information, knowledge and decisions to be supported
- Focus: What IT support is necessary to improve the way work is done?

Environment – alterations to activities carried out at the edge of or outside the process, especially at a process-process interface (external environment view)

- Basic question: How does the process interact or align with other processes?
- Items: Process-process interfaces; process-agent (internal and external) interfaces
- Focus: Integration

(b) Improvement measures: the outcome aimed for by making modifications

Four measures are considered central to an improved business process (Hammer and Champy 1993; Reijers and Mansar 2005; Forster 2006b):

1. Time: The time an activity requires to be executed, from the very beginning to the very end. It comprises service, queue, and wait time. Service time is considered as the amount of time that is actually required to execute the task. Queue time is defined as the time when nothing happens to the transaction as there are no free resources for making progress. Wait time is the time
resources are free but have to stand still due to a lack of synchronization with other processes. Ideally, redesign of a business process decreases the time required to handle a transaction.

2. **Quality**: Quality refers to the “degree to which a set of inherent characteristics fulfils requirements” (ISO 9000). Therefore, quality can only be measured in relation to a requirement. There are several different ways of looking at quality. Quality can be seen as “fitness” perceived by the customer of the process, which is defined as an external quality; or as “operability and reliability” as perceived by the performer who is executing the process. This is called internal quality and refers to the situation when working within the business process. Ideally, redesign of a business process improves the quality of the service delivered.

3. **Cost**: One of the primary ways of measuring business improvement is to look at financial figures of the business – cost and profit. Cost is chosen as we relate to the individual business process; the process cost is largely independent of external factors. Specifically, we refer to two cost sources: the cost of process enactment; and the cost of (process) quality (COQ).

Enactment or operation costs of a process are defined through four categories:

(a) **Human agent costs**: costs associated with salaries and expenses surrounding the process performer and the process supervisor, and other governance and monitoring activities

(b) **Resource costs**: costs associated with facilities such as equipment, utilities, workspaces

(c) **Automation costs**: costs associated with the supporting IT application and data and knowledge base maintenance

(d) **Reliability costs**: costs associated with execution errors (by human agents) and interface or integration misfits

COQ is defined through four categories (PQA 2007; Campanella 1999):

(e) **Internal failure costs**: costs associated with internal losses within the process (e.g. unplanned or undesired problems, losses, lost opportunities, work stoppages, poor productivity, low process reliability, etc.)

(f) **External failure costs**: costs external to the process after it has been executed. These costs are usually discovered by or affect third parties (e.g. customers). Some external costs may have originated from within, or been caused, created by, or made worse by the process being analyzed. They are defined as external because of where they were discovered, or who is primarily or initially affected (e.g., customer complaints, latent defects found by the customer, warranty infractions, etc.)

(g) **Preventive costs**: costs associated with the prevention of future losses (e.g. unplanned or undesired problems, losses, lost opportunities, work stoppages, etc.); costs of all activities specifically designed to prevent poor quality of the process (e.g., planning, mistake-proofing, scheduled maintenance, quality assurance)
(h) **Appraisal costs**: costs associated with measurement and assessment of the process; costs associated with measuring, evaluating or auditing the process to assure conformance to quality standards and performance requirements (e.g., KPIs, inspection, quality check, third party audits, measuring devices, reporting systems, data collection systems, forms)

Ideally, redesign of a business process decreases the cost of its execution.

4. **Flexibility**: A flexible process is characterized by a ready capability to adapt to new, different, or changing requirements and an essential property for the maintenance of fit between business processes, their supporting systems and changing environments. Ideally, redesign of a business process improves its ability to react to variation and to comply with future needs.

(c) **Patterns for process improvement**

As stated in Sect. 13.2, improvement of a business process is achieved by applying a business process improvement pattern – a manipulation or change of the components constituting the business process. These components are organized into the six categories detailed previously: process (actions, decisions, controls); objects (inputs received and outputs provided); organization (performers, customers); informatics (data, information and knowledge support); IT application (computerized support); and environment (process-process). Combining “what to change” with “how to change” results in a set of patterns that can be applied in order to effect an improvement in a business process.

Table 13.1 presents 43 patterns based on Reijers and Mansar (2005) and Forster (2006b). (A more extensive compilation is provided by Reijers and Mansar (2005) and Forster (2006a).) It serves as a guideline or checklist for scanning a process and applying a change which can lead to improvement. Table 13.2 provides some indication of the likely impacts of each pattern on the four improvement measures. Examples of pattern-based improvement are given in Sects. 13.4 and 13.5.

### 13.4 Redesign: Business Process Improvement Procedures

The designer can approach the problem of BPI in three ways:

1. **Type 1 – improvement-invoked procedure**: the designer is cognizant of a required improvement and seeks an appropriate pattern to realize it. For example:
   - **Improvement**: Obtain immediate confirmation from warehouse management that the order has been received
   - **Pattern**: Add a process step or action (pattern #1)
Table 13.1 Business process improvement patterns (based on Reijers and Mansar 1994; Forster 2006b)

<table>
<thead>
<tr>
<th><strong>Process view</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Add a process step or</td>
<td>action</td>
</tr>
<tr>
<td>2 Eliminate a process step</td>
<td>or action</td>
</tr>
<tr>
<td>3 Replace a process step</td>
<td>or action</td>
</tr>
<tr>
<td>4 Decrease the execution</td>
<td>time of a process step</td>
</tr>
<tr>
<td>5 Combine two (or more)</td>
<td>process steps</td>
</tr>
<tr>
<td>6 Resequence two (or more)</td>
<td>consecutive tasks</td>
</tr>
<tr>
<td>7 Parallelize two (or</td>
<td>more) tasks instead of sequencing them</td>
</tr>
<tr>
<td>8 Relocate check/knock-out</td>
<td>task</td>
</tr>
<tr>
<td>9 Resequence two (or</td>
<td>more) check/knock-out tasks</td>
</tr>
<tr>
<td>10 Combine two (or more)</td>
<td>check/knock-out tasks</td>
</tr>
<tr>
<td>11 Parallelize two (or</td>
<td>more) check/knock-out tasks instead of sequencing them</td>
</tr>
<tr>
<td>12 Relocate exception</td>
<td>detection and handling</td>
</tr>
<tr>
<td>13 Relocate exception</td>
<td>detection and handling</td>
</tr>
<tr>
<td>14 Increase transaction</td>
<td>types/tasks processed by process</td>
</tr>
<tr>
<td>15 Decrease transaction</td>
<td>types/tasks processed by process</td>
</tr>
<tr>
<td>16 Increase process scope</td>
<td></td>
</tr>
<tr>
<td>17 Decrease process scope</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Object view</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18 Add some item to the</td>
<td>process input</td>
</tr>
<tr>
<td>19 Eliminate some item</td>
<td>from the process input</td>
</tr>
<tr>
<td>20 Add some item to the</td>
<td>process output</td>
</tr>
<tr>
<td>21 Eliminate some item</td>
<td>from the process output</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Organizational view</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>22 Increase specialization</td>
<td>of process performer</td>
</tr>
<tr>
<td>23 Decrease specialization</td>
<td>of process performer</td>
</tr>
<tr>
<td>24 Assign flexible roles</td>
<td>to perform processes (flexibility/generalize)</td>
</tr>
<tr>
<td>25 Assign fixed roles</td>
<td>to perform processes (centralization/specialize)</td>
</tr>
<tr>
<td>26 Increase the number of</td>
<td>performers carrying out a process</td>
</tr>
<tr>
<td>27 Decrease the number of</td>
<td>performers carrying out a process</td>
</tr>
<tr>
<td>28 Create a new role to</td>
<td>express empowerment</td>
</tr>
<tr>
<td>29 Increase customer</td>
<td>contact in process</td>
</tr>
<tr>
<td>30 Reduce customer contact</td>
<td>in process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Informatics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>31 Add a knowledge resource</td>
<td>to the process</td>
</tr>
<tr>
<td>32 Eliminate a knowledge</td>
<td>resource from the process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>IT view</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>33 Automate a task within</td>
<td>the process</td>
</tr>
<tr>
<td>34 Remove the automation</td>
<td>of a task within the process (difficult or dangerous)</td>
</tr>
<tr>
<td>35 Computerize a reference</td>
<td>document</td>
</tr>
<tr>
<td>36 Computerize a transaction</td>
<td>document</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Location view</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>37 Relocate process control</td>
<td></td>
</tr>
<tr>
<td>38 Rely on the trustworthi-</td>
<td>ness of an existing external agent (e.g., customer, supplier,</td>
</tr>
<tr>
<td>39 Rely on the trustworthi-</td>
<td>applicant) when transacting</td>
</tr>
<tr>
<td>40 Integrate processes by</td>
<td>having a common performer (empower)</td>
</tr>
<tr>
<td>41 Buffer inputs and</td>
<td>outputs to ensure end-to-end continuity of process execution</td>
</tr>
<tr>
<td>42 Allow the process to</td>
<td>deal with batched inputs (homogeneous iterative processing)</td>
</tr>
<tr>
<td>43 Restrict the process to</td>
<td>deal with single inputs (heterogeneous once-through processing)</td>
</tr>
</tbody>
</table>
### Table 13.2 Business process improvement impacts (cf. Reijers and Mansar 1994)

<table>
<thead>
<tr>
<th>Ideas/Impacts</th>
<th>Time</th>
<th>Qual</th>
<th>Cost</th>
<th>Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process view</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Add a process step or action</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>2. Eliminate a process step or action</td>
<td>↓</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3. Replace a process step or action</td>
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<td>↑</td>
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<td></td>
</tr>
<tr>
<td>4. Decrease the execution time of a process step</td>
<td>↓</td>
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<td></td>
</tr>
<tr>
<td>5. Combine two (or more) process steps</td>
<td></td>
<td></td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>6. Resequence two (or more) consecutive tasks</td>
<td>↑</td>
<td></td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>7. Parallelize tasks instead of sequencing them</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>8. Relocate check/knock-out task</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Resequence two (or more) check/knock-out tasks</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Combine two (or more) check/knock-out tasks</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Parallelize two (or more) check/knock-out tasks</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Parallelize end controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Relocate exception detection and handling</td>
<td>↓</td>
<td></td>
<td></td>
<td>↑</td>
</tr>
<tr>
<td>14. Increase transaction types/tasks processed by</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Decrease transaction types/tasks processed by</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Increase process scope</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>17. Decrease process scope</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Object view</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Add some item to the process input</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>19. Eliminate some item from the process input</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>20. Add some item to the process output</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>21. Eliminate some item from the process output</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Organizational view</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Increase specialization of process performer</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>23. Decrease specialization of process performer</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>24. Assign flexible roles to perform processes</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>25. Assign fixed roles to perform processes</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>26. Increase the number of performers carrying out</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>a process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Decrease the number of performers carrying out</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>a process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Create a new role to express empowerment</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>29. Increase customer contact in process</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>30. Reduce customer contact in process</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Informatics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31. Add a knowledge resource to the process</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>32. Eliminate a knowledge resource from the process</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>IT view</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. Automate a task within the process</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>34. Remove the automation of a task within the</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Computerize a reference document</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>36. Computerize a transaction document</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
</tr>
</tbody>
</table>
Table 13.2 Business process improvement impacts (cf. Reijers and Mansar 1994) (continued)

<table>
<thead>
<tr>
<th></th>
<th>Environment view</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>Relocate process control (outside the process)</td>
</tr>
<tr>
<td>38</td>
<td>Rely on the trustworthiness of an existing external agent</td>
</tr>
<tr>
<td>39</td>
<td>Rely on the trustworthiness of a new external agent</td>
</tr>
<tr>
<td>40</td>
<td>Integrate processes by having a common performer</td>
</tr>
<tr>
<td>41</td>
<td>Buffer inputs and outputs to ensure end-to-end continuity</td>
</tr>
<tr>
<td>42</td>
<td>Allow the process to deal with batched inputs</td>
</tr>
<tr>
<td>43</td>
<td>Restrict the process to deal with single inputs</td>
</tr>
</tbody>
</table>

(a) Select a required improvement to be implemented
(b) Determine the dominant measure or measures to be achieved by applying the pattern
(c) Select a pattern through which the improvement could be realized
(d) Select an activity (one or more) to which to apply the pattern
(e) Apply the pattern and revise the flowchart (e.g., Fig. 6.1) and/or PAT (e.g., Table 6.5)

2. Type 2 – *pattern-invoked procedure*: the designer wishes to seek a pattern that can suggest a possible improvement in the process. For example:

- **Pattern**: Add some item to the process input (pattern #18)
- **Improvement**: Record order urgency

(a) Scan the list and select a pattern
(b) Consider how application of the pattern could improve the process
(c) Select an activity (one or more) to which to apply the pattern
(d) Determine the dominant measure to be achieved by applying the pattern
(e) Apply the pattern and revise the flowchart (e.g., Fig. 6.1) and/or PAT (e.g., Table 6.5)

3. Type 3 – *measure-invoked procedure*: the designer wishes to upgrade process performance in terms of one of the four measures. For example:

- **Measure**: Time – reduce the order handling cycle in order to be able to increase the customer/sale agent ratio
- **Improvement**: Transfer pre-emption execution from the sales agent to the order dispatcher
- **Pattern**: Replace a process step or action (pattern #3)

(a) Select a measure to be achieved or improved
(b) Select a pattern through which an improvement could be realized
(c) Select an activity (one or more) which can impact the measure significantly
(d) Apply the pattern and revise the flowchart (e.g., Fig. 6.1) and/or PAT (e.g., Table 6.5)
35 Try to convince customer to accept price

36 Price acceptable?

36.1 Decide whether to escalate

36.2 Escalate?

36.3 Inform customer of escalation

36.4 Explain problem to supervisor

36.5 Transfer call to supervisor

36.6 Try to reach agreement with customer on price

36.7 Retrieve call from supervisor

36.8 Obtain decision from supervisor

36.9 Agreement reached?

(a) Pattern: create a new role to express empowerment (escalate conversation)

8 Check if exceeds customer credit limit

9 Less than credit limit?

9.1 Decide whether credit limit can be personalized

9.2 Possible?

9.3 Register personalized limit for order

9.4 Inform customer of special credit limit for order

(b) Pattern: rely on the trustworthiness of an external agent (extend credit limit of existing customer)

17 Authorize order for execution

17.1 Check if on-order stock from supplier needed

17.2 On-order stock needed?

17.3 Allocate amount needed to customer order

(c) Pattern: parallelize end controls (allocate “on order” stock to customer when authorizing)

Figure 13-1: Redesigned telesales process neighbourhoods
13.5 Redesign Example: Improving the Telesales Process

The original telesales process is detailed in Fig. 6.1 and Table 6.5. Evaluation of the original design (Table 6.7) indicates that the process has some weaknesses, and that some improvements could be made to the process. Table 13.3 highlights these evaluations. Further improvements to the process should also be investigated and, if necessary, introduced.

- Table 13.4 outlines five improvement-invoked improvements stemming from the design evaluation. As a first step the question is asked: what is gained by the improvement? This is followed by selecting a pattern and applying it by redesigning the process flow in the neighborhood of a relevant activity.
- Table 13.5 outlines nine pattern-invoked improvements obtained by selecting nine patterns and asking the question: what improvement can be achieved by applying the pattern? This is followed by applying the pattern by redesigning the process flow in the neighborhood of a relevant activity.
- Table 13.6 outlines four measure-invoked improvements obtained for each of the four improvement measures (Sect. 13.3 (b)). The question is asked: what pattern can help to better performance? This is followed by applying the pattern by redesigning the process flow in the neighborhood of a relevant activity.

The way in which a question is invoked and a solution sought brings to mind the concept of “engineering creativity”.

13.6 A Note on Engineering Creativity

Creativity in engineering is usually defined as the generation of ideas for solving engineering problems (Gurteen 2002). Thus, idea generation is a key component of engineering creativity (McAdam and McClelland 2002). From the time of Osborn (1963) a large number of idea generation methods have been proposed (see, e.g., Smith (1998) for 172 techniques and Mycoted (2007) for 183 techniques). Those most preferred include unorganized techniques such as brainstorming; and organized techniques such as morphological analysis, product checklists and product attribute listing. These demonstrate a juxtaposition of two main approaches: the first unstructured, and the second structured according to the product configuration (Coates et al. 1996; Kelley and Storey 2000; McAdam and McClelland 2002). The overwhelming majority of structured techniques have been applied to product innovation; they include free-association word lists (e.g., Product Improvement Check List (VanGundy 2007)), or forced-association word lists such as product-based (component) checklists and attribute-based (feature) checklists.
### Table 13.3  Improvements indicated as part of a process design evaluation – illustrative example (abstracted from Table 6-7)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomy</td>
<td>Process execution independent of extraneous constraints or other processes</td>
</tr>
<tr>
<td>Control</td>
<td>Sub-processes and/or rules for credit assignment, item substitution, order prioritization</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Various mechanisms provided to maximize success – convincing customers, substituting items, order preemption</td>
</tr>
<tr>
<td>Streamlining</td>
<td>The process is designed to execute efficiently</td>
</tr>
<tr>
<td>Process economy</td>
<td>Knowledge management facilitates credit assessment and order prioritization</td>
</tr>
<tr>
<td>Role balancing</td>
<td>Roles are correctly delineated in terms of scope and authority</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Process restricted to regular selling – no marketing is included</td>
</tr>
<tr>
<td>Empowerment</td>
<td>Performer empowered to set credit limit and to preempt orders</td>
</tr>
<tr>
<td>Escalation</td>
<td>May be required to overcome customer objections</td>
</tr>
<tr>
<td>Robustness</td>
<td>The ability to ensure that the process achieves its aim (in a range of circumstances)</td>
</tr>
<tr>
<td>Validity</td>
<td>Includes actions for creating/modifying/finalizing/authorizing/ transferring the sales order; no confirmation from warehouse management included</td>
</tr>
<tr>
<td>Improvement</td>
<td>The ability to enable the performer himself/herself to continuously improve the process</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>The performer can evaluate whether the “convince” scripts and other stratagems are effective when the customer balks</td>
</tr>
<tr>
<td>Productivity</td>
<td>The performer can suggest refinements such as improved scripts, additional methods (e.g., customer incentives) to increase the likelihood of closing a sale, or the incorporation of cross-sales</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, weaknesses, opportunities, threats in attaining the process goal</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>No mechanisms to provide confirmation from warehouse management</td>
</tr>
<tr>
<td>Opportunities</td>
<td>Improve scripts, add methods (e.g., customer incentives) to increase the likelihood of closing a sale, or incorporate cross-sales</td>
</tr>
<tr>
<td>Threats</td>
<td>Alternative suppliers may offer better conditions (e.g., credit limits)</td>
</tr>
</tbody>
</table>

### Table 13.4  Examples of business process improvements: improvement-invoked

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Measure</th>
<th>Pattern</th>
<th>Activity</th>
<th>Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain immediate confirmation from warehouse management that the order has been received</td>
<td>Quality – increase the reliability of “closing the circuit” end to end</td>
<td>Add a process step or action (1)</td>
<td>Authorize order for execution (17)</td>
<td>Receive order confirmation</td>
</tr>
<tr>
<td>Have a customer agent on immediate call to personalize the credit limit depending on the current situation – customer and items to be purchased</td>
<td>Flexibility – improved CRM</td>
<td>Increase the number of performers carrying out a process (26)</td>
<td>Check standard credit limit for new customer (20)</td>
<td>Performer is the customer agent if indicated by the sales agent</td>
</tr>
<tr>
<td>Escalate the conversation if the customer does not accept the suggested delivery date or price</td>
<td>Flexibility – perhaps the sales supervisor can find an acceptable solution</td>
<td>Create a new role to express empowerment (28)</td>
<td>Try to convince customer to accept price (35)</td>
<td>Escalate conversation if indicated by the sales agent</td>
</tr>
<tr>
<td>Pattern</td>
<td>Improvement</td>
<td>Activity</td>
<td>Measure</td>
<td>Apply</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>Increase the number of performers carrying out a process (26)</td>
<td>Try to convince customer to accept price (35)</td>
<td>Quality – reliability of the process</td>
<td>Change performer from “sales agent” to “order dispatcher”</td>
</tr>
<tr>
<td></td>
<td>Add a KM resource to the process (31)</td>
<td>Try to convince customer to accept date (37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computerize a reference document (35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Add some item to the process input (18)</td>
<td>Ask the customer how urgent the order is</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computerize a reference document (35)</td>
<td>Record order urgency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease the execution time of a process step (4)</td>
<td>Time – contributes to reduction in ordering cycle time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallelize two (or more) knock-out tasks instead of sequencing them (11)</td>
<td>Change driver from “S” to “K(R)”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allow the agent to decide which quote to give first depending on the circumstances of the order</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quote order price (10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quote delivery date (13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexibility – particularize sales strategy to maximize chance of sale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quote price or order date first?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 13.5 Examples of business process improvements: pattern-invoked (continued)

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Improvement</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase process scope (16)</td>
<td>Try to make a cross-sale or up-sale whilst the customer is purchasing goods</td>
<td>Thank customer for order (18)</td>
</tr>
<tr>
<td>Try to make a cross-sale</td>
<td>Rely on the trustworthiness of an existing external agent (e.g., customer,</td>
<td>Empower the sales agent to extend the “standard” credit limit if the customer “reliability” warrants it</td>
</tr>
<tr>
<td></td>
<td>supplier, applicant) when transacting (38)</td>
<td></td>
</tr>
<tr>
<td>Cost – avoid added promotion cost by extra selling during a customer transaction</td>
<td>Check if order/value exceeds customer credit limit (8)</td>
<td>Assess trustworthiness of (existing) customer</td>
</tr>
<tr>
<td>Perform a cross- or up-sale sub-process</td>
<td>Flexibility – particularize credit strategy to maximize chance of sale</td>
<td></td>
</tr>
</tbody>
</table>

Table 13.6 Examples of business process improvements: measure-invoked

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pattern</th>
<th>Activity</th>
<th>Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time – locate time-consuming activity</td>
<td>Replace process step or action (3)</td>
<td>Preempt another customer order (41)</td>
<td>Signal order dispatcher to execute preemption</td>
</tr>
<tr>
<td>Cost – prevention: ensure items on order from supplier not preempted</td>
<td>Parallellize end controls (12)</td>
<td>Authorize order for execution (17)</td>
<td>Assign required amount of “on order from supplier” stock to current order</td>
</tr>
<tr>
<td>Flexibility – flexibilize credit limit to attract new customers</td>
<td>Rely on the trustworthiness of a new external agent (39)</td>
<td>Check standard credit limits for new customers (20)</td>
<td>Assess trustworthiness of (new) customer</td>
</tr>
<tr>
<td>Quality – use incentive to retain new customer (CRM)</td>
<td>Add process step or action (1)</td>
<td>Thank customer for order (18)</td>
<td>Instruct to enclose gift with order (for new customer)</td>
</tr>
</tbody>
</table>

The BPI dimensions described in Sect. 13.3 constitute two lists for forced association:

- The set of improvement patterns stimulates ideas regarding how the improvement can be achieved (equivalent to a component checklist)
- The set of improvement measures stimulates ideas regarding why the improvement should be achieved (equivalent to a feature checklist)

These lists support idea generation and creativity within the three redesign procedures described in Sect. 13.4:

1. Improvement-invoked procedure
   
   (a) Select a required improvement to be implemented
   (b) Determine the dominant measure to be achieved by applying the pattern (stimulus)
   (c) Select a pattern through which the improvement could be realized (stimulus)
   (d) Select an activity (one or more) to which to apply the pattern (ideation)
   (e) Apply the pattern and revise the process (response)
2. Pattern-invoked procedure
   (a) Scan the list and select a pattern (stimulus)
   (b) Consider how application of the pattern could improve the process (ideation)
   (c) Select an activity (one or more) to which to apply the pattern (ideation)
   (d) Determine the dominant measure or measures to be achieved by applying the pattern (response)
   (e) Apply the pattern and revise the process (response)

3. Measure-invoked procedure
   (a) Select a measure to be achieved or improved (stimulus)
   (b) Select a pattern through which an improvement could be realized (stimulus)
   (c) Select an activity (one or more) which can impact the measure significantly (ideation)
   (d) Apply the pattern and revise the process (response)

13.7 Redesign: Incorporating an Improvement into the Process Flowchart and PAT

We illustrate process redesign through three examples from Tables 13.4, 13.5 and 13.6.

- Pattern: Create a new role to express empowerment (28)
- Activity: Try to convince customer to accept price (35)
- Apply: Escalate conversation if indicated by the sales agent

The revised flowchart neighborhood is detailed in Fig. 13.1 (a) and the corresponding PAT is given in Table 13.7 (a).

- Pattern: Rely on the trustworthiness of an existing external agent (e.g., customer, supplier, applicant) when transacting if the agent “reliability” warrants it (38)
- Activity: Check if (order value) exceeds customer credit limit (8)
- Apply: Assess trustworthiness of (existing) customer

The revised flowchart neighborhood is detailed in Fig. 13.1 (b) and the corresponding PAT is given in Table 13.7 (b).

- Pattern: Parallelize end controls (12)
- Activity: Authorize order for execution (17)
- Apply: Assign required amount of “on order from supplier” stock to current order when order authorized

The revised flowchart neighborhood is detailed in Fig. 13.1 (c) and the corresponding PAT is given in Table 13.7 (c).
Table 13.7 Redesigned telesales process activity table (PAT) – illustration

<table>
<thead>
<tr>
<th>Step</th>
<th>Action/decision</th>
<th>Descriptor</th>
<th>Enactor</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a) Escalate conversation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>A</td>
<td>Try to convince customer to accept price</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>D</td>
<td>Price acceptable to customer? (Y go to 12; N go to 36.1)</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>36.1</td>
<td>A</td>
<td>Decide whether to escalate</td>
<td>Sales agent</td>
<td>K (R)</td>
</tr>
<tr>
<td>36.2</td>
<td>D</td>
<td>Escalate? (Y go to 36.3; N go to 23)</td>
<td>K (R)</td>
<td></td>
</tr>
<tr>
<td>36.3</td>
<td>A</td>
<td>Inform customer of escalation</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>36.4</td>
<td>A</td>
<td>Explain problem to supervisor</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>36.5</td>
<td>A</td>
<td>Transfer call to supervisor</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>36.6</td>
<td>A</td>
<td>Try to reach agreement with customer on price</td>
<td>Supervisor</td>
<td>P</td>
</tr>
<tr>
<td>36.7</td>
<td>A</td>
<td>Retrieve call from supervisor</td>
<td>Sales agent</td>
<td>H</td>
</tr>
<tr>
<td>36.8</td>
<td>A</td>
<td>Obtain decision from supervisor</td>
<td>D (U)</td>
<td></td>
</tr>
<tr>
<td>36.9</td>
<td>D</td>
<td>Agreement reached? (Y go to 12; N go to 23)</td>
<td>D (U)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Extend credit limit of existing customer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>Check if exceeds existing customer credit limit</td>
<td>K (R)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Greater than limit? (Y go to 9.1; N go to 10)</td>
<td>K (R)</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>A</td>
<td>Decide whether credit limit can be personalized</td>
<td>Sales agent</td>
<td>K (R)</td>
</tr>
<tr>
<td>9.2</td>
<td>D</td>
<td>Personalization possible? (Y go to 9.3; N go to 23)</td>
<td>K (R)</td>
<td></td>
</tr>
<tr>
<td>9.3</td>
<td>A</td>
<td>Register personalization limit for order</td>
<td>D (U)</td>
<td></td>
</tr>
<tr>
<td>9.4</td>
<td>A</td>
<td>Inform customer of special credit limit for order (Go to 10)</td>
<td>D (R)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c) Allocate “on order” stock to customer when authorizing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>A</td>
<td>Authorize order for execution</td>
<td>D (U)</td>
<td></td>
</tr>
<tr>
<td>17.1</td>
<td>D</td>
<td>Check if on-order stock from supplier needed</td>
<td>D (R)</td>
<td></td>
</tr>
<tr>
<td>17.2</td>
<td>D</td>
<td>On-order stock from supplier needed? (Y to 17.3; N to 18)</td>
<td>D (R)</td>
<td></td>
</tr>
<tr>
<td>17.3</td>
<td>A</td>
<td>Allocate amount to customer order (Go to 18)</td>
<td>D (U)</td>
<td></td>
</tr>
</tbody>
</table>

13.8 Performer Capability: Path to Improvement

BPI usually demands some corresponding improvement in the capability of the process performer. If we study the BPI patterns (Table 13.1) we see they imply, for the performer, an increase in capabilities such as:

- ability to acquire and utilize knowledge (specialization)
- aptitude for decision making (judgment)
- competency to exercise authority (empowerment)
- ability to work within a team (end-to-end process integration)
- competency in utilizing IT (databases) and knowledge systems (knowledge bases) (automation)
Thus, in parallel with the redesign of the process, the designer has to ensure that those responsible for carrying out the process have the capacity to do so. This increase in competency is usually referred to as capability maturity. “Capability is a distinctive attribute of a business unit that creates value for its customers. Capabilities are measured by the value they generate for the organization. Thus capabilities differentiate an organization from others and directly affect its performance” (Balasubramanian et al. 1999). Capability acquisition and achievement in being able to execute a current and then improved process are expressed through a capability maturity model (CMM). We define a capability maturity model as follows, basing ourselves upon definitions posted on the Web (Google 2007): “A capability maturity model is a formal representation of the levels through which an organization evolves as it defines, implements, measures, controls and improves its processes in a particular area of operation. The levels mark out an evolutionary improvement path from an immature process to a mature, disciplined process. The model serves as a guide for selecting process improvement strategies that lead toward a desired level of competency or maturity by facilitating the determination of key elements of current and potential process capabilities and identification of the issues most critical to process quality and improvement. It thus enables the organization to consciously choose a certain target level of maturity, and then to work towards that level”.

A CMM is represented by a table with columns specifying “levels” – the evolutionary improvement path from an immature process to a mature, disciplined process; and rows specifying “dimensions” – the attributes of capability. Each cell in the table indicates the required capabilities for a given attribute at each level. Although there is no theory behind the selection of five levels for a CMM, the precedent set by Crosby (1979), who originated the idea of quality management maturity, and who chose this number of levels for reasons of management intuition, is usually accepted for formulating maturity models. Our performer capability maturity model (PCMM) comprises five levels grounded in the Lean Enterprise Self Assessment Tool (LESAT), an enterprise transformation model developed at MIT (Nightingale and Mize 2002) based upon the process viewpoint of the enterprise. Our five levels of process performer capability are:

- Level 1 – Little or some awareness of process execution and the skills required to do so
- Level 2 – Awareness of process execution and the skills required to do so
- Level 3 – Systematic approach towards process execution and the skills required to do so
- Level 4 – Ongoing refinement and continuous improvement of the skills required for process execution
- Level 5 – Exceptional, well-defined innovative approaches, fully deployed (across internal and external value streams); recognized as best practice
We identify twelve competency dimensions which have to be nurtured in and achieved by the process performer in order to attain the goal of an improved business process:

1. Role allocation: does the performer know which set of activities s/he is expected to carry out?
2. Job description: does the performer know how to carry out the expected set of activities?
3. Process execution: does the performer carry out the process as designed?
4. Consistency: does the performer carry out the process in the same way each time?
5. Empowerment: does the performer have the authority to carry out all steps in the process?
6. Process knowledge: how well does the performer understand the process and its context?
7. Execution skills: what experiential skills does the performer bring to the process?
8. IT/KM skills: what computer and knowledge management skills does the performer bring to the process?
9. Decision-making knowledge: how does the performer obtain the knowledge needed to make decisions?
10. Decision-making and business goals: how much is the performer aware of business goals when carrying out the process?
11. Training (process execution): how extensively is the performer trained in the concept of an enterprise business process suite?
12. Training (BP perspective): how extensively is the performer trained in the concept of a “business process”?

The PCMM is detailed in Table 13.8. The maturation of each dimension is expressed by moving along each row from the “unaware” level through the “innovative” level. For example, the “process knowledge” dimension expresses how well the performer understands the process and its relationship to other processes. Such insight is essential not only to perform the process successfully, but also to ensure that improvements are correctly integrated into the work of the performer. Comprehending a process progresses through five levels:

1. Unaware: can name process; does not understand process; does not know performance levels
2. Aware: somewhat understands process; can describe flow; knows effect on customers and other workers; some idea of performance levels
3. Systematic: understands process; knows effect on other processes; can identify process metrics; knows performance levels
4. Refined: understands process enough to suggest modifications; knows business concepts; knows effect of process performance on enterprise performance
5. Innovative: understands process enough to suggest improvements; knows industry and trends; knows enterprise drivers
<table>
<thead>
<tr>
<th>Level</th>
<th>Unaware</th>
<th>Aware</th>
<th>Systematic</th>
<th>Refined</th>
<th>Innovative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role allocation</td>
<td>Ad-hoc role allocation</td>
<td>Department-based role allocation</td>
<td>Function-based role allocation</td>
<td>Business case-based role allocation</td>
<td>Inter-enterprise coordination-based role allocation</td>
</tr>
<tr>
<td>Job description</td>
<td>No job description</td>
<td>Process-based job description</td>
<td>Function-based job description</td>
<td>Enterprise-based job description</td>
<td>Inter-enterprise-based job description</td>
</tr>
<tr>
<td>Process execution (practice)</td>
<td>Arbitrary practices (personal methods)</td>
<td>Repeatable practices</td>
<td>Standardized practices</td>
<td>Quantitatively managed practices</td>
<td>Continuously improving practices</td>
</tr>
<tr>
<td>Consistency</td>
<td>Performance not consistent</td>
<td>Performance somewhat consistent</td>
<td>Performance consistent</td>
<td>Process consistently performed well</td>
<td></td>
</tr>
<tr>
<td>Empowerment</td>
<td>No empowerment</td>
<td>Limited transaction-based empowerment</td>
<td>Empowerment rationalized across department</td>
<td>Empowerment rationalized across function</td>
<td>Empowerment rationalized across enterprise</td>
</tr>
</tbody>
</table>
| Process knowledge | Can name process  
Does not understand process  
Does not know performance levels | Somewhat understands process  
Can describe flow  
Knows effect on customers and other workers  
Some idea of performance levels | Understands process  
Knows effects on other processes  
Can identify process metrics  
Knows performance levels | Understands process enough to suggest modifications  
Knows business concepts  
Knows effects of process performance on enterprise performance | Understands process enough to suggest improvements  
Knows industry and trends  
Knows enterprise drivers |
| Execution skills | Ad-hoc mechanical skill  
Skilled in problem solving | Skilled at business decision making  
Skilled at self-management | Skilled at process improvement  
Skilled at working in teams | Skilled at change management and change implementation |                                     |
| IT and knowledge management (KM) skills | Mechanical form filling  
No knowledge sources | Some skill at using IT for retrieval and review  
Use of hardcopy knowledge sources | Experienced in using IT for data input and retrieval  
Some skill at using computer-based knowledge sources | Experienced in using IT and DSS  
Experience in knowledge retrieval from KM sources | Expert in utilizing all IT resources: databases, DSS and knowledge bases |
Table 13.8 A capability maturity model for a process performer (continued)

<table>
<thead>
<tr>
<th>Tacit knowledge</th>
<th>Decision-making knowledge (sources)</th>
<th>Decision-making and business goals</th>
<th>Training (process execution)</th>
<th>Training (BP perspective)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No sources provided</td>
<td>No sources provided</td>
<td>Decision-making related to process goals</td>
<td>No training in process execution</td>
<td>No training in the business process concept</td>
</tr>
<tr>
<td>Hard copy guidelines provided</td>
<td>Provided</td>
<td>Decision-making related to departmental goals</td>
<td>Training in specific process execution</td>
<td>Some training in the business process concept</td>
</tr>
<tr>
<td>Decision support system (DSS) aligned with process</td>
<td>Decision-making related to functional goals</td>
<td>Training in departmental process set execution</td>
<td>Function-based training in the business process concept</td>
<td>Enterprise-wide and coordinated training in the business process concept</td>
</tr>
<tr>
<td>Decision support (DSS) imbedded in process</td>
<td>Decision-making related to enterprise goals</td>
<td>Training in functional process set execution</td>
<td>Training in inter-enterprise coordination and collaborative business process concepts</td>
<td></td>
</tr>
</tbody>
</table>

The insight of the process performer into the process attributes progresses in the following way:

- As the process structure is mastered, the performer can eventually suggest modifications and, at a further stage, improvements.
- As the dependencies surrounding the process are better appreciated, the performer becomes more aware that the process affects other processes, customers and workers.
- As the positioning of the process is better perceived, the performer appreciates how process enactment affects process performance and how this performance eventually affects the enterprise.

Using the PCMM, a maturity profile can be constructed for each performer and process combination. This is done by shading the levels achieved by the performer in relation to the process, thus representing his/her current capability level. Table 13.9 (a) shows, for example, the current capability of a process performer. When the process requires redesigning, the designer must specify the new capability levels required – skills, knowledge, training, empowerments and so on. Table 13.9 (b) illustrates the capability level required. The difference between the two tables indicates a possible capability gap (Type III: current capability compared to required capability – see Sect 3.2 (o)). The designer analyzes this gap and formulates a program of training and role enhancement to bridge it. Of course, capability upgrading does not need to wait for an improvement cycle in order to be carried out.
Table 13.9 (a) Capability maturity profile for the telesales process performer (current)

<table>
<thead>
<tr>
<th>Level</th>
<th>Unaware</th>
<th>Aware</th>
<th>Systematic</th>
<th>Refined</th>
<th>Innovative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role allocation</td>
<td>Ad-hoc role allocation</td>
<td>Department-based role allocation</td>
<td>Function-based role allocation</td>
<td>Business case-based role allocation</td>
<td>Inter-enterprise coordination-based role allocation</td>
</tr>
<tr>
<td>Job description</td>
<td>No job description</td>
<td>Process-based job description</td>
<td>Function-based job description</td>
<td>Enterprise-based job description</td>
<td>Inter-enterprise-based job description</td>
</tr>
<tr>
<td>Process execution (practice)</td>
<td>Arbitrary practices (personal methods)</td>
<td>Repeatable practices</td>
<td>Standardized practices</td>
<td>Quantitatively managed practices</td>
<td>Continuously improving practices</td>
</tr>
<tr>
<td>Consistency</td>
<td>Performance not consistent</td>
<td>Performance somewhat consistent</td>
<td>Performance consistent</td>
<td>Process consistently performed well</td>
<td></td>
</tr>
<tr>
<td>Empowerment</td>
<td>No empowerment</td>
<td>Limited transaction-based empowerment</td>
<td>Empowerment rationalized across department</td>
<td>Empowerment rationalized across function</td>
<td>Empowerment rationalized across enterprise</td>
</tr>
</tbody>
</table>
| Process knowledge                   | Can name process
Does not understand process
Does not know performance levels | Somewhat understands process
Can describe flow
Knows effect on customers and other workers
Some idea of performance levels | Understands process
Knows effects on other processes
Can identify process metrics
Knows performance levels | Understands process enough to suggest modifications
Knows business concepts
Knows effects of process performance on enterprise performance | Understands process enough to suggest improvements
Knows industry and trends
Knows enterprise drivers |
| Execution skills                    | Ad-hoc mechanical skill                                                | Skilled in problem solving                                           | Skilled at business decision making
Skilled at self-management                                               | Skilled at process improvement
Skilled at working in teams                                          | Skilled at change management and change implementation |
| IT and knowledge management (KM) skills | Mechanical form filling
No knowledge sources                                                         | Some skill at using IT for retrieval and review
Use of hardcopy knowledge sources                                       | Experienced in using IT for data input and retrieval
Some skill at using computer-based knowledge sources                    | Experienced in using IT and DSS
Experience in knowledge retrieval from KM sources                         | Expert in utilizing all IT resources:
databases, DSS and knowledge bases                                     |
**Table 13.9 (a) Capability maturity profile for the telesales process performer (current) (continued)**

<table>
<thead>
<tr>
<th>Decision-making knowledge (sources)</th>
<th>Tacit knowledge</th>
<th>No sources provided</th>
<th>No guidance provided</th>
<th>Decision support system (DSS) aligned with process</th>
<th>Decision support system (DSS) imbedded in process</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Decision-making and business goals</th>
<th>Decision-making related to process goals</th>
<th>Decision-making related to departmental goals</th>
<th>Decision-making related to functional goals</th>
<th>Decision-making related to enterprise goals</th>
<th>Decision-making related to inter-enterprise goals</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Training (process execution)</th>
<th>No training in process execution</th>
<th>Training in specific process execution</th>
<th>Training in departmental process set execution</th>
<th>Training in functional process set execution</th>
<th>Training in interface process set execution</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Training (BP perspective)</th>
<th>No training in the business process concept</th>
<th>Some training in the business process concept</th>
<th>Function-based training in the business process concept</th>
<th>Enterprise-wide and coordinated training in the business process concept</th>
<th>Training in inter-enterprise coordination and collaborative business process concepts</th>
</tr>
</thead>
</table>

**Table 13.9 (b) Capability maturity profile for the telesales process performer (improved)**

<table>
<thead>
<tr>
<th>Level</th>
<th>Unaware</th>
<th>Aware</th>
<th>Systematic</th>
<th>Refined</th>
<th>Innovative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role allocation</td>
<td>Ad-hoc role allocation</td>
<td>Department-based role allocation</td>
<td>Function-based role allocation</td>
<td>Business case-based role allocation</td>
<td>Inter-enterprise coordination-based role allocation</td>
</tr>
<tr>
<td>Job description</td>
<td>No job description</td>
<td>Process-based job description</td>
<td>Function-based job description</td>
<td>Enterprise-based job description</td>
<td>Inter-enterprise-based job description</td>
</tr>
<tr>
<td>Process execution</td>
<td>Arbitrary practices (personal methods)</td>
<td>Repeatable practices</td>
<td>Standardized practices</td>
<td>Quantitatively managed practices</td>
<td>Continuously improving practices</td>
</tr>
<tr>
<td>(practice)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistency</td>
<td>Performance not consistent</td>
<td>Performance somewhat consistent</td>
<td>Performance consistent</td>
<td>Process consistently performed well</td>
<td></td>
</tr>
<tr>
<td>Empowerment</td>
<td>No empowerment</td>
<td>Limited transaction-based empowerment</td>
<td>Empowerment rationalized across department</td>
<td>Empowerment rationalized across function</td>
<td>Empowerment rationalized across enterprise</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Process knowledge</th>
<th>Can name process</th>
<th>Somewhat understands process</th>
<th>Understands process enough to suggest modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Does not understand process</td>
<td>Can describe flow</td>
<td>Knows effects on other processes</td>
</tr>
<tr>
<td></td>
<td>Does not know performance levels</td>
<td>Knows effect on customers and other workers</td>
<td>Can identify process metrics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some idea of performance levels</td>
<td>Knows performance levels</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Execution skills</th>
<th>Ad-hoc mechanical skill</th>
<th>Skilled at business decision making</th>
<th>Skilled at process improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skilled in problem solving</td>
<td>Skilled at self-management</td>
<td>Skilled at working in teams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IT and knowledge management (KM) skills</th>
<th>Mechanical form filling</th>
<th>Some skill at using IT for data input and retrieval</th>
<th>Experienced in using IT and DSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No knowledge sources</td>
<td>Use of computer-based knowledge sources</td>
<td>Experience in knowledge retrieval from KM sources</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision-making knowledge (sources)</th>
<th>Tacit knowledge</th>
<th>No sources provided</th>
<th>Hard copy guidelines provided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No guidance provided</td>
<td>Decision support system (DSS) aligned with process</td>
<td>Decision support system (DSS) imbedded in process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision-making and business goals</th>
<th>Decision-making related to process goals</th>
<th>Decision-making related to departmental goals</th>
<th>Decision-making related to functional goals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decision-making related to enterprise goals</td>
<td>Decision-making related to inter-enterprise goals</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training (process execution)</th>
<th>No training in process execution</th>
<th>Training in specific process execution</th>
<th>Training in functional process set execution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Training in interface process set execution</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training (BP perspective)</th>
<th>No training in the business process concept</th>
<th>Some training in the business process concept</th>
<th>Enterprise-wide and coordinated training in the business process concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Training in inter-enterprise coordination and collaborative business process concepts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The PCMM, and its application as a performer-process capability profile, serves four important functions:

(a) The model (Table 13.8) delineates the path along which process performers can advance – and, together with them, the organization – and acquire mastery in carrying out their tasks both in the current and improved versions of the process. It identifies aspects of skill, knowledge and experience which can serve as the basis for both employee evaluation and training.

(b) The current profile (Table 13.9 (a)) provides the designer and the organization with a snapshot of the abilities of each employee within his/her job framework and indicates where reinforcement is required for better performance.

(c) The upgraded profile (Table 13.9 (b)) provides the designer with an instrumentality for specifying the desired qualifications of the process performer which are necessary to enable him/her to perform the improvements introduced into the process.

(d) The upgraded profile (Table 13.9 (b)) also constitutes a framework for planning a training program to bridge the capability gap. The benefits of this framework are clearly stated in the two extensive quotations set out in the following section.

13.9 A Discourse on Business Process Training

Decision Focus (2007) expresses the strong belief “that the only way to realize benefits from business process improvement is when the relevant people have been trained to operate processes and systems in the best possible way. Training can only be effective if it is targeted to achieve the requirements of the people receiving the training and the objectives of the organisation”. … A three-phased approach is used to design and deliver tailored training programs:

- Analyze the needs of each person’s role against his/her current skills and knowledge. Evaluation criteria are established to define the required level of performance to be achieved after the training.
- Use the training needs analysis to ensure that the training delivery itself is focused on the business needs and the real world. Review working practices and procedures, target the training on the job role and consolidate the training with real-life exercises.
- Evaluate the relevance of the training event to the business environment, i.e. whether the knowledge, skills and understanding acquired during the training prove of value to the user in performing his/her job better or more quickly.

Cochran (2001) emphasizes that “ISO 9001:2000 now mandates that training be based on competency needs. Competence is defined by ISO 9000:2000 as the demonstrated ability to apply knowledge and skills. In other words, it specifies the condition that enables a person to carry out a task in a manner that meets the required performance standard.
"Many employees can be grouped together based on common roles and job functions; two employees with different job titles won’t necessarily have different competency requirements. The converse is also true: Personnel working in the same area, doing ostensibly the same job, may actually have differing competency requirements. The bottom line is that organizations need to break down existing paradigms regarding the way work is performed and who performs it. It is helpful to think about the organization as a series of processes rather than as a collection of departments. The determination of competency requirements is often an eye-opening exercise when performed in a thoughtful manner.

"Once competency needs have been determined for the full range of personnel performing work affecting quality, the organization must compare individuals to the competency needs for their functions and identify where gaps exist. Training and other actions are then applied where they are actually needed, based on the gaps in competency. This approach can result in significant cost savings because it eliminates unnecessary training. The approach also sends a valuable signal to employees that the management understands the needs of a given job or function and is willing to ensure that employees possess the requisite education, training, skills and experience to succeed in their roles.

"ISO 9001:2000 also mandates awareness training on the relevance and importance of an employee’s activities and how they contribute to reaching quality objectives. This is more complex than it sounds. Awareness training of this sort, when correctly applied, will have three results: First, employees will have a full understanding of the measurable objectives their departments or functions are trying to achieve; second, employees will understand how their actions – whether packing boxes, driving a forklift or processing contracts – contribute on a day-to-day basis in working toward their area’s measurable objectives; and, finally, employees will gain a “big picture” understanding of the organization and its competitive environment, which is a perspective that is often lacking at all but the highest levels”.

13.10 Performer Capability and Training – Telesales Example

We apply the lessons of Sect. 13.9 in the following way:

- Table 13.9 (a) displays the profile of the sales representative corresponding to the requirements of the current telesales process (Fig. 6.1, Table 6.5). The agent functions at the “aware” level for most dimensions, reflecting recognition of the importance of sales and customer contact; and at the “unaware” level in terms of goal orientation and the conceptualization of a “business process” (see Sect. 8.4).
- The designer wishes to move the representative to the “systematic” level (Table 13.9 (b)) for most dimensions, with the aim of expanding his/her perspective to encompass the total sales function and increasing his/her ability to use managed knowledge within the process.
The new profile serves as the basis for a training program to accompany the implementation of the improved process. The topics outlined in Table 13.10 set out the desired profile, and suggests two sets of topics – one generalized for all employees at this level, and one specialized for the specific process involved – to create an individualized program for the sales agent.

**Table 13.10** Telesales example: training topic outline on the basis of desired capability maturity

<table>
<thead>
<tr>
<th>Level</th>
<th>Systematic</th>
<th>General training topics</th>
<th>Specific training topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role allocation</td>
<td>Function-based role allocation</td>
<td>Role concepts in the framework of an enterprise function</td>
<td>Jobs within the sales function</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Job definition of the performer</td>
</tr>
<tr>
<td>Job description</td>
<td>Function-based job description</td>
<td>Job concepts in the framework of an enterprise function</td>
<td>Jobs within the sales function</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Job definition of the performer</td>
</tr>
<tr>
<td>Process execution (practice)</td>
<td>Standardized practices</td>
<td>Concepts of standardized operations and operational metrics</td>
<td>Standardized pass-through handling of customers and orders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concepts of standardized service levels and service metrics</td>
<td>Exception and escalated handling of customers and orders</td>
</tr>
<tr>
<td>Consistency</td>
<td>Performance consistent</td>
<td>Concepts of operational consistency and consistency metrics</td>
<td>Consistency in handling customers and orders</td>
</tr>
<tr>
<td>Empowerment</td>
<td>Empowerment rationalized across departments</td>
<td>Concepts of departmental decision-making centers</td>
<td>Decision-making centers within the sales department</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Process-performer empowerment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decision sharing</td>
</tr>
<tr>
<td>Process knowledge</td>
<td>Understands process</td>
<td>Process flowcharting</td>
<td>Sales function process set and interactions</td>
</tr>
<tr>
<td></td>
<td>Knows effects on other processes</td>
<td>Concepts of cross-function processes</td>
<td>Metrics for sales-related processes</td>
</tr>
<tr>
<td></td>
<td>Can identify process metrics</td>
<td>Process interactions and sources of interaction</td>
<td>Service levels of sales-related processes</td>
</tr>
<tr>
<td></td>
<td>Knows performance levels</td>
<td>Concepts of process metrics</td>
<td>Service levels for the telesales process</td>
</tr>
<tr>
<td>Execution skills</td>
<td>Skilled at business decision making</td>
<td>Concepts of business decision making</td>
<td>Decision-making within the sales department</td>
</tr>
<tr>
<td></td>
<td>Skilled at self-management</td>
<td>Concepts of self-reliance and self-management</td>
<td>Simulation of business cases and decision making</td>
</tr>
<tr>
<td><strong>Table 13.10</strong> Telesales example: training topic outline on the basis of desired capability maturity (continued)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>IT and knowledge management (KM) skills</strong></td>
<td>Experienced in using IT for data input and retrieval Some skill at using computer-based knowledge sources</td>
<td>Concepts of knowledge and knowledge management Concepts of inline and out-of-line data and knowledge sources Concepts of retrieval and review of sources</td>
<td>Inline and out-of-line data and knowledge sources available to the process performer Sales-related review of retrieved sources</td>
</tr>
<tr>
<td><strong>Decision-making knowledge (sources)</strong></td>
<td>Decision support system (DSS) aligned with process</td>
<td>Concepts of decision support systems</td>
<td>DSS available to the process performer (credit, available to promise, substitute items, order prioritization)</td>
</tr>
<tr>
<td><strong>Decision-making and business goals</strong></td>
<td>Decision-making related to departmental goals</td>
<td>Concepts of business goals and processes as a means for goal realization</td>
<td>Sales goals and their relationship to the telesales process</td>
</tr>
<tr>
<td><strong>Training (process execution)</strong></td>
<td>Training in departmental process set execution</td>
<td>Concepts of teamwork (within the department)</td>
<td>Enumeration of department process set Simulation of process set execution Participation in process set execution</td>
</tr>
<tr>
<td><strong>Training (BP perspective)</strong></td>
<td>Some training in the business process concept</td>
<td>Introduction to the business process concept</td>
<td></td>
</tr>
</tbody>
</table>

### 13.11 Designer Capability: The Path to Improvement

Fisher (2004, 2005) points out that a process-driven organization has to move the organization from inefficient functional “silos” to a highly efficient and effective cross-enterprise organization. In Fisher’s terms, the company has to migrate from these silos – operating solely within the context of departments (or at best functions) and optimizing their own piece of the organization – towards aligning strategy and governance across the whole enterprise to provide end-to-end effective solutions. Moreover, information also tends to be siloed in such organizations as well (often with each entity being supported by its own set of information systems), yielding slow responses to ever-changing conditions. From the process design viewpoint, this migration means that processes cannot be assumed to act independently; the designer has to be attentive to the overall context in which a process operates in order to ensure that improvements are aligned with related processes; that the relevant managers and operatives have been consulted (and agreement reached); and that the required IT and knowledge support is available within the enterprise IT framework. We term this the “design focus”.
Our designer capability maturity model (DCMM) characterizes the design focus and the proficiency required of the process designer. It reflects the scope of process–process alignment and interaction; end-to-end process chains; business goals and performance metrics along the organizational hierarchy; organizational involvement in Business Process Management at various levels; and the nature and extent of IT support at the local and enterprise levels. The designer must be fully responsive to the design environment: within which organizational grouping or unit s/he functions (e.g., working alone as an expert or advisor, or in a team as a member of the Enterprise Process Authority); and what requirements and constraints must be taken into account when setting design strategies and parameters. It is up to the designer, on the one hand, and enterprise management or the Enterprise Process Authority, on the other, to ensure that the designer has acquired the required qualifications and has been granted the necessary access and authority to carry out his mission. We define five levels, based upon Fisher’s Business Process Maturity Model (Fisher, 2004) and a widening perspective of enterprise processes:

- Level 1 Silo – focus on a single process
- Level 2 Department – focus on all processes within the department
- Level 3 Function – focus on all processes within the function
- Level 4 Enterprise – focus on all processes within the enterprise
- Level 5 Network – focus on all interfacing processes along the supply chain

We identify eight contextual dimensions which have to be considered by the process designer in order to attain the goal of an improved business process:

1. Authority: who else beside the designer has a say in process design, redesign and authorization?
2. Integration and coordination: what other processes within the enterprise have to be considered by the designer?
3. Management: who is the process owner and who is responsible for managing the process?
4. Metrics and evaluation: how is the process performance evaluated; and how does this impact the process design?
5. IT support and fit to process: what IT support is available for the process; can the process and IT work seamlessly together; does available IT support place limitations on the process?
6. Process alignment: what features of what processes must the designer take into account: inputs, outputs, database content and status, knowledge base content and status, inter-process dependencies and relative execution sequence, triggering; collaboration in process execution?
7. Strategy and goals: what department, function, enterprise and inter-enterprise goals influence or dictate the process strategy and goals?
8. Improvement management: what are the driving forces for process improvement and who or what is behind these forces?
The DCMM is detailed in Table 13.11. The maturation of each dimension is expressed by moving along each row from the “silo” level through the “networking” level. For example, the “authority” dimension expresses with whom the designer has to consult in order to specify and obtain approval for the process. Such contact is essential not only to ensure that improvements are correctly integrated within the process suite, but also that cooperation is achieved when enacting end-to-end process chains. Accrediting and endorsing a process specification and design progresses through five levels:

1. **Silo**: the designer alone is responsible for designing and approving the process
2. **Department**: the designer is part of a department team and must take departmental policies into account in his/her design; the team is responsible for approving the process
3. **Function**: the designer is part of a function team and must take function policies into account in his/her design; the team is responsible for approving the process
4. **Enterprise**: the designer acts within the framework of an Enterprise Process Authority, which is ultimately responsible for all process maintenance and approval
5. **Network**: the designer acts within the framework of a collaborative inter-enterprise process authority, which is ultimately responsible for maintenance and approval of all inter-enterprise process interfaces

Insight into the design frame of reference progresses in the following way:

- As the dependencies between processes are better understood, the designer must consult a growing circle of designers and approvers who may influence modifications and improvements in the process
- In particular, as the localized perspective gives way to an ever-widening cross-department, cross-function, cross-enterprise and lastly trans-enterprise perspective, the designer needs to pay more and more attention to the nature of inputs, outputs, database updating, knowledge base updating and process-process interfaces to ensure consistency along the end-to-end process chain

### 13.12 Designer Capability: An Example of Design Focus Maturation

To illustrate the idea of design focus maturation we utilize a simplified enterprise model for the Wholesale Industry based on the corresponding SAP business solution (SAP 2004). The Wholesale capstone model and its decomposition for the “Sales” functionality are given in Table 13.12. From a consideration of our basic process to be redesigned: “Outbound order acquisition” (including “Availability check”) we distinguish the interdependencies – linked processes or sub-functions – to be considered at each of the subsequent four levels (Table 13.13).
### Table 13.11 A capability maturity model for the process designer (based on Fisher 2004)

<table>
<thead>
<tr>
<th>Level</th>
<th>Silo (design focus: single process)</th>
<th>Department (design focus: cross-department)</th>
<th>Function (design focus: cross-function)</th>
<th>Enterprise (design focus: cross-enterprise)</th>
<th>Network (design focus: supply chain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority (specification)</td>
<td>Subject matter expert: understanding and maintenance of specific process</td>
<td>Departmental process team: understanding of cross-department process needs and dependencies</td>
<td>Function-based process team: understanding of cross-function process needs and dependencies</td>
<td>Enterprise process authority: specifies and maintains all core processes</td>
<td>Inter-enterprise process authority: specifies and maintains all interface processes</td>
</tr>
<tr>
<td>Integration and coordination</td>
<td>Processes are performed independently; each performer does something different</td>
<td>Processes are performed cooperatively within the department Integration within departmental domain</td>
<td>Processes are performed cooperatively within the function Integration within functional domain</td>
<td>Processes are performed collaboratively within the enterprise Integration within enterprise domain</td>
<td>Processes are performed collaboratively with partners Bi-directional integration within partner domain (suppliers &amp; customers)</td>
</tr>
<tr>
<td>Management</td>
<td>Process owner authority and autonomy</td>
<td>Departmental authority and autonomy</td>
<td>Functional authority and autonomy</td>
<td>Enterprise-wide enterprise process authority (EPA) Business process management system in place</td>
<td>Inter-enterprise process teams Supply chain management system in place</td>
</tr>
<tr>
<td>Metrics and evaluation</td>
<td>No metrics (or: metrics tied to process performance) Evaluated by process owner</td>
<td>Metrics tied to departmental performance Evaluated by departmental management</td>
<td>Metrics institutionalized and tied to functional performance Evaluated by function level management</td>
<td>Metrics institutionalized and tied to enterprise performance Evaluated by the EPA</td>
<td>Collaborative metrics tied to bi-directional partner performance</td>
</tr>
<tr>
<td>IT support and fit to process</td>
<td>Independent or legacy systems No alignment with process</td>
<td>Independent systems Poor alignment with processes</td>
<td>Function-based ERP system module Some alignment with processes</td>
<td>Enterprise-based ERP system Full alignment with all processes</td>
<td>Supply chain management (SCM) system Full alignment with interface processes and inter-enterprise communication</td>
</tr>
<tr>
<td>Process alignment</td>
<td>No alignment with other processes</td>
<td>Alignment with other departmental processes</td>
<td>Alignment with other function processes</td>
<td>Total cross-enterprise process alignment</td>
<td>Total trans-enterprise interface process alignment</td>
</tr>
</tbody>
</table>
### Table 13.11 A capability maturity model for the process designer (based on Fisher 2004) (continued)

<table>
<thead>
<tr>
<th>Strategy and goals</th>
<th>Process goals</th>
<th>Departmental goals</th>
<th>Function goals</th>
<th>Enterprise goals</th>
<th>Business partner goals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No alignment</td>
<td>Some alignment</td>
<td>Some alignment</td>
<td>All processes</td>
<td>All processes</td>
</tr>
<tr>
<td></td>
<td>with other</td>
<td>with function goals</td>
<td>with enterprise goals</td>
<td>aligned with enterprise goals</td>
<td>aligned with business partner goals</td>
</tr>
<tr>
<td></td>
<td>goals</td>
<td>goals</td>
<td>goals</td>
<td>goals</td>
<td>goals</td>
</tr>
<tr>
<td>Improvement management</td>
<td>Limited</td>
<td>Departmental</td>
<td>Functional</td>
<td>EPA leads</td>
<td>Inter-enterprise</td>
</tr>
<tr>
<td></td>
<td>concept of</td>
<td>management leads</td>
<td>management leads</td>
<td>in process</td>
<td>process team leads</td>
</tr>
<tr>
<td></td>
<td>process</td>
<td>in process</td>
<td>in process</td>
<td>improvement</td>
<td>in process improvement</td>
</tr>
<tr>
<td></td>
<td>improvement</td>
<td>improvement</td>
<td>improvement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 13.12 Wholesale industry capstone model and function decomposition for the “Sales” function (based on SAP 2004)

<table>
<thead>
<tr>
<th><strong>Sales</strong></th>
<th><strong>Enterprise management</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>Sales planning and account management</td>
</tr>
<tr>
<td>Customer service</td>
<td>Sales planning and forecasting</td>
</tr>
<tr>
<td>Field sales</td>
<td>Account and contact management</td>
</tr>
<tr>
<td>Telesales</td>
<td>Credit management</td>
</tr>
<tr>
<td>Internet sales</td>
<td>Opportunity management</td>
</tr>
<tr>
<td>Stationary sales</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Sales planning and account management</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td><strong>Customer service</strong></td>
<td>Showroom management</td>
</tr>
<tr>
<td><strong>Field sales</strong></td>
<td>Inquiries and quotations</td>
</tr>
<tr>
<td><strong>Telesales</strong></td>
<td>Order acquisition</td>
</tr>
<tr>
<td><strong>Internet sales</strong></td>
<td>Product recommendation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Capstone</strong></th>
<th><strong>Sales</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterprise management</strong></td>
<td><strong>Sales planning and account management</strong></td>
</tr>
<tr>
<td>Strategic enterprise management</td>
<td>Sales planning and forecasting</td>
</tr>
<tr>
<td>Corporate governance</td>
<td>Account and contact management</td>
</tr>
<tr>
<td>Managerial accounting</td>
<td>Credit management</td>
</tr>
<tr>
<td>Financial accounting</td>
<td>Opportunity management</td>
</tr>
<tr>
<td>Business analytics</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Sales</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Sales planning and account management</td>
<td>Showroom management</td>
</tr>
<tr>
<td>Field sales</td>
<td>Sales planning and forecasting</td>
</tr>
<tr>
<td><strong>Enterprise management</strong></td>
<td>Account and contact management</td>
</tr>
<tr>
<td><strong>Field sales</strong></td>
<td>Credit management</td>
</tr>
<tr>
<td><strong>Telesales</strong></td>
<td>Opportunity management</td>
</tr>
<tr>
<td><strong>Internet sales</strong></td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Sourcing and product management</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Supplier management</td>
<td>Showroom management</td>
</tr>
<tr>
<td>Product management</td>
<td>Sales planning and forecasting</td>
</tr>
<tr>
<td><strong>Customer service</strong></td>
<td>Account and contact management</td>
</tr>
<tr>
<td>Product safety</td>
<td>Credit management</td>
</tr>
<tr>
<td>Procurement</td>
<td>Opportunity management</td>
</tr>
<tr>
<td><strong>Order and service management</strong></td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Telesales</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td><strong>Internet sales</strong></td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Supply chain planning</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Strategic planning and optimization</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td>Demand and supply planning</td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Distribution planning</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td>Transportation planning</td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td><strong>Order and service management</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Order management</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td>Value-added services</td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Global trade</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td>Legal services</td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td><strong>Supply chain execution</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Inventory management</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td><strong>Field sales</strong></td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Assembly</td>
<td>Incentive and commission management</td>
</tr>
<tr>
<td>Warehouse management</td>
<td>Pricing, discounts and rebates</td>
</tr>
<tr>
<td>Distribution and fulfillment</td>
<td>Incentive and commission management</td>
</tr>
</tbody>
</table>
### Table 13.12 Wholesale industry capstone model and function decomposition for the “Sales” function (based on SAP 2004) (continued)

<table>
<thead>
<tr>
<th>Business support</th>
<th>Fixed asset management</th>
<th>Employee transaction and life cycle management</th>
<th>Financial supply chain management</th>
<th>Availability check</th>
<th>Order status and tracking</th>
<th>Product recommendation</th>
<th>Collaborative selling</th>
<th>Stationary sales</th>
<th>Store inventory management</th>
<th>Customer order and billing</th>
<th>Staff management</th>
<th>Store controlling</th>
<th>Promotion management</th>
</tr>
</thead>
</table>

### Table 13.13 Design focus levels for the process “Inbound order acquisition”

<table>
<thead>
<tr>
<th>Level 1: process</th>
<th>Level 4: enterprise (“Wholesale”) (linked functions and sub-functions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbound order acquisition</td>
<td>Sales</td>
</tr>
<tr>
<td>Availability check (included in process)</td>
<td>Sales planning and account management</td>
</tr>
<tr>
<td>Level 2: department (“Telesales”) (linked processes)</td>
<td>Customer service</td>
</tr>
<tr>
<td>Outbound order acquisition</td>
<td>Field sales</td>
</tr>
<tr>
<td>Product proposal</td>
<td>Telesales</td>
</tr>
<tr>
<td>Inquiries and quotations</td>
<td>Internet sales</td>
</tr>
<tr>
<td>Level 3: function (“Sales”) (linked processes)</td>
<td>Stationary sales</td>
</tr>
<tr>
<td>Sales planning and account management</td>
<td>Sourcing and product management</td>
</tr>
<tr>
<td>Credit management</td>
<td>Procurement</td>
</tr>
<tr>
<td>Opportunity management</td>
<td>Order and service management</td>
</tr>
<tr>
<td>Pricing, discounts and rebates</td>
<td>Order management</td>
</tr>
<tr>
<td>Customer service</td>
<td>Supply chain execution</td>
</tr>
<tr>
<td>Complaint processing</td>
<td>Inventory management</td>
</tr>
<tr>
<td>Field sales</td>
<td>Distribution and fulfillment</td>
</tr>
<tr>
<td>Inquiries and quotations</td>
<td></td>
</tr>
<tr>
<td>Order acquisition</td>
<td></td>
</tr>
<tr>
<td>Product recommendation</td>
<td></td>
</tr>
<tr>
<td>Telesales</td>
<td></td>
</tr>
<tr>
<td>Inbound order acquisition</td>
<td></td>
</tr>
<tr>
<td>Outbound order acquisition</td>
<td></td>
</tr>
<tr>
<td>Product proposal</td>
<td></td>
</tr>
<tr>
<td>Inquiries and quotations</td>
<td></td>
</tr>
<tr>
<td>Internet sales</td>
<td></td>
</tr>
<tr>
<td>Online quoting</td>
<td></td>
</tr>
<tr>
<td>Online ordering</td>
<td></td>
</tr>
<tr>
<td>Price management</td>
<td></td>
</tr>
<tr>
<td>Credit check</td>
<td></td>
</tr>
<tr>
<td>Stationary sales</td>
<td></td>
</tr>
<tr>
<td>Promotion management</td>
<td></td>
</tr>
</tbody>
</table>

### Level 5: network (suppliers and customers) (linked functions and sub-functions)

<table>
<thead>
<tr>
<th>Sales</th>
<th>Field sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telesales</td>
<td>Internet sales (“Collaborative selling”)</td>
</tr>
<tr>
<td>Stationary sales</td>
<td>Sourcing and product management</td>
</tr>
<tr>
<td>Procurement</td>
<td>Supply chain planning</td>
</tr>
<tr>
<td>Supply chain planning</td>
<td>Demand and supply planning</td>
</tr>
<tr>
<td>Demand and supply planning</td>
<td>Distribution planning</td>
</tr>
<tr>
<td>Distribution planning</td>
<td>Transportation planning</td>
</tr>
<tr>
<td>Transportation planning</td>
<td>Order and service management</td>
</tr>
<tr>
<td>Order and service management</td>
<td>Global trade</td>
</tr>
<tr>
<td>Global trade</td>
<td>Supply chain execution</td>
</tr>
<tr>
<td>Supply chain execution</td>
<td>Warehouse management</td>
</tr>
<tr>
<td>Warehouse management</td>
<td>Distribution and fulfillment</td>
</tr>
</tbody>
</table>
At level 2 (Telesales, as a whole) the designer should, for example:

- Ensure that inbound and outbound sales are consistent in the conditions offered to the customer
- Note that customers may have made previous inquiries about the sales item
- Note that customers may have previously received a proposal for the sales item

At level 3 (Sales, as a whole) the designer should, for example:

- Be acquainted with credit conditions and how they are administered and updated
- Be acquainted with pricing and discounts, how they are formulated and updated
- Note that customers may have previously registered complaints
- Ensure that the various channels – telesales, field sales and Internet sales – are consistent in the conditions offered to the customer
- Make sure that gridlock does not occur on checking availability when the same item is offered at the same time to different customers by more than one agent or through more than one channel

At level 4 (Enterprise, as a whole) the designer should, for example:

- Ensure that all sales channels are consistent in how products are promoted, how inquiries are handled, how credit is appraised and what delivery terms are offered to customers
- Be acquainted with conditions under which items being procured can be considered as available to promise
- Be acquainted with conditions under which orders are dispatched and distributed to customers

At level 5 (the supplier-wholesaler-customer network) the designer should, for example:

- Ensure that the methods through which orders are recorded, confirmed, authorized and transferred for execution are consistent for all sales channels, as customer may submit inquiries or order items through more than one channel
- Determine how demand and supply planning can be integrated with the delivery dates promised to customers
- Determine how distribution and transportation planning can be integrated with the delivery dates promised to customers

13.13 Summary

Business process improvement – often termed business process re-engineering – is an ongoing activity vital to the well-being and progress of a process-centered organization. In this chapter we have concentrated on the three aspects directly
involved in improving a business process: (a) the process itself; (b) the process performer; and (c) the process designer. We have described and demonstrated several tools in these three areas:

(a) **Process redesign**: the redesign procedure is based upon the responses to three questions:

- **What** can be modified (the process, inputs, outputs, organization, data, information, knowledge, automation, interfaces)?
- **Why** should it be modified (decreased operation time, reduced cost, increased quality, augmented flexibility)?
- **How** is it modified (stimuli: needed process improvement, needed performance improvement, ideated process improvement; response: find and apply a BPI pattern to achieve the required objective)?

Our central mechanism is the novel _BPI pattern_, introduced by Forster (2006a; 2006b): a set of generic transformations of one or more of the modifiable elements in the process.

(b) **Enhancement of process performer capability**: specification of the capabilities demanded of the process performer is based upon the responses to three questions:

- **What** capabilities are required (responsibilities, skills, expertise, decision making, training)?
- **When** are these capabilities required (staged and heightened awareness of the importance of the process and the skills required to execute it)?
- **How** is the performer to obtain these capabilities (individualized training program based upon capability gaps)?

Our central mechanism is the _capability maturity model_, which recognizes that organizations are not “ideal”, that capabilities are acquired incrementally, and that competence should be aligned with the demands of the task at hand. Many business process capability maturity models have appeared in the literature (see, for example, Fisher (2005); Hammer (2007)), but their emphasis is on the process context, rather than on the process itself or those concerned with its execution.

(c) **Enhancement of process designer capability**: specification of the capabilities demanded of the process designer is based upon the responses to three questions:

- **What** capabilities are required (access, authority, teamwork, strategy, integration, management)?
- **Where** are these capabilities required (focus on a single process through focus on intra- and inter-enterprise processes)?
- **Who** must provide these capabilities to the designer (the designer, the enterprise process authority, enterprise management)?
Our central mechanism is again the capability maturity model, which has been adapted to the idea of design focus – the scope of enterprise business activity to be taken into account when redesigning an individual process. It recognizes that processes are, to a lesser or greater extent, interdependent, and that competence should be aligned with the demands of the various departments, functions and business partners interacting inside and outside the enterprise. Many explicit or implicit enterprise or inter-enterprise maturity models have appeared in the literature (see, for example, Hammer (2007); Santana Tapia et al (2007)), but their emphasis is on the total organization, rather than on the process itself or those concerned with its redesign.

Problems

1. In Sect. 13.13 we have illustrated a four-level design focus maturation analysis for the telesales process within the framework of a Wholesale enterprise, starting from the process being redesigned: “Outbound order acquisition”.
   (a) Carry out a four-level design focus maturation analysis for another process from the “Telesales” main function.
   (b) Carry out a four-level design focus maturation analysis for a process from another main function within the “Sales” major function.

2. In Sect. 13.13 we have illustrated a four-level design focus maturation analysis for the telesales process within the framework of a Wholesale enterprise.
   (a) Select a process from the “Hotel Front Desk” reference model (Table 3.2) and perform a two-level analysis: (1) process within main function; (2) process within major function (“Hotel Front Desk Management”).
   (b) Repeat the exercise selecting processes from different main functions.
   (c) Select a process from the “Purchasing” reference model (Table 3.3) and perform a two-level analysis: (1) process within main function; (2) process within major function (“Procurement/Purchasing”).
   (d) Repeat the exercise selecting processes from different main functions.

3. In Sect. 13.8 two examples have been given of a redesigned neighborhood within the telesales process flowchart and process activity table (PAT).
   (a) Carry out an independent redesign of the relevant process neighborhood for each of the improvements detailed in Tables 13.4, 13.5 and 13.6.
   (b) Is it possible to incorporate all the improvements together into the telesales process?
   (c) Would this create an unnecessarily complex process?
   (d) Do some of them create contradictions when redesigning a process neighborhood?
(e) How could improvements be prioritized if it is felt that not all of them can be implemented at one time?
(f) Ultimately, could this lead to the creation of more than one telesales process?

4. We have termed one of our change foci “Informatics” (Sect. 13.3 (a)), covering data, information and knowledge. The number of definitions of the terms “data”, “information” and “knowledge” is almost as large as the number of authors contributing to the field (Allweyer 1998). In the context of business process informatics we utilize the following definitions:

- “Data is a set of discrete, objective facts” (Abecker et al. 2002).
- “Information is data that has been organized or given structure – that is, placed in context and thus endowed with meaning” (Glazer 1991).
- “Knowledge is information combined with experience, context, interpretation and reflection … that is ready to apply to decisions and actions”. Moreover, “knowledge is best understood as the capacity to take effective action … the action is effective when it produces the anticipated and desired results” (Davenport et al. 1998).

(a) Would you regard these as three separate concepts? If so, what is the difference?
(b) Is there a difference between a data base and a knowledge base?
(c) Is there a difference between data management and knowledge management?
(d) Is there a difference between IT support for data and IT support for knowledge?
(e) Would a process performer be trained differently to deal with data, information or knowledge?
(f) Is there a difference in approach to the following three actions? Do they dictate different approaches to handling data, information and knowledge?

- Filling out a form (e.g., a customer order)
- Reviewing past history (e.g., previous sales to a customer)
- Deciding which path to take in a process (e.g., whether to increase the customer credit limit above the standard amount)

5. One of the measures of process performance is time (Sect. 13.3 (b) (1)), comprising service time, queue time (no resources available) and wait time (lack of synchronization with other processes). If we study the first three suggested improvements to the telesales process (Table 13.4) we have:

- “Obtain immediate confirmation from warehouse management that the order has been received”
  - Although this is intended to improve quality, it adds wait time as the process now waits for the warehouse to confirm
• “Have a customer agent on immediate call to personalize the credit limit depending on the current situation – customer and items to be purchased”
  ▪ Although this is intended to increase flexibility, it adds wait time as the process now waits for the customer agent to respond

• “Escalate the conversation if the customer does not accept the suggested delivery date or price”
  ▪ Although this is intended to increase flexibility, it adds queue time if the supervisor is not available to take the call

(a) Examine each of the improvements detailed in Tables 13.4, 13.5 and 13.6. Determine their impacts on one or more elements of cycle time – service, wait and queue.
(b) Repeat this with quality as the process measure.
(c) Repeat this with flexibility as the process measure.
(d) Repeat this with cost as the process measure.

6. One of the measures of process performance is flexibility (Sect. 13.3 (b) (4)). However, one of the aims of process maturity is standardization (Table 13.8: dimension: process execution; level: systematic). Each has different objectives, often contradictory.

(a) What are the aims of process flexibility?
(b) What are the aims of process standardization?
(c) When is one approach preferable to another?
(d) Can the two approaches be reconciled?

7. The five maturity levels (Table 13.8) in our process performer maturity model – “unaware”, “aware”, “systematic”, “refined”, “innovative” – are based on the LESAT model (see Sect. 13.8). Other published business process maturity models provide other names for these levels. For example: “siloed”, “tactically integrated”, “process driven”, “optimized enterprise”, “intelligent operating network” (Fisher 2004); “initial state”, “defined”, “repeated”, “managed”, “optimized” (Harmon 2005); “initial state”, “managed”, “standardized”, “predictable”, “optimizing” (Weber et al. 2005).

(a) Use an Internet search to find these and other business process maturity models.
(b) Examine and discuss the maturity levels proposed in each model.
(c) Try to define the maturity concept behind each of these models – i.e. what specifically is “maturing” in each model?
(d) Does there seem to be a consensus about what constitutes business process maturity?
(e) Does there seem to be a consensus about what constitutes a business process maturity model?
(f) If not, what is the contribution of each model to the concept of “process maturity?”
8. Cochran (Sect. 13.9) states emphatically that “once competency needs have been determined for the full range of personnel performing work affecting quality, the organization must compare individuals to the competency needs for their functions and identify where gaps exist. Training and other actions are then applied where they are actually needed, based on the gaps in competency”.

(a) Do you agree that individual training is the most effective way to mature the capability of a process performer?
(b) What are the drawbacks of this approach to training?
(c) Would modularization of training topics, as illustrated in Table 13.10, constitute an effective compromise between individuated and group training?

9. Business process improvement is often referred to as business process “optimization”. Local optimization implies that an individual process is brought to the level of “best practice”; whilst global optimization implies that the end-to-end chain functions at its best, even though some of the constituent processes may be sub-optimal. For example, the process incorporating “Obtain immediate confirmation from warehouse management that the order has been received” is sub-optimal, as wait time has been introduced; however, it increases the reliability of the process chain in delivering a customer order.

(a) Does global optimization always imply sub-optimality in some constituent process(es)?
(b) Does local optimization always imply sub-optimality in the process chain?
(c) How is local optimization, versus global optimization, linked to design focus maturity (Table 13.11)?

10. In the process designer capability maturity model (Table 13.11), the design focus ranges from a single process, through cross-department, cross-function and cross-enterprise processes, to the supply chain. Design thus involves process, the performer, various levels of management, IT, and IT personnel. This raises the following question: should the designer best be:

- a member of the department staff (e.g., telesales)?
- a member of the function staff (e.g., sales)?
- a member of the enterprise staff (e.g., EPA – Enterprise Process Authority)?
- a member of the IT staff?
- an external consultant, expert in the industrial sector with which the enterprise is associated?
- an external consultant, expert in business process modeling and management?

Discuss the advantages and disadvantages of each affiliation.
Appendix: Simulating Process Life Cycles: Serious Games as Teaching Aids

A.1 The Use of Simulators for Training

Simulations are recognized as an efficient and effective way of teaching and learning complex and dynamic systems. Using simulators as a teaching tool is widespread, both in academic areas and in business areas. The gaming approach, utilizing interactive media and/or simulation, has been shown to be effective in improving teaching and learning of various subjects (Hsieh et al. 2004). A simulation-based teaching environment creates the conditions that give the user the ability to acquire experience and consider the previous results (Nahvi 1996). There are some well-known advantages in using simulations as a learning means (Thompson et al. 1997). Simulators are characterized as tools enabling the acquisition of practical experience and acceptance of an immediate response of the learned system to the user’s decisions and actions. The nature of an online device yields a higher level of efficacy than traditional lectures (Nguyen and Pascal 2002). The advantages of using simulation-based training include the reduction of the gaps between the learning environment and the “real” environment, and the availability of training in situations that are difficult to obtain and practice in the “real world.” Simulations promote active learning, especially at the stage of debates that arise because of the complexity, interconnectedness, and novelty of decisionmaking. Additionally, simulations develop critical and strategic thinking skills. The skills of strategic planning and thinking are not easy to develop and the advantage of simulators is that they provide a strong tool for dealing with this problem (Wolfe 1993). Commercial simulators are commonly used (Wankat 2002).

In previous chapters we have described several aspects of the operations and process viewpoints: in particular, integrated production and order management (Chaps. 9 and 10). In this appendix we study the lifecycle of operations and processes through the medium of an interactive educational game.

A.2 The Order Life Cycle

The order process lifecycle comprises the following main steps (compare Table 10.1):
1. Strategic planning and control (management view)
2. Sales cycle management (marketing view)
3. Purchasing/procurement cycle management (purchasing view)
4. Operations cycle management (production view)
5. Inventory cycle management (material view)
6. Delivery cycle and BPM management (delivery view)

### A.3 MERP™-Background

The Dynamic Case Study Simulator – MERP™ (Management Enterprise Resource Planning) – is a teaching aid designed to facilitate the teaching of integrated operations of a business organization, with a focus on corporate performance management. It is based on the ERP concepts of a model base, a data base and integrated functions. The model base contains well-known models such as exponential smoothing, MRP, inventory management (reorder point model), rough-cut capacity planning, scheduling and sequencing. These models can be applied at any time or can be used in an automatic decisionmaking mode.

The simulator operates in the following way: customer orders are generated from a “virtual” market and are registered automatically. They are then transferred to the production department and work orders are generated. These permit the automatic release of appropriate materials to the shop floor and assign the relevant machines to work on them. In parallel, the purchasing department has to maintain the inventory levels of the required materials. The machines or work centers process the orders; and on completion, orders are stored until the delivery (due) date. The orders are then shipped automatically to the customers who pay upon receipt.

Unlike the usual static, written case studies, MBE Simulations provide students with a Serious Game product named: Dynamic Case Studies Scenarios (DCSS™), reflecting a live business environment, and computerized scenarios that they must manage and thereby control the destiny of their own business operations. Students participate in a virtual organization made real and dynamic as minute-by-minute business events and conditions unfold. They must respond and make complex managerial decisions in real time based on the big picture view.

While traditional strategic business games deal with results on a periodic basis (i.e., monthly, quarterly or yearly), the MERP™ experience involves real-time execution of strategies and their results, reflected in Corporate Performance Management (CPM). Students can integrate theory into practice while they learn to test, retest, think and rethink constantly, while dealing with various real-life, dynamic situations.
A.4 Functional Views

The simulated company is driven by five main functions or views through which the user can access information and set or change policies and procedures. Each view represents a department within the simulated company and contains information about that department: marketing, production, purchasing, finance and management. Similar to an ERP or IPOM system, all views have to be coordinated in order to obtain the best results.

- **Marketing view** (Fig. A.1): This is where linkage to customers is maintained. The market is usually noted for the critical importance of maintaining an adequate due-date performance and clearly favors faster response time and, of course, reduced prices. Marketing policy is based on the commitment to ship every order within a quoted lead time. Demand is increased when the quoted lead time and/or the selling price are reduced. Uncertainty is introduced through market demand: the number of orders received is random.

- **Production view** (Fig. A.2): This incorporates the shop floor, where transformation of raw materials into finished goods takes place. There are four work centers. Production planning and control is provided by an internal information system, which produces work-orders based on the exact order quantities received, and the planning parameters as set by the user. Operations policy is based on make-to-order, without safety stock. Uncertainty is introduced through the exact timing of the production machine operations.

Fig. A.1 The Marketing functional view
Purchasing view (Fig. A.3): Here raw material control is performed. Usually there is more than a single vendor. The faster vendor is typically more expensive. Purchasing policy is based on purchase-to-stock and managed according to maximum-order levels. Uncertainty is introduced through response time of suppliers.

Finance view (Fig. A.4): This tracks the financial status of the company. It does not incorporate policies or actions. Customers pay upon receipt of goods; suppliers are paid on delivery. Interest is earned on the cash held at the bank. A monthly profit and loss statement informs the user how well (or badly) he/she is doing financially.

Management view: Here overall performance is displayed through three main KPIs (Key Performance Indicators): reputation, cash and profit. The importance of reputation (percentage of on-time orders) is that customers are unhappy if they receive their orders later than the promised date. When orders are late or missed the company’s reputation declines. When the reputation is low, future market demand declines. More detailed KPIs in various business processes (Supply Chain Management, Marketing and Management) are dynamically presented in various graphs (see Fig. A.5).
A.4 Functional Views

**Fig. A.3** The Purchasing functional view

Here is where the company purchases the materials. You will notice that each box represents a different material. Placing the mouse over the material’s box shows open orders from suppliers, detailing Supplier’s name, quantity ordered, date of order and promised arrival date.

The information displayed shows the quantity On order (580) and the available stock On hand (203).

**Fig. A.4** The finance functional view

This is the P&L statement for January detailing Income, expenses and the calculated profit.
A.5 DCSS™ Scenarios

MERP™ consists of a whole suite of differing scenarios covering practices at various levels of complexity and scope. Focusing on individual departments (such as Production, Purchasing and more), different industrial business processes (Make-to-stock versus Make-to-order), and the fluctuation of customer orders and client contracts, allows the use of different management models for inventory purchasing and replenishment (e.g., Materials Resources Planning (MRP) or “Order-up to inventory with order level policy”).

These DCSS™ scenarios illustrate aspects of integrative IPOM and ERP and include:

(a) **Department-focused DCSS™ scenarios**

- **Production orientation (TSCProduction):** This focuses on the shop floor where users manage a one-product, four-machine production line. The setup allows them to experience production efficiency with various random characteristics and the basic concepts of balancing a production line.
- **Purchasing orientation (TSCPurchasing):** Here users have to contend with a stochastic demand for two raw materials (with limited shelf life) from one supplier to meet the material requirements of a single final product. The goal here is to make supply meet demand while keeping costs down.
• *Operations orientation (TSCOperations)*: This scenario combines production and purchasing through the manufacture of two final products. Users need to develop policies for dispatching, MRP scheduling, run frequencies and alignment between purchasing and shop floor needs.

(b) *Organization focused DCSS™ scenarios (see Fig. A.6)*

• *Marketing-operations orientation (TSC)*: Marketing demand impact is added to the production and purchasing aspects. Users may change marketing policies to increase customer demand. The challenge is to obtain maximum profit without hurting the company’s reputation. The scenario incorporates all the TSC Operations scope with additional marketing demand impact. Students may change marketing policies to increase customer demand. They are challenged to balance the whole organization value-chain resources aimed at increasing profit. The challenge is to obtain maximum profit without harming the company’s reputation.

• *MRP orientation (TSCMRP)*: This scenario enables the user to switch from the “reorder point purchasing model” of the TSC scenario to the MRP inventory replenishment mechanism. It enables students to practice the mechanism, and to learn how to understand and gain control over the various fluctuating events that affect this sensitive mechanism.

• *ERP/MRP orientation (ERP/MRP)*: This is a real semi-complex environment with a fairly good integrative information system. The company sells three different products, based on four raw materials and produced by six different machines. It faces a highly uncertain market demand, with a big seasonal peak.

<table>
<thead>
<tr>
<th>Function</th>
<th>DCSS™ scenario</th>
<th>Production</th>
<th>Purchasing</th>
<th>Marketing</th>
<th>Customers demand</th>
<th>Client Contracts</th>
<th>Complexity level (1–3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The TSC Production</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>The TSC Purchasing</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The TSC Operations</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The TSC</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The TSC MRP</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The ERP MRP</td>
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<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>3</td>
</tr>
</tbody>
</table>

*Fig. A.6 DCSS™ scenarios*
In all these DCSS™ scenarios the user needs to ask three critical questions: How should he/she set the information system parameters for optimal results? What information supports the planning process? What information is needed to support the control process? Another critical element is how effectively the information and coordination help make decisions that follow high-quality principles of production planning and control, such as pull production, lean manufacturing, and constraint-based flows. For example, if the marketing manager wants to increase sales, he/she has to first consult the production manager to check whether there is enough resource capacity to handle the increased production orders. He/she also needs to consult the purchasing manager to determine whether there is sufficient raw material inventory to handle this potential increased production on time. Finally, the financial manager will have to evaluate whether sales are indeed increased in the longer term, and, if they are, whether they generate more profit and a better market reputation, or only increase costs and diminish customer satisfaction. The user may prefer to increase short-term sales by sacrificing reputation. In this case, the company may generate large profits in the short time, but at the same time, lose customers.

A.6 How MERPTM Provides Value

MERPTM is based on the following principles:

- A case study scenario approach – MERPTM is based on simulation by case studies. Details of these case studies are built into the simulation and all the data required for analysis and decisionmaking is easily accessed through the user interface.
- A simulation approach – MERPTM simulates an actual IPOM system. Models of job shops and flow shops are built into it. The simulation is controlled by a simple user interface and no knowledge of simulation or its languages is required.
- A model based approach – A decision support system is built into MERPTM. This system is based on the ERP concepts of a model base and a data base. The model base contains well-known models: exponential smoothing, MRP, inventory management (a reorder point model), rough-cut capacity planning, scheduling and sequencing. These models can be consulted at any time or can be used in an “automatic” decisionmaking mode.
- A suite of evolving decision case studies (DCSS™) – MERPTM provides seven different scenarios. Three of them are aimed at zooming into a specific department: Production, Purchasing and Operations. The other four provide a holistic, simple view of more complex situations of an integrated ERP system. The scenarios can be used as a curriculum for learning, either individually or all together.
• **Dynamic decisionmaking and reflection** – A Web-enabled business simulation allows the student to make continuous decisions; effects of market and external responses are immediately invoked through a dynamic dashboard of various KPI (Key Performance Indicator) outcomes.

• **Integrated cause and effect** – Relationships between the various decisions across all departments are described. Four functions and a management view are represented in the MERPTM: Marketing, Production, Purchasing and Finance. The four functions are integrated by the simulation, the database and the model base. Thus, decisions made by any of the four functions affect the state of the simulated system and the database.

• **Effective execution atmosphere** – The dynamics of modern competitive business is reflected here. A random effect is introduced to simulate the uncertainty in the environment, and decisions made by the user cause changes in the simulation.

• **Easy to learn and run** – MERPTM is designed as a teaching and training tool. As such, its user interface is friendly and easy to learn. Although quite complicated scenarios are simulated, and the decision support tools are sophisticated, a typical user can learn how to use the MERPTM within a few hours, as only the most important features of a real ERP system are available.

### A.7 Benefits to Students

• **Practical real world insights** – Better positioning students to compete in the job market and bringing academic business theory to life.

• **Combining operational management models with actual practice**: forecasting, inventory replenishment management, dispatch policy management, applied costing theory, and more.

• **Macro and micro understanding** – Viewing the big picture of a global organization, as well as coping with detailed operations management issues.

• **Uncertainty is the truest business reality** – MERPTM enables students to dictate the managerial policies for running a manufacturing company in the face of uncertainty, as in real business life.

• **Cause and effect thinking** – Students see the big picture and truly understand the effects of their operational management and collaborative business policies on their business results.

• **Realistic dynamic decisionmaking** – Based on daily events that affect the organizational outcomes. Students must choose when and which decisions to make in parallel with the evolving KPI status.

• **Reinforced learning** – Unlimited practice runs, enabling testing, and retesting, either at the university or in free time at home. Students can log in and run scenarios repeatedly, always learning from mistakes and thus improving their business acumen.

• **Competition based on shared online results** (optional) – Students compete in random scenarios reflecting turbulent daily business life.
A.8 Tools Available to Students and Professors

The reader of this book is referred to the following link: www.mbe-sim.com/book or the enclosed CD, which details how to access and use the MERP™ simulator. Those in need of more information or wishing to purchase the full package, may contact MBE-Simulations Ltd. directly at book-support@mbe-sim.com.

A.9 How to Get to Know the MERP™ Tool and the Various Scenarios

The MERP™ solution provides very effective videos and flash tutorials, enabling students to learn in less than an hour how to run the virtual organization, although their time devoted to learning OM and increasing CPM results will take much, much longer.

For supporting quick takeoff, it is suggested to first explore the videos. These five demo videos, varying from 2 to 9 min each, will demonstrate the flow as well as examples of dynamic management. We highly recommend watching the videos; viewing time is about 24 min for all five videos. We recommend first going through the flash tutorial “MERP Essential Tutorial” that lasts about 13 min; and then, the scenarios – specific tutorials that you will practice. This will add about 10 more minutes to each scenario. Figure A.7 demonstrates a screen from the flash tutorial.

Fig. A.7 The board room
The videos and the tutorials can be accessed from within the MERP™-Guide portal. The MERP™-Guide portal link is available at each of the pull down menus in the MERP simulator.

A.10 The Registration Process

A.10.1 Licensing Agreement

Please read and agree to the following before installing the simulator (MERP™ program).

By installing or using the MERP™ program you acknowledge that you have read and agreed to the following terms and limitations. In the case that you do not agree to any part of the agreement, do not install or use the software.

MBE Simulations Ltd. grants the owner of the book “ERP: the Dynamics of Supply Chain and Process Management,” by Avraham Shtub and Reuven Karni, a limited featured license for one installation of the MERP™ program on one PC only, to be used only once. The coupon inserted in the book by the publisher involves a total of up to 4 h of use or a maximum of a 3-month period of times, whichever is reached earlier.

The simulator is a web-enabled program; and as such it requires an Internet connection as well as enabling the communication of the simulator program with the MBE simulation server. It is the user’s responsibility to remove all communication obstacles caused by the PC (such as firewalls, etc.) that prevent the communication between the PC and the server. The usage time will be monitored by the MBE simulation server.

Use of the program is limited to personal learning only; and as such it is forbidden to copy or reproduce it through a LAN or other network system or through any computer subscriber system. Any commercial use of this version of the software is strictly prohibited. Use of this version of MERP™ in any kind of workshop, in class or through a classroom presentation, or any other public presentation, is forbidden unless a special license from MBE Simulation Ltd. is obtained in advance. Universities, consultants, management learning centers and educators who wish to use MERP™ as a tool in courses, workshops, or commercial presentations are encouraged to obtain a license from MBE Simulations Ltd. at sales@mbe-simulations.com.

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A.10.2 How to Start?

The MERPTM is a Web-enabled technology – therefore, you should be connected to the Internet while using it and you should also install a part of the software – the client part – on your PC. (Apple/Mac versions are not available.) Please allow sufficient time when switching scenarios, or any other activity that might require the communication for transferring data. It might take a number of minutes to establish proper communication each time such activities are required. The time delay varies depending on the Internet traffic and the speed of your Internet connection.

Please follow the instructions in the following sections carefully. Note that these instructions are also available on the CD as soft copy.

A.10.3 Registration

Step 1 – Go to the following link: www.mbe-sim.com/registration.
Step 2 – In the first registration page enter the unique user key from the CD or the coupon provided in the book, and type the letters that are written on the verification image.
Step 3 – In the second registration page fill in the required personal details. You will be able to assign a personal log-in username and password. The log-in username and password are used for activating the program.
Step 4 – You will receive registration confirmation. Later, you will receive an e-mail confirming your sign-on data.

Note: This process can be performed only once. This promotional limited license is limited to up-to 4 h of use or a maximum of 3-month period time, whichever is reached earlier. The license is provided for one installation only.

A.10.4 Installing the Client and Running the Simulator

(a) Install the Setup program by double clicking on merp_setup.exe file in the attached CD; or download the program from the following URL: www.mbe-sim.com/merp
(b) Follow the instructions to install the program. At the end of the installation, a MERPTM icon will appear on your desktop.
(c) Now run the program by clicking on the MERP icon. The software will open a window asking you to register yourself. As you have already done so, close this screen and provide your personal ID and your password.

(d) Choose the scenario you would like to run.

### A.11 General Notes

- Today, most organizations restrict access to their network from a distant site by protecting themselves with firewalls. As passing these firewalls is difficult if not impossible, we suggest allowing the firewall to access our programs and server. Please note that the simulator will NOT work through any firewall, including personal firewalls. If you have more technical expertise, you should only enable the following programs to access the internet: MERP.exe, MerpUpd.exe, Appwiz32.exe as well as allowing ports 20 and 21.

- Please remember that this is a Web-enabled technology; therefore the server might be busy at certain points. As we are committed to constantly improving our product and services, we might need to update our program from time to time. Should you be unable to log on, please try again after a few minutes.

- For the MERPTM guide, we recommend that you use the Internet Explorer browser, as some features might not function properly on other browsers.

- The simulator runs under Windows XP. The recommended screen resolution is 1024 × 768 and normal font size.
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**CD content**

- The registration instructions as a soft copy (more convenient then the hard copy in the appendix).
- Useful information about how to teach by example by Professor G. Vastag.
- Learning and academic benefits
- A thorough background regarding the learning platform
- DCSS™ scenarios suite description

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The book’s scenarios and features were carefully chosen to satisfy the needs of this book. However, the version provided by this book is limited in usage period and time.

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