SYSTEMS
AND INDUSTRIAL ENGINEERING SERIES

E-Enabled Operations Management

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Contents

Preface

Although the theory of operations management has been presented in many textbooks published over the last two decades, the subject of e-enabled operations management is rather short on literature which is easily accessible to students. When they want to gain some understanding of what it is all about, students are obliged to search journals and select papers from a large number of books. Even then they will find it difficult to arrive at a uniform view of the matter.

The objective of this book is to expound the subject at an "intermediate" level. By "intermediate", it is not assumed that students are specialists in mathematics and statistics, but it is supposed they have a working knowledge of calculus, algebra, probability and statistics.

The approach to operations management described in this book is unusual with respect to what is found in standard textbooks. Information and communication technologies (ICTs) impact the ways firms are organized and managed, and, as a result, change the practical means used to conduct business operations.

The features of this book are threefold.

– *system approach to business modeling*

Business activities, controlling functions and associated information systems are described within a coherent analytical system framework enabling a clear understanding of the various current control and costing concepts. Operations costing is not usually included in textbooks as part of operations management, but it should be. Cost targeting has become an integral part of good practice of business management.

– *validity of models*

Apparently simple models are analyzed in detail. Students must be completely aware of the assumptions made when models are formulated and of their conditions of validity. Applying a model automatically implies that assumptions of a particular type are taken for granted.

– *logistics, procurement and quality management*

These three business functions are critical key success factors for managing e-enabled supply chains from suppliers to customers. That is why their main tools are introduced in this book.

Jean-Pierre BRIFFAUT
May 2015

Part 1

Modeling of Business Structures

1

System Approach to Business Operations and Information Engineering

1.1. System approach to conduct business operations

1.1.1. *General considerations*

The system approach is instrumental in tackling complexity in the managerial as well as technical worlds. The system concept is a modeling tool based on interacting entities. Its purpose is to understand complex structures by (de)composing them into entities having specific functions and interacting with each other.

The "composition" approach is implemented when designing a real or virtual object. The "decomposition" approach is implemented when analyzing some existing part of the world.

In both approaches, systems are constructed with a view to identifying certain function capabilities perceived by the users to be desirable. Examples of function-based systems include: defending the country, transmitting messages, transporting people and goods, manufacturing goods, exchanging products and services, etc.

In general, users are known not to be able to articulate all their requirements and expectations. Therefore, at the planning stage, there always exists a considerable uncertainty about many aspects of the system to be built, or, in other words, the system behavior. That explains why prototypes

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have to be built for checking whether the users' requirements are adequately fulfilled.

Systems do not exist in isolation. Each operates within a definite environment. But the ways a system interacts with its environment may prove to be of a wide variety. In other words, how and when some types of interaction take place have to be ascribed to uncertain or random events. As a result in certain circumstances, the system behavior can run out of control. These circumstances refer to events or sequences of events which have not been taken into account at the design stage of the system.

1.1.2. System description

Describing a system implies:

– describing its constituent entities as attributes;

– describing the inter-entity relationships;

– describing the relationships between entities and the environment.

Each entity can be a system in itself.

When a business unit is described as a system, the purpose is to control its business operations. Three entities have to be identified, i.e. the controlled system, the controlling system and the information system (IS). The controlled system, often called the transformation system, because it converts inputs into outputs, is modeled generally as a process. The relationships between these three entities are shown in Figure 1.1.

It is noteworthy to elaborate on Figure 1.1 for understanding the features of the system approach to business description. What is meant by direct and indirect control? Direct control refers to the direct action on the controlled process to maintain or change its state. Indirect control resorts to some entity external to the system for influencing the state of the controlled process by means of inputs.

Let us take an example to explain how the messages exchanged between the entities involved are articulated and how their contents trigger decisions. The controlled process is assumed to be a manufacturing process made of storage and production activities. A message coming from the market place (environment data) is captured and processed by the IS. The message content says that a market slump is forecast. It is directed to the production scheduler in an appropriate format (control data). As a consequence, the scheduler decides to reduce the production level by releasing orders to the manufacturing shops (direct control) on the basis of inventory levels (process data) and to send orders to suppliers to decrease the number of deliveries (indirect control).

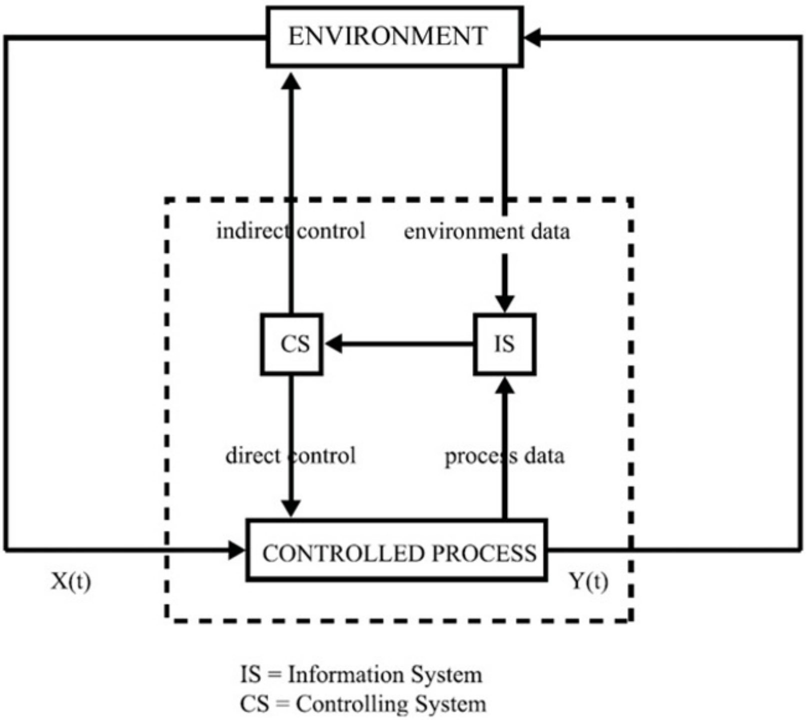

Figure 1.1. *Relationships between the various entities of a business unit within the framework of a system approach*

Describing any business organization as a system means:

– identifying and modeling the system to be controlled (WHAT);

– identifying decision-making functions (WHO) and defining management rules (HOW);

– producing the IS requirement.

1.2. Information engineering

1.2.1. *Information as a resource*

Central to any human activity is the process of *decision-making*, i.e.:

– defining a goal;

– identifying a number of alternative *actions* which may lead to the goal;

– evaluating the consequences of each action;

– selecting the action which is most likely to lead to the desired goal.

The decision maker, in general, faces uncertainty mainly about the results of the envisaged action. Decisions vary in uncertainty associated with their outcomes. The greater the uncertainty, the greater the risk of a negative outcome. This uncertainty can be reduced or even completely removed by obtaining the relevant information about the courses of action in progress. It follows that information is defined as a resource by means of which uncertainty is reduced.

For large systems, as a rule, a part of the required information on the behavior of system environment becomes available only after the system has been put in operation. For this reason, there is a need for incorporating a control function of a sort into the very system. The role of control is to make decisions on the system behavior effective. When some deviation from the set goals is detected corrective control action is engineered to reach the set goals.

1.2.2. *Explicit and implicit information*

Information may be explicit or implicit. Implicit information or know-how is that piece of information which is an integral part of skill and can be gained only by apprenticeship from an expert. The term "expert" is used here to denote a person who knows how to perform an activity without necessarily understanding why his/her methods work. In contrast, explicit information or know-how exists independently from any skill. It can be readily represented, stored and made available for general use.

1.2.3. *Clarification of some terms*

The body of knowledge, methods and established practices related to the handling of information as well as the associated devices will be called *information technology*. Systems of artifacts, the purpose of which is to handle information will be called here *information systems*. The engineering discipline concerned with the design, production, installation, operation and maintenance of ISs will be called *information engineering*.

1.2.4. *Characteristics of information systems*

It is quite clear that no organization could operate without some type of IS. The main functional capabilities an IS must fulfill are:

– capturing data;

– processing data;

– memorizing data.

These are followed in order to support the decision makers to conduct business operations.

– *Contents of an information system*

Even if users are not aware of this fact, IS designers posit that ISs are a modeled vision of the business universe. Whatever the assumptions made about the chosen representation of the business universe, IS constructs reflect how the enterprise is organized and operates. It implies that business information systems contain, in a way or another, a description of the enterprise's organizational structures, functioning mechanisms and deliverables. The contents of business information system include:

– static properties of operations and controls;

– description of deliverables (products or services);

– dynamic behavior of operations.

Several types of ISs are considered in businesses.

– *Transaction processing systems*

A transaction is a business operation modifying the state of the enterprise. Whenever a transaction occurs, data describing the transaction is created. Capturing, storing, processing, distributing and reporting of transaction data is the objective of transaction processing systems.

Let us consider an example. When a client places an order, an order form is created where the order content is described in terms of items, quantities and delivery dates and payment conditions. This order triggers updating of the inventory, sending an invoice, launching the manufacturing of new items, recording provisional income in the balance sheet, etc.

Somehow transaction processing systems are the front office of management information systems (MISs)

– *Management information systems*

MISs must give a relevant, accurate, significant and updated image of business activities and incoming and outcoming goods flows. Today, this is achieved by means of artifacts (software programs and databases) modeling the activities and goods flows involved.

1.2.5. *Information system content for a manufacturing company*

The IS content comprises the models representing the business from different points of view (processes/functions/organization). As an example, the products/services delivered, the control pattern and the infrastructure can be modeled for a manufacturing company as shown in Figure 1.2.

1.3. System approach to describing inventory-controlled storage

Storage is a buffer activity decoupling inflows of materials from outflows. Materials consist of raw materials, finished products, goods in progress and any type of supplies held by business firms. Inflows and outflows are usually controlled by different business functions.

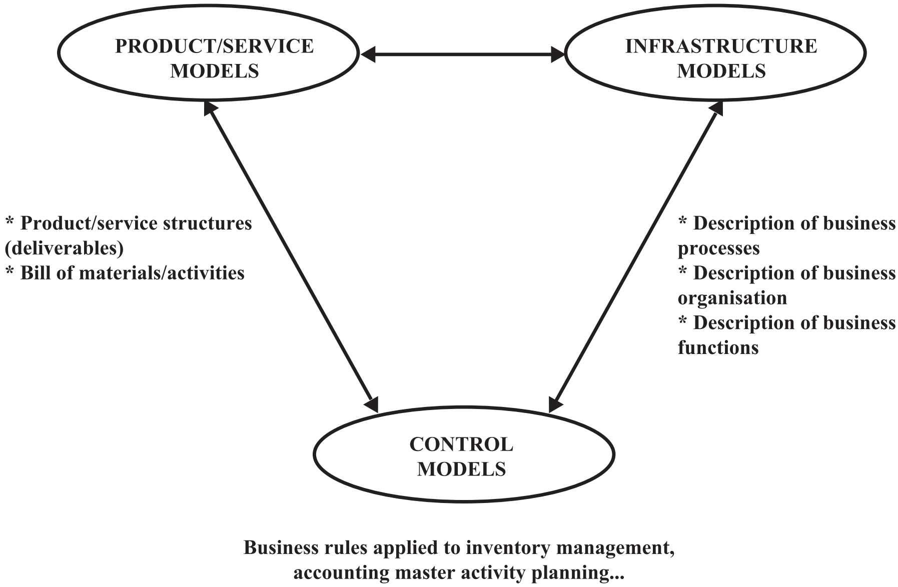

Figure 1.2. *Content of an information system for a manufacturing company*

Despite costs incurred when holding stocks, multiple motives to carry inventories justify their presence in businesses.

– *Cover of stockout situations*

If suppliers are not reliable, buffer stocks facilitate clients to be provided with the materials they require on time. In other words, it ensures a chosen service level of deliveries to clients. At the same time, if demand is stochastic it gives the possibility of sustained deliveries to clients over a period of time within limits derived from the chosen service level.

– *Economies of scale in supply*

When orders of large quantity are placed, reduced prices are obtained (quantity discount) and some fixed costs (transportation, ordering costs) are portioned out to a larger quantity reducing the unit cost as a consequence.

> Consider a storage activity receiving raw materials from suppliers and dispatching them to manufacturing shops when called off.
>
> – Identify the sequence of activities from suppliers to the manufacturing shops.
>
> – Identify the controlling functions.
>
> – Describe the requirements of the associated information system.

The safest procedure to identify the sequence of activities involved is to follow the goods flow from suppliers to clients (here the manufacturing shops). In this case under consideration, three sequenced activities are identified, i.e. receiving, storage and distribution to manufacturing shops.

The controlling functions are found by answering this question: who triggers the activities? The receiving unit becomes active because the procurement function has released delivery orders to suppliers. The distribution unit becomes active when the manufacturing scheduler releases requisition lists of materials to be picked up from storage and delivered to the manufacturing shops.

It is worth noticing that inflows of materials are controlled by the procurement function whereas outflows are controlled by the production scheduling function. This feature stresses the decoupling role of storage.

Inflow and outflow transactions have to be recorded by the IS so that the on-hand inventory for each material is known at every moment. It is assumed that inflows are controlled with the inventory control system (ICS) concept. When the on-hand inventory level comes to a threshold, a replenishment order is released. The reorder level depends on the replenishment lead time and the depletion rate. In fact, it is the demand size during lead time.

The whole system is described in Figure 1.3.

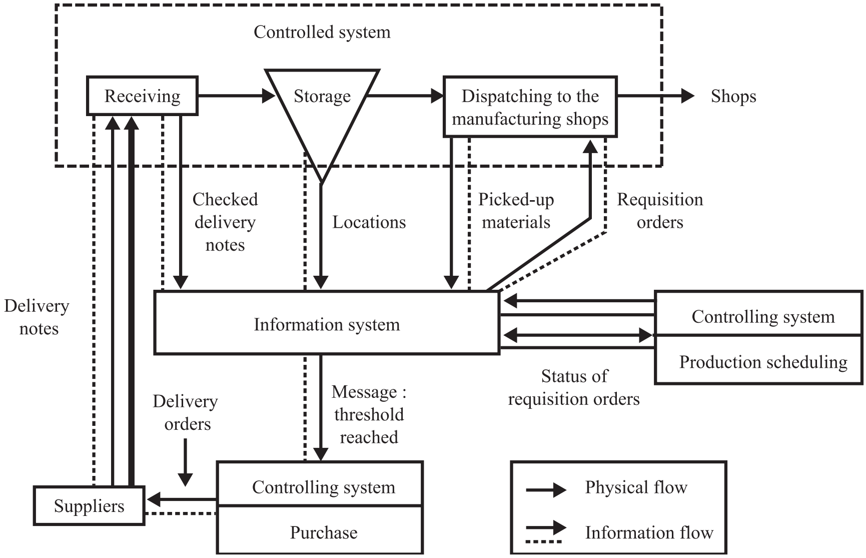

Figure 1.3. *System description of an inventory-controlled storage*

2

Business Modeling by Process and Management Applications

2.1. Process definition and control

2.1.1. *Definition*

Process has a Latin origin "processus" meaning "having progressed". It strongly connotes the dynamics of tasks. It was widely used to describe non-stop manufacturing industries such as steel mills, glass mills, oil refineries, etc.

The use of this wording in the management arena is now widespread. In order to avoid any misunderstanding, definitions have been given by standardization bodies or other institutions and will be commented on hereafter.

A process is a set of means and activities converting input into output (ISO 8402 and 9004).

A definition was given by IBM in an in-house journal of IBM research center at La Gaude/France in 1987 and provides a telling insight. It can be summarized as follows.

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A process is a chain of tasks performed to yield a final product/service. It is modeled by a sequence of activities characterized by:

– measurable inputs;

– value added;

– measurable outputs;

– repetitive running.

Any process must yield a product/service

Any product/service is the outcome of a process

The purpose of process management is to bring process operations under full control, to make them more efficient (productivity) while improving the output (quality).

2.1.2. *Process control mechanisms*

Once a process has been designed and implemented and its operational objectives assigned, controlling how it performs is the main focus. Two types of process control mechanism derived from automation, i.e. feed-forward and feedback can be put in operation. In practice, they are combined to achieve the full control of the process under consideration.

The feed-forward control mechanism can be described in this way. A sensor located on the input flow of a primary business process detects an event and sends a reporting signal to the controlling function. As a result, instructions are issued to make the primary process capable to deal with the incoming flow in the most efficient way. Figure 2.1 exemplifies the mechanism in the case of goods receipt from suppliers.

The feedback control mechanism is intended to let know to the controlling function whether a released order has been fulfilled or not. A sensor located on the output flow of a primary business process sends a reporting signal to the controlling function. In case a deviation with respect to the set objective is detected, a corrective action is triggered to meet the requirements of the set objective. Figure 2.2 exemplifies the mechanism in the case of work orders to be carried out by manufacturing shops. These orders include a quantity of products to deliver at a due date.

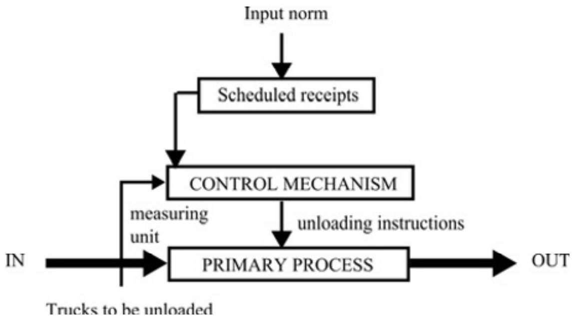


Figure 2.1. *Example of feed-forward control when incoming trucks bring deliveries from suppliers*

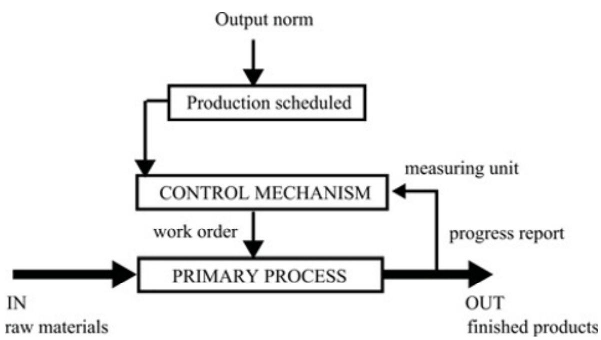


Figure 2.2. *Example of feedback control in a manufacturing process converting raw materials into finished products*

When the system concept is called upon in the management sphere, the only control mechanism referred to is *feedback control.*

In fact, the feed-forward mechanism is operative whenever scheduling takes place.

2.2. Process modeling in perspective

2.2.1. *General considerations*

The concept "process" is evolved as a modeling tool. It is not in competition with the system approach and may complement it in a very useful way.

The system approach focuses on identifying interacting entities for reaching an understanding of complexity. Breaking down a whole into pieces allows studying each piece independently from others with the proviso that the influence of other interacting pieces is incorporated into its behavioral attributes.

When sequencing the entities of a decomposed system is required for whatever reason, process modeling is the right implement. Several more or less sophisticated formalisms can be used. Each has its advantages and disadvantages: we should never forget that process modeling and modeling in general, are a means of communication and which does not make them vernacular.

System and process concepts can be tied together to produce a relevant framework for representing business entities. It will be elaborated later as "business models". How system and process concepts complement each other is shown in Figure 2.3.

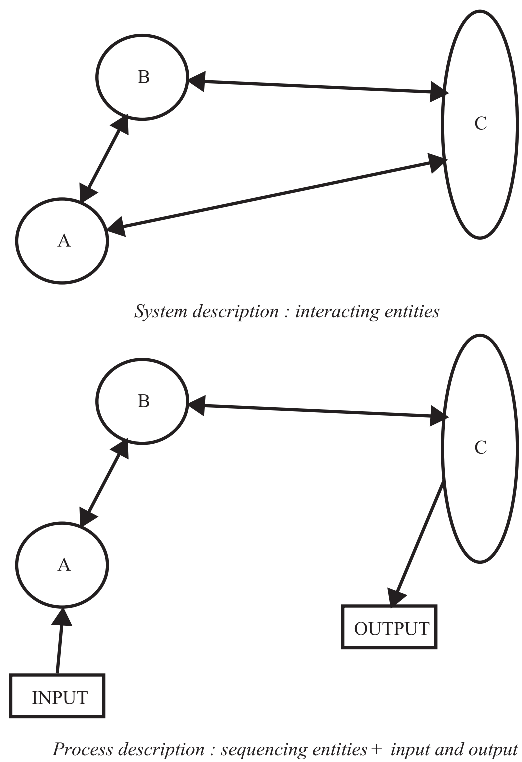


Figure 2.3. *Comparing system and process concepts*

For example, a car is a complex system; several processes can be identified inside this complex system, i.e. the propulsion process, the braking process, the driving process, etc.

A model is a representation of a part of the world, built from a certain point of view to serve a purpose.

This definition induces the fact that the same part of the world can be represented by different models depending on the purposes to serve. For example, a personal computer can be represented by different models as a function of the possible points of view: manufacturing, maintenance, software developers, end users, etc.

2.2.2. *Management applications*

2.2.2.1. *Introduction*

Process modeling is already widely used for management applications. The various domains of application in the management context are the value chain concept, information system design, supply and demand chain management and control of activities as shown in Figure 2.4.

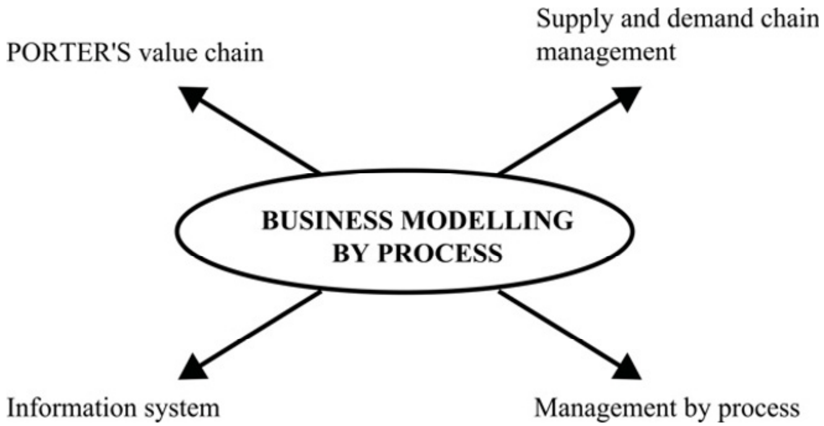


Figure 2.4. *Domains of application of business modeling by process*

2.2.2.2. *Supply and demand chain management*

The supply chain is a set of processes taking input from suppliers, adding value and producing output for clients.

The concept of supply chain management is described as an integrated approach to planning and controlling the whole goods flow through a network of suppliers, factory sites, warehouses, distribution centers, retailers to end users. The key role played by logistics is portrayed in Figure 2.5.

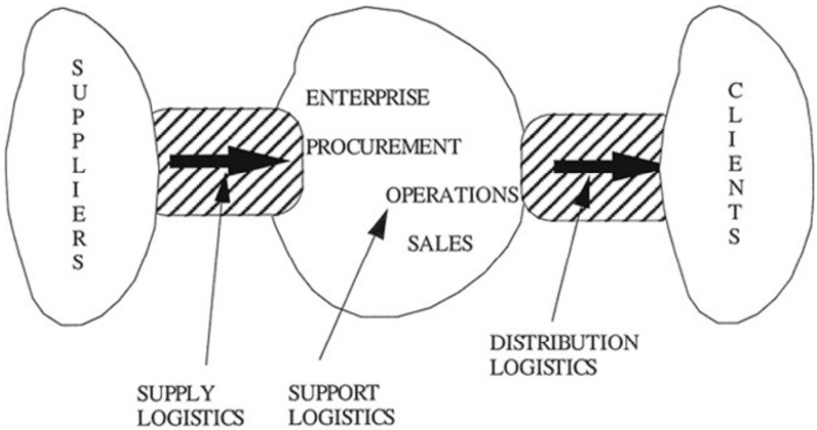


Figure 2.5. *Supply chain process from suppliers to clients and the key role of logistics*

When the focus is put on the control side, the wording "supply chain process" and "demand chain process" can be used to distinguish the push mechanism from the pull mechanism, both triggering the chained activities of the supply process.

Supply and demand chain management focuses on customer satisfaction. From this angle, business modeling by process has the following advantages which justify this choice:

– it allows the focus to be put on the business deliverables (products/services) to customers. They are the true purpose of any business and unavoidable market partners;

– it allows us to understand how a process is performed by describing its activities and their relationships to yield deliverables. Such a "transparency" of business operations helps us to give a clear picture how actual activities and tasks are realized and how they can be improved to achieve the output of deliverables to meet customer demands in terms of *quality*, *delivery time* and *cost*.

2.2.2.3. *Porter's value chain*

The value chain concept is a tool for examining a firm's activities and the way they interact, enabling the analysis of the sources of margin and competitive advantages.

Activities are interdependent building blocks with which a firm creates a product/service valuable to its buyers. They are configured in processes as shown in Figure 2.6.

Figure 2.6. *Value chain process introduced by Porter*

The economic performance is globally measured by the profit margin. It is the difference between the turn-over generated by the sales (i.e. the price customers are willing to pay) and the costs incurred by performing the activities. Through value analysis Porter's business model is supposed to enable assessing how an activity interacting with others can increase its contribution to the process profit margin. The key activities can be identified by their relatively large contribution.

2.3. Management by process

In the paradigm of management by process, a systematic, structured approach is set to analyze, improve, control and manage the work activities configured into processes. This approach, to the study of processes, has received various labels such as "process simplification", "process improvement", and "(re)engineering" covering bottom-up as well as top-down methods.

Activity-based process modeling can then be used for various management purposes:

– activity-based costing (ABC) and budgeting of products/services;

– activity-based management.

2.3.1. *Activity-based costing and budgeting of products/services*

2.3.1.1. *Shortcomings of the traditional cost model and features of the activity-based approach*

The traditional cost model distorts product/service cost for several reasons:

– Overhead costs are often apportioned rather than traced to cost objects (products/services). The apportionment rate has in many cases no "rational" basis and is chosen for a matter of convenience.

– As the overhead component of costs has become a larger percentage of total costs, the cost distortion induced by the apportionment key produces increasingly non-accurate figures.

When the management wants to take action for reducing costs, the traditional cost model does not provide the right information tracing back the sources of overhead costs. Somehow the management is blind. The activity-based approach has been developed to resolve these shortcomings.

In activity-based accounting, resources are consumed in the execution of activities. Products/services consume activities and materials. Emphasis is put on determining the cost of support activities that are labeled "overheads". Activities are clearly linked with their causes, i.e. the consumptions of resources. The tracing of activities to products/services reduces, as much as possible, the amount of overheads to be apportioned to products/services.

This approach aims at establishing cause-and-effect relationships between an activity and its output and between an activity and the resources consumed to make this activity instrumental. This results in a focus on causes of cost allowing for traceability.

2.3.1.2. *Some words clarified tasks-activity-process*

A task is a piece of work to be carried out.

An activity is a set of tasks assigned to a person/machine or a group of persons/machines and aimed at achieving an objective.

A process is a chain of activities triggered by a common signal and designed to produce a specific result as products or services.

The relationship between task, activity and process is shown in Figure 2.7.

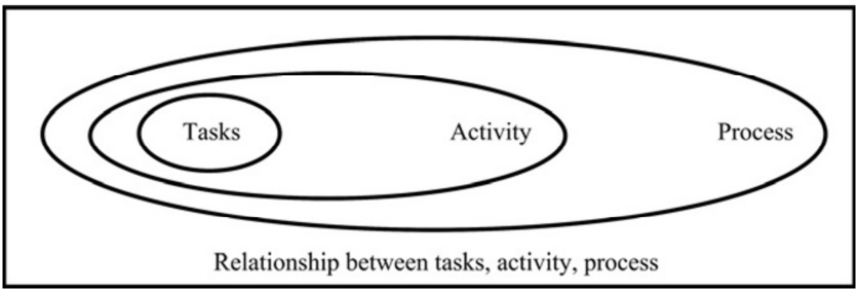


Figure 2.7. *Relationship between task, activity and process*

Delineation between process and activity is not always clear-cut and is somewhat arbitrary. Here are some commonplace criteria to distinguish between processes and activities:

– a process can aggregate several activities controlled by different departments (matrix organization);

– a process can be viewed as a chain reaction of interrelated activities triggered by an external event (complaints office);

– a process can be considered as chained activities organized to reach a goal (market- or product-oriented organization, retailing channels, etc.);

– a process has always an input and an output and can be defined in relation to its suppliers and customers.

Drivers

The term "cost driver" has been used for quite a while and its spreading usage is closely associated with the dissemination of ABC. However, there has been little consistency over what is meant by the term. R. Cooper coined the term *first stage cost driver* as a way of transferring costs from a general ledger line item to an activity cost and the term *second stage cost driver* to get the activity cost onto the cost object.

This approach reflects an accounting type of influence and is exemplified in Figure 2.8.

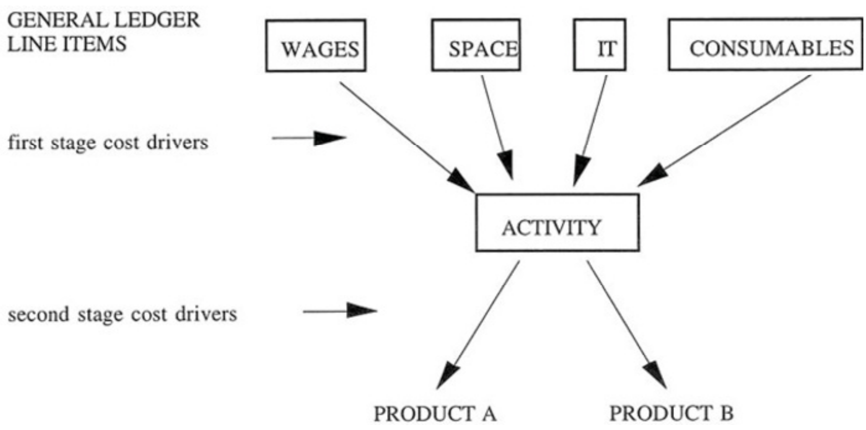


Figure 2.8. *Mapping of general ledger line items onto cost objects*

The difference between *first stage cost drivers* and *second stage cost drivers* has other dimensions to be taken into account by two types of factors:

– factors which trigger resources to be consumed when an activity or a chain of activities (process) takes place and as a consequence cause a cost to occur;

– factors which cause an activity to operate frequently so as to achieve an objective.

The first types of factors are used to improve process effectiveness and efficiency. The second types of factors are linked up with operating practices.

Cost ascertainment of products/services must warrant that unit costing mirrors actual operational costs as closely as possible.

Whatever wording is used, the central issue after decomposing an organization into activities is to choose a pertinent variable (cost driver) in order to apportion activity costs to outcoming product/service units. The important point is to know and make known what you are talking about.

2.3.1.3. *Principles*

Activity analysis has to be undertaken to produce a base line of building blocks defining tasks and resources consumed, allowing for processes to be easily established and visibly reflecting for what and how outputs are worked out.

A five-step procedure can be used:

– identify activities;

– portion out to activities the resources consumed;

– aggregate granular activities into manageable activity pools;

– list objects (products/services) to be cost;

– allocate pools' costs to cost objects.

This approach can be denominated as a top-down or forward one, i.e. assessing causes (resources/activities) producing effects (output).

Another approach has been proposed for costing mass-customized service operations in a public utility. Within this context, indirect resources are first traced forward to the direct resources consumed, the latter being traced forward to basic activities classified in service components. It is referred to a customized chain of component services to frame a customized service and trace back the cost of providing this specific service.

A schematic diagram of this mechanism is shown in Figure 2.9.

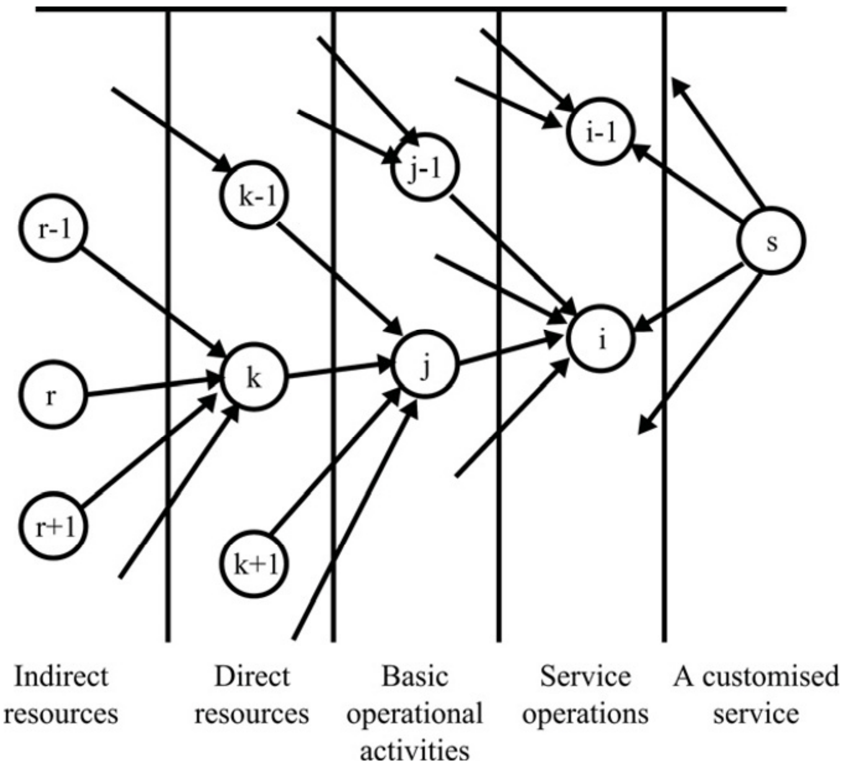
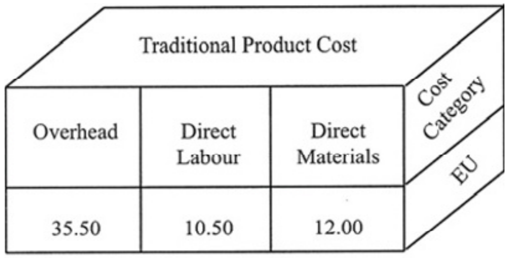


Figure 2.9. *Backward approach to costing customized services by finding out the causes (resources) from observable effects (services)*

This approach can be termed as a bottom-up or backward approach, i.e. finding out causes (resources) from observable effects (services).

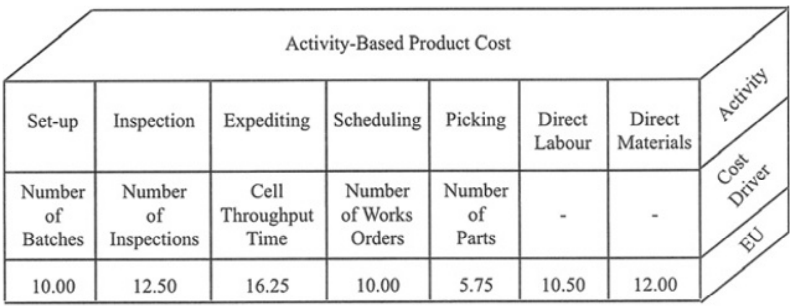
EXAMPLE.– Contrasting a traditional costing method with an activity-based costing.

Figures 2.10. and 2.11 contrast a traditional costing method with an ABC approach for the same product. The difference in total cost can be explained by the fact that a more meaningful cost model reflecting the real-consumption of resources is provided. From a computational point of view overheads are "converted" into direct costs.



Total cost : € 57.5

Figure 2.10. *The traditional product cost*



Total cost : € 77.00

Figure 2.11. *A typical activity-based product cost*

Let us explain the details of the two computational models. Consider a production line manufacturing two types of products A and B. The cost price of A is to be ascertained.

The materials costs and labor costs incurred by both manufacturing processes can be easily controlled and traced to the two products without major problem. Incurred costs common to the two manufacturing processes (overhead) have to be divided among the two cost objects:

– The traditional approach makes use of cost centers and rates: their choice is based more often on criteria of convenience than on conformance with facts. The approach is shown in Figure 2.12.

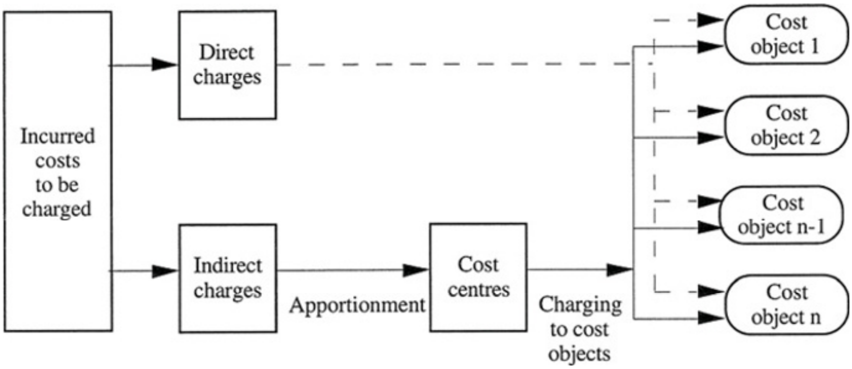


Figure 2.12. *Traditional costing method*

– The activity-based approach recognizes diversity of cost sources, i.e. consumptions of resources, and how these resources are combined in activities. This approach requires the capture of a wider variety of data and building an activity-based business model. In the present example, overhead costs are analyzed as four activity costs (set-up, inspection, expediting, scheduling and picking) traced to cost object A by cost drivers.

2.3.1.4. *Activity-based budgeting*

The budgeting cycle has a closed loop control for aligning actual expenses with planned targets as shown in Figure 2.13.

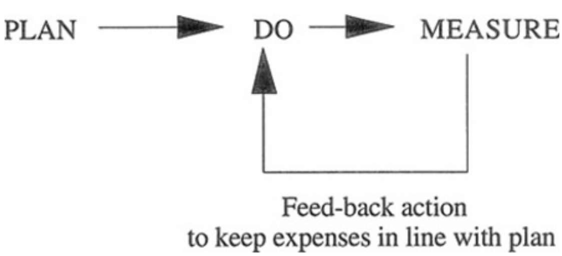


Figure 2.13. *Closed-loop control to execute the targets of a plan*

Feedback action must be effective and efficient. This is ensured by using a relevant business model mirroring the ways operations are organized and tasks performed. Activity-based business models have proved to fulfill this requirement. Furthermore, when preparing the next-year budget, they allow an easy critical review of existing business structures and provide the right tools for:

– cutting out some activities not adding value;

– assessing the impact of such a decision upon other activities;

– if necessary, reconfiguring activities and/or reorganising the way tasks are performed.

ABC traces costs from resources (people and machines) to activities and then from activities to specific products and services. Activity-based budgeting moves in the opposites direction – it traces costs from products to activities and then from activities to resources.

Resource-down approach for costing products/services versus resource-up approach for budgeting is portrayed in Figure 2.14.

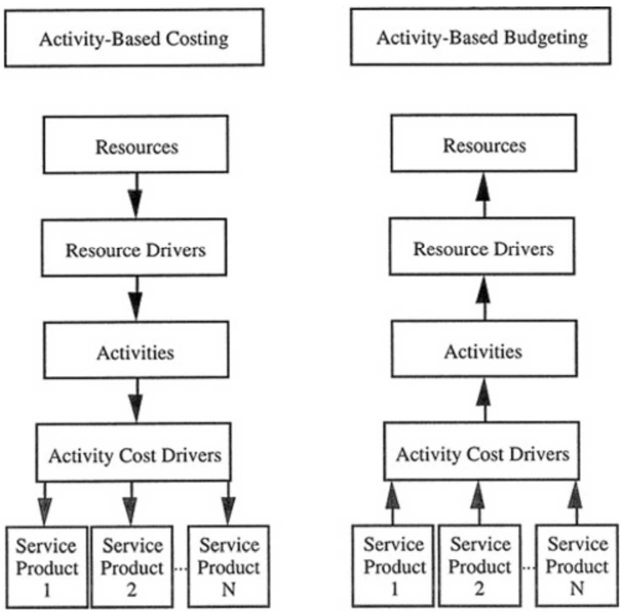


Figure 2.14. *Showing the differences between activity-based costing and activity-based budgeting*

The way the ABC system is articulated with other management systems is shown in Figure 2.15.

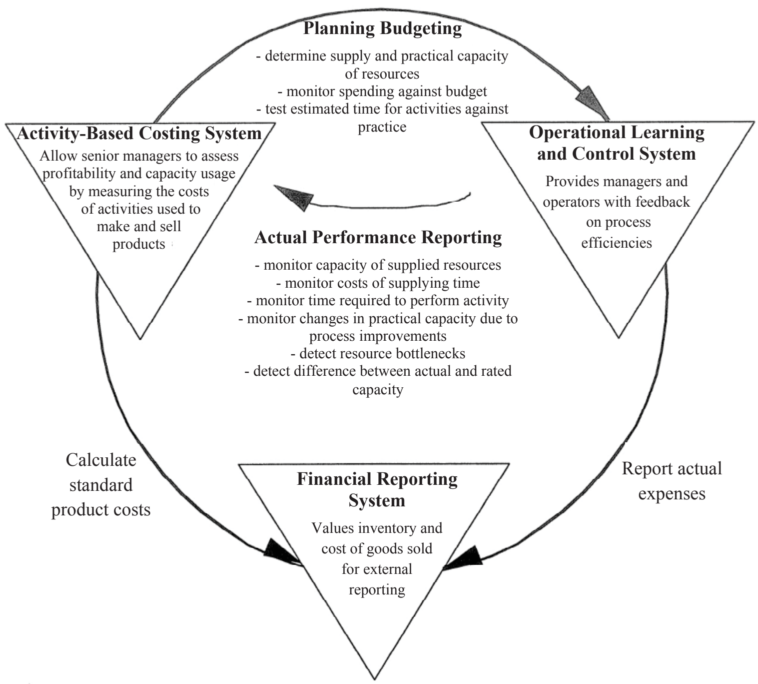


Figure 2.15. *Integration of ABC system into the managerial and financial business systems*

2.3.2. *Activity-based management*

Planning and control are two interdependent phases of good managerial practice. Planning without subsequent control of planned activities is a useless exercise and control of activities without previous explicit or implicit planning cannot be effectively worked out.

Controlling activities requires the previous setting of objectives by planning, otherwise no reference is available to evaluate performance by controlling and take corrective action if required. Planning activities is also a prerequisite for costing products/services and conducting effective cost control.

It is essential to evolve and implement planning and control on the basis of a relevant business model. In present business circumstances, the most preferred business model is the activity-based model. Within this framework, company operations are viewed as networked activities engineered with and supported by resources. In order to gain control of complex activity patterns, activities are configured into processes, each serving well-defined purposes.

Much effort has been deployed in the management arena to satisfy customer needs. A metrics with three dimensions has been chosen to assess customer satisfaction as follows:

– cost;

– quality;

– delivery reliability.

It is a paramount issue to have the right means to take corrective action of a sort when the parameters deviate from their set target values. Endeavors have to be made to deal with the causes of measured effects instead of addressing only the output symptoms. Activity-based process modeling provides the right tools for this purpose. This view is summarized in Figure 2.16.

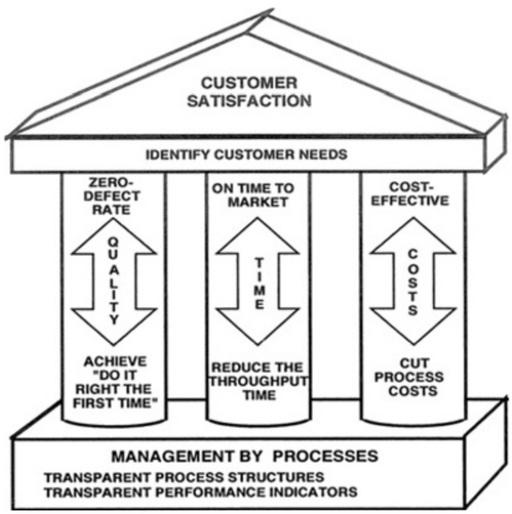


Figure 2.16. *Overview of the relationships between customer needs and the performance metrics of business processes (quality, time and costs)*

Activity-based business processes conform to ISO quality standard 9000-Version 2000 (procedures = activities).

Tracing back the causes of effects is made easier by this type of modeling, i.e. linking output to activities through sensors as shown in Figure 2.17. Devices measuring the behaviors of activities have to be placed at relevant points to provide an efficient control system.

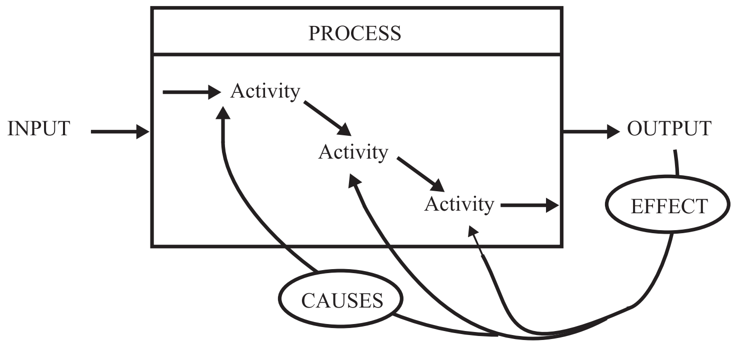


Figure 2.17. *The feedback loop to control the causes of output deviations*

2.3.3. *Information system: relationships between processes, activities and data*

Many studies have described how the lifecycle of information systems does or should proceed. The consensus is that it is necessary to clarify, as a first step, the requirements and to quantify the benefits that can accrue and the costs that are incurred in fulfilling these requirements. More literature has been devoted to technical systems design and implementation than to improvements of the methods whereby requirements are perceived, specified and evaluated.

In this first step, the major issue is the requirement-finding protocol. The fundamental dilemma which bedevils analysts when managing information system projects is either asking users what they need or telling them what they need. Both attitudes are wrong. The real challenge is addressing specific ill-structured and fuzzy problems by converting them into clear decision patterns for helping end users and decision makers themselves take the right decisions. This is ensured by understanding the detailed business processes by the way of relevant models. Activity-based process models form a very powerful communication media between users and analysts. Information requirements refer to proper knowledge of the activities and the resources which a manager is responsible for. Data needed for managing each activity and its associated resources can be clearly identified as shown in Figure 2.18.

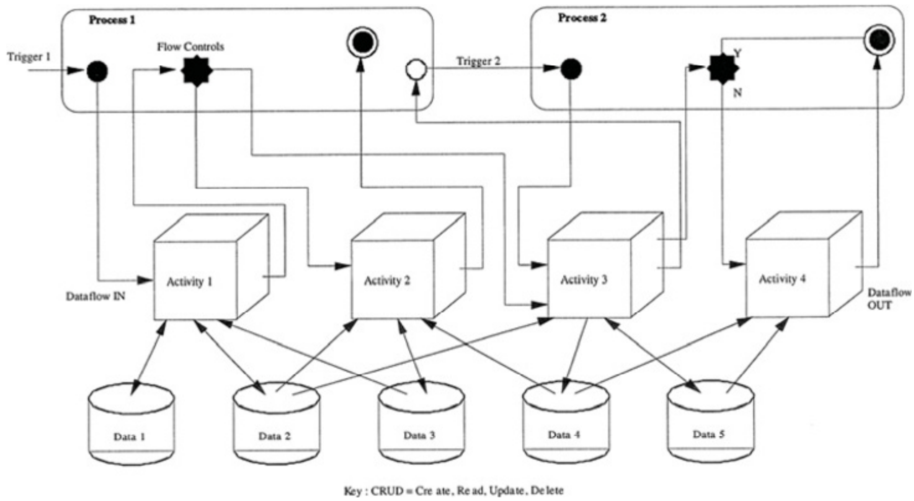


Figure 2.18. *Alignment of an activity-based process and its data requirements*

The same process model can be used for the various management purposes above described: this basic fact is of paramount importance because, when achieved, it ensures that information systems and managerial implements are aligned with the business operations involved. Furthermore, when a process is planned to be changed for whatever reason, the impact of the associated information system can be assessed. If possible, steps can be taken to maintain the alignment of the information systems with the operational processes.

3

Business Models: Control Models, Flow Models, Organization Models, Function Models

3.1. Organizational structure as a blueprint for information systems

A management information system is intended to give support to decision makers to bring business operations under control. More than a linkage must exist between the business organizational structure and its representation perceived by decision makers in information system architectures. A mapping of the organizational structure onto the components of the information system architecture must be made easy for the business actors involved. When output data is produced by an information system, the business actors involved must be able to understand its full meaning in terms of sources and processing carried out. Otherwise a discrepancy can develop to a chasm between the business reality and its perception through the eyes of the artifact "information system".

An organizational structure is identified by four components:

– the description of the allocation of tasks and responsibilities to individuals and departments throughout the organization;

– the designation of formal reporting relationships, including the number of levels in the hierarchy and the span of control of managers and supervisors;

– the identification of the grouping together of individuals into departments and the grouping of departments into the total organization;

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– the inclusion of the coordination mechanisms.

At this point, it is useful to clarify the meanings of organization and function in order to avoid misleading interpretation. When considering the function of an entity, it is important to distinguish:

– what the entity does in the normal course of events (its activity);

– what the entity brings about in the normal course of events (the result is the outcome of the activity).

In the first sense, the function of a sales department is to sell products/services by fulfilling customer orders. In the second sense, the function of a sales department is to generate revenue and allow the company for making profit.

Table 3.1 lists the main business departments of a manufacturing company and their associated functions enabling it to plan, execute and control its operations.

Two major forms of organization were adopted in the past, i.e. the functional organization and the matrix organization.

The *functional organization* is highly centralized. The primary coordination mechanism is the hierarchy of levels, and the functional heads are inherently dependent upon a central head for coordinating their work. The top level is primarily responsible for the strategic direction and coordination of operations, the middle management is responsible for the operating organization and the lower levels carry out productive activities.

The functional organisation served well for companies that were active in a single industry sector or dealt with only a few products and operated in a relatively stable environment.

The divisional form of organization is a variety of the functional organization. The coordination functions are decentralized to divisions. Each division, which is a more or less self-contained unit, has its own functional organization.

Main business departments	Associated functions
Accounting and finance	Assets accounting Cash management Cost center accounting Product cost accounting Profitability analysis General ledger Accounts receivable and payable
Production planning and Materials management	Purchasing Vendor evaluation Inventory management Warehouse management Material requirements planning Plant maintenance Production planning Quality management
Human resources	Personnel planning Monitoring payroll
Sales and distribution	Sales planning Customer order management Distribution planning Customer satisfaction

Table 3.1. *The main business departments of a manufacturing enterprise and their associated functions*

The matrix organization was adopted in the last few decades by many companies that had to grapple with the dual pressure of market responsiveness and operating efficiency. This matrix organization was designed to facilitate communication between the vertical "silos" representing the various business functions, by cutting across the traditional organization borderlines. This attempt to improve cooperation between all the business actors appeared to lead to conflicts and confusion. The proliferation of communication channels created more chaos than performance by producing overlapping responsibilities and a loss of accountability.

The models and frameworks that shaped the leading companies from the end of World War II to the emergence of e-enabled activities are clearly obsolete. The design of today's complex enterprises requires an entirely new way of thinking about organizations. End-to-end control of goods flow from suppliers to customers has to be engineered in one way or another.

The issue is not to centralize or decentralize decision-making and accountability but to ensure seamless collaboration of all the stakeholders along end-to-end business processes. The stakeholder theory can contribute significantly to evolve an efficient organizational structure. It attempts to ascertain which groups are stakeholders in a company and its environment, and deserve management attention. Within this school of thought, any company is embedded in a network of relationships between groups of actors sharing common interest and objectives, their links being either of material nature (goods flows) or of informational nature (exchanges of messages to timely organize the goods flow involved). The members of a group of stakeholders can be associated with different companies, for instance, a purchase department and its suppliers, or a sales department and its delivery carriers. These ideas will be elaborated in Chapter 6.

3.2. Business models

3.2.1. *Definitions*

Several models are required for giving a fully-fledged representation of an enterprise. They can be ascribed to two main streams of points of view, i.e. organization and functions and their enforcement as dynamic processes (inter-related tasks) producing deliverables. These models are intended to provide a telling insight into the controlled systems and controlling systems of a company so that they can be easily articulated with the contents of the associated information systems, as explained in Chapter 1.

Business control model

Business control models explicitly represent the primary flows (goods/services, finance) and the business control functions at the operational and tactical levels. They provide an overall picture of the firm based on the core business process. Business control models facilitate seamless linking of companies' supply chain and information systems.

In the past, software packages were presented module by module. Their presentation by business processes takes the lead. Business control models provide a synthetized description of business types. They lend themselves to the emergence of reference models by industry sector. This opportunity was taken by software editors to devise business models and patterns of software modules mapping the models.

Business organization model

The business organization model is the representation of the enterprise from the perspective of its structure. It depicts the organizational structure in terms of divisions, business units, departments and roles assigned to persons.

Business function model

The layout of that model enables us to design processes (business flow models). A hierarchical tree is well suited for providing a convenient orderly view of the situation. The functional tree can be object-oriented, activity-oriented or process-oriented. Business functions control business operations and can be depicted by their various capabilities.

Business functions appear in business control models without detailing how activities of processes are controlled.

Business flow model

Business flow models take a process perspective and depict relationship between functions and organizational units. They describe a chain of function-controlled tasks to be carried out in a flow line to produce deliverables serving the requirements of stakeholders inside or outside the firm.

These models make explicit the way an enterprise conducts its operations in terms of procedures and resources involved. Customer order fulfillment, call-off orders to suppliers and invoicing can be cited among a host of examples.

It is often appropriate to complement business flow models with data models. This allows alignment of business processes with information systems as shown in Chapter 2. Figure 3.1 shows the logical deployment of models describing the different facets of an enterprise.

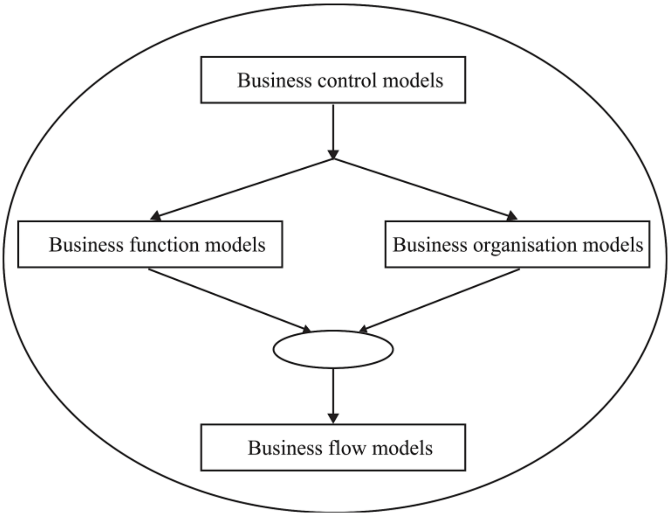

Figure 3.1. *Articulation of models representing an enterprise*

3.2.2. *Examples of business models*

Some business control models are depicted in Figures 3.2, 3.3 and 3.4. They refer to the main flow process and control functions of a company, i.e. wholesale/distribution, manufacturing of assembled products and maintenance services. The model of Figure 3.4 can also describe the activities of the maintenance department of a manufacturing company.

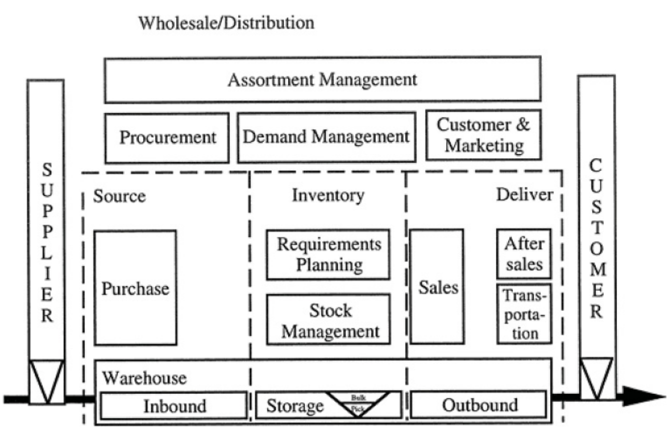

Figure 3.2. *Business control model of a wholesale/distribution company*

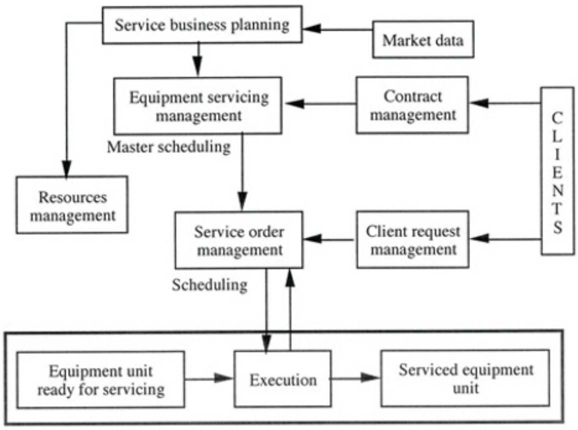

Figure 3.3. *Business control model of a maintenance company*

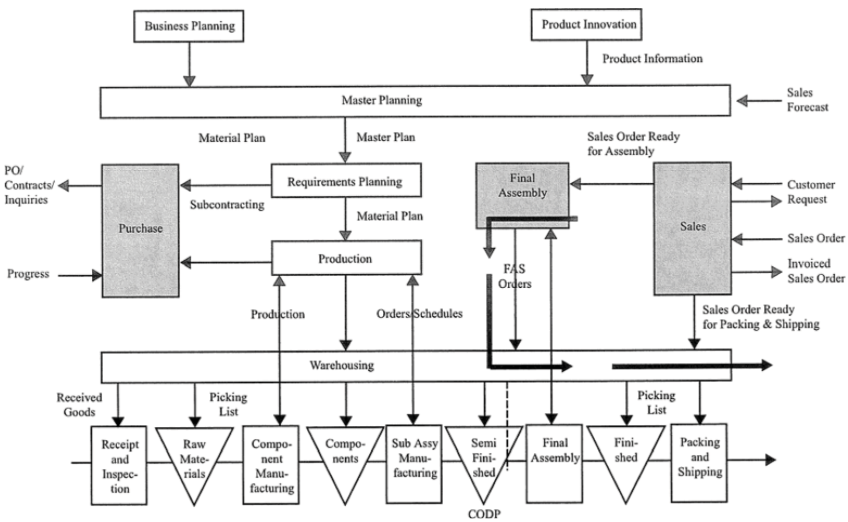

Figure 3.4. *Business control model of a manufacturing company*

3.2.3. *Example of business function model*

Figure 3.5 shows what is understood by a business function model. It is the functional organization derived from Fayol's system of general management. Fayol observed that management was an activity to all human undertakings. From his view point, all these undertakings required some degree of planning, organizing, commanding, coordinating and controlling. He divided the total industrial undertaking into six independent activities: (1) technical, (2) commercial, (3) financial, (4) security, (5) accounting, and (6) managerial. His ideas are embodied in the hierarchical business function model depicting how an industrial enterprise is articulated in major functions (manufacturing, R and D, sales, etc.) monitored by the enterprise top management and broken down into main functions. This model does not depicts the procedures used to make these functions work together to produce deliverables.

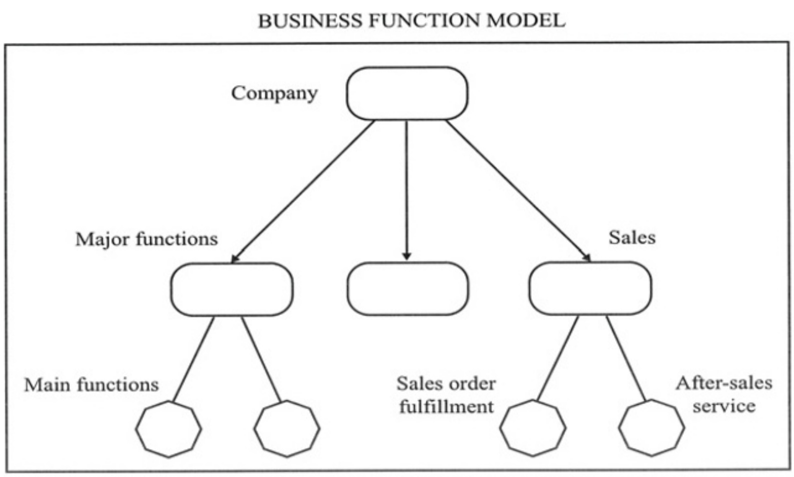

Figure 3.5. *Hierarchical modeling of business functions by a tree description*

3.2.4. *Examples of business flow model*

These models are typically cross-functional. Two examples of business flow model are described here. Both of them refer to customer order fulfillment in different contexts. The first case is considered for a wholesale/distribution company shipping products from stocks. For a matter of simplification, no stockout situations are taken into consideration. The main steps of the customer-order-fulfillment process are: *sales order acceptance*, *stock picking* and *shipping*. Each step can be described by a chain of tasks embodied in procedures. A formalism called logical data flow is used to portray in details the customer-order-fulfillment process in Figure 3.6.

The second case is considered for a manufacturing company where the final assembly of products is triggered when a customer order is received. The main steps of the customer-order-fulfillment process are: *sales acceptance*, *final assembly configuration and scheduling (FAS)*, *FAS order execution and control*, and *sales order delivery.* It is a detailed description of the right part of Figure 3.4 (the front office to the market). It is adapted from Figure 3.6 as shown in Figure 3.7.

The philosophy behind the two cases is the same:

– function (1) “respond to a customer request” by checking the feasibility of the request (inventory or assembling capacities available);

– function (2) “validate the sales order” by checking the financial credentials of the customer and issuing a manufacturing order;

– functions (3) and (4) “picking and shipping” in connection with a carrier for delivery.

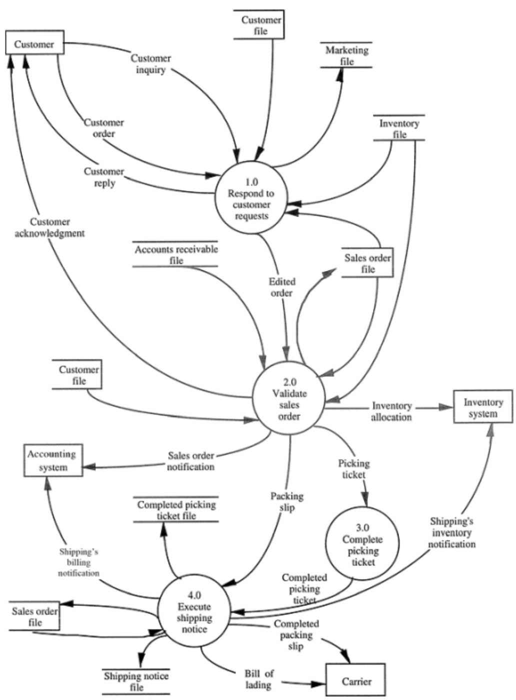

Figure 3.6. *Logical description of the order entry/sales system for a wholesale/distribution company*

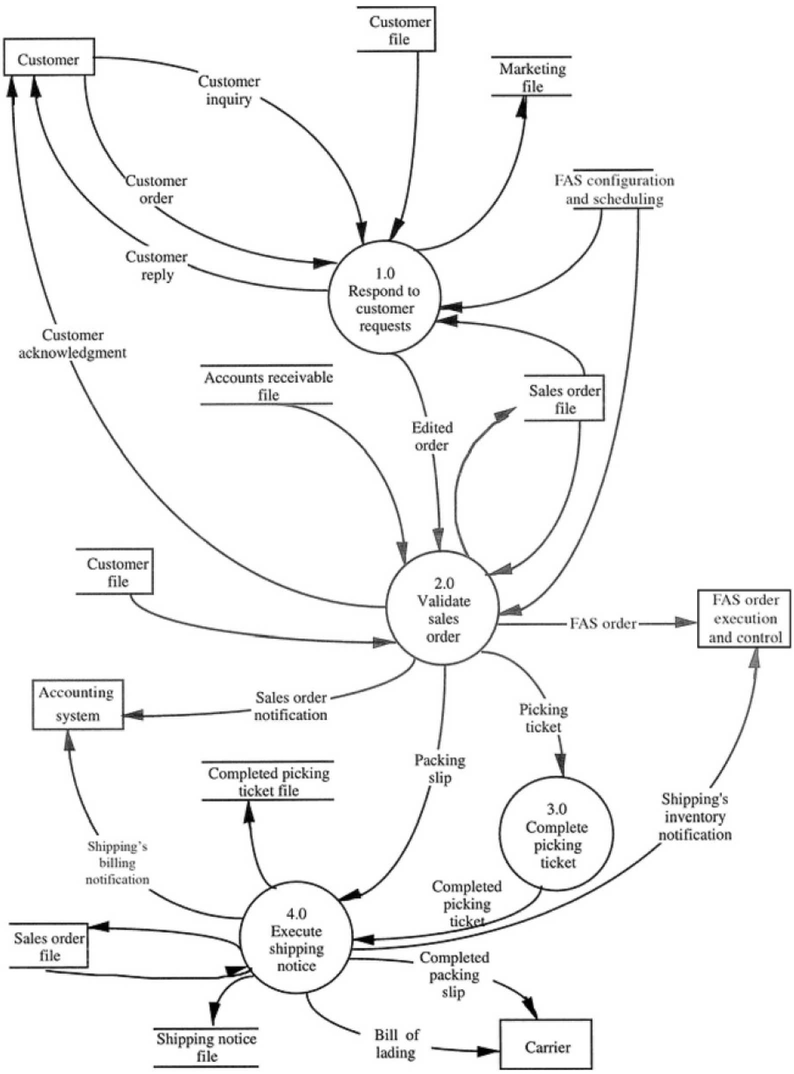

Figure 3.7. *Logical description of the order entry/sales system for a make-to-order manufacturing company*

3.3. Aris-toolset: a software-toolset: a software package for business modeling

3.3.1. *Introduction*

Architecture of information system (ARIS) is a software package developed by Pr. Scheer, University of Saarbrücken (BRD), for supporting the requirements definition, the design specifications and the implementation description of information system in coherence with business processes and procedures. The formalism used is a chain of event-driven functions to make clear how functions interact and are triggered in the business organization. *A process is always triggered by an event (triggering event) and ends with a finishing event showing that the process is completed.* Inter-function events fulfill the same purpose: when a function is completed an event is produced so that the downstream function can be safely performed.

A modeling tool:

– enforces a method;

– improves quality and rigor of design.

A software tool:

– provides a simple, consistent record of models through a single repository;

– encourages the use of a well-understood formalism and makes communication easier between designers and end users;

– supports reuse;

– allows multiple points of view;

– facilitates shared access by business actors.

Models show the relationships between objects depicted by symbols.

Some words have to be clarified to shun any ambiguity:

– *object*: a real-world entity (task, organization, data, item, etc.);

– *symbol*: visual depiction of an object;

– *relationship*: representation of the interaction between objects;

– *connection*: a visible relationship;

– *occurrences*: instances of an object.

The event-driven process is characterized by:

– *events* representing the changing states of objects;

– *functions* representing the activities and tasks;

– *rules*;

– *resources* (data and organization).

ARIS provides four views of the modeled world: organization, functions, data and processes.

Other formalisms are used to describe processes, for instance structured analysis and design technique (SADT), which is based on actigrams and data flow diagrams. Different formalisms do not exclude each other. In fact, they complement each other, each focusing on a specific feature. SADT like data flow models states in detail the messages exchanged between the functions.

Figure 3.8 pictures the process chain for producing a quote and shows the four entities involved (organizational units, events, functions and data resources).

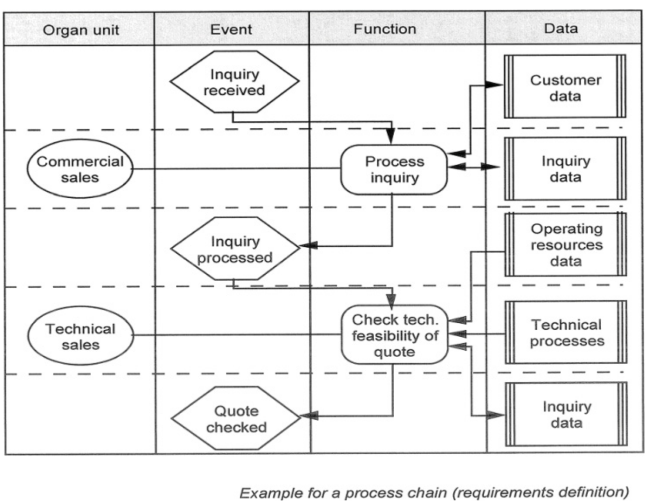

Figure 3.8. *View of the four related entities involved in a request-for-quote process*

3.3.2. *Logic connectors in event-driven processes*

Connections between functions and events (function links) and between events and functions (event links) can be governed by logic connectors (AND, OR and XOR). The different cases are elaborated in Figures 3.9, 3.10 and 3.11.

Operator	Following a Function (single input, multiple outputs)	Preceding a Function (multiple inputs, single outputs)
OR ⓥ	**OR** Decision One or many possible paths will be followed as a result of the decision	**OR** Trigger Any one Event, or combination of Events, will trigger the Function
XOR ⊗	**Exclusive OR** Decision One, but only one, of the possible paths will be followed	**Exclusive OR** Trigger One, but only one, of the possible Events will be the trigger
AND ⓐ	**AND** Branch Process flow splits into two or more parallel paths	**AND** Trigger All Events must occur in order to trigger the following Function [Note]

Note : It may be necessary to consider a time period during which all the Events must occur in order for the AND trigger to be valid.

Figure 3.9. *Usage of the three logical connectors with respect to functions*

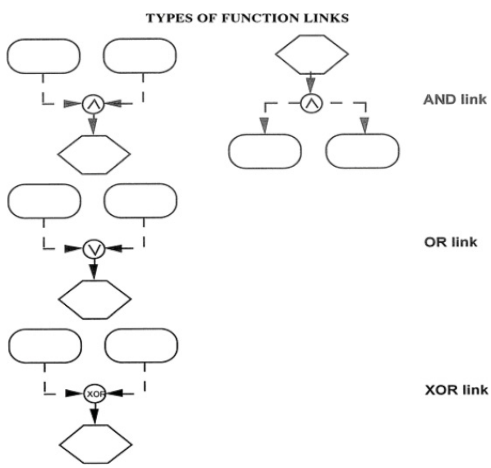

Figure 3.10. *Examples of function links elaborated with logical connectors*

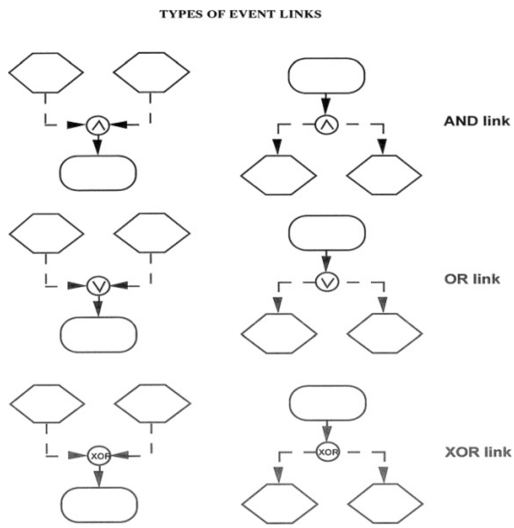

Figure 3.11. *Examples of events links elaborated with logical connectors*

Figure 3.12 is illustrative of the way the ARIS formalism is implemented to describe a new car sales process. Boxes on the left side of the figure represent parts of the information system. The section "Inquiry" is the front office of the company in charge of customer relationships. As a result of the recorded profile of a customer, the quotation created from his/her inquiry may be processed and adjusted accordingly. The section "Production-Purchase" deals with the scheduling of production and supply, whatever the control mechanism could be, i.e. make-to-order organization or frozen manufacturing schedules. In any case, information about the market behavior is of relevance to monitor the manufacturing and supply activities dynamically in the most practical way. The section "customer invoice" refers to a part of the accounting system.

3.3.3. *Exercises*

1) *Convert the data flow diagram of the "order entry/sales" system into the ARIS formalism (event-driven processes) and give your comments*.

Figure 3.13 is a rough-cut suggested solution with a more detailed description for the inquiry request process.

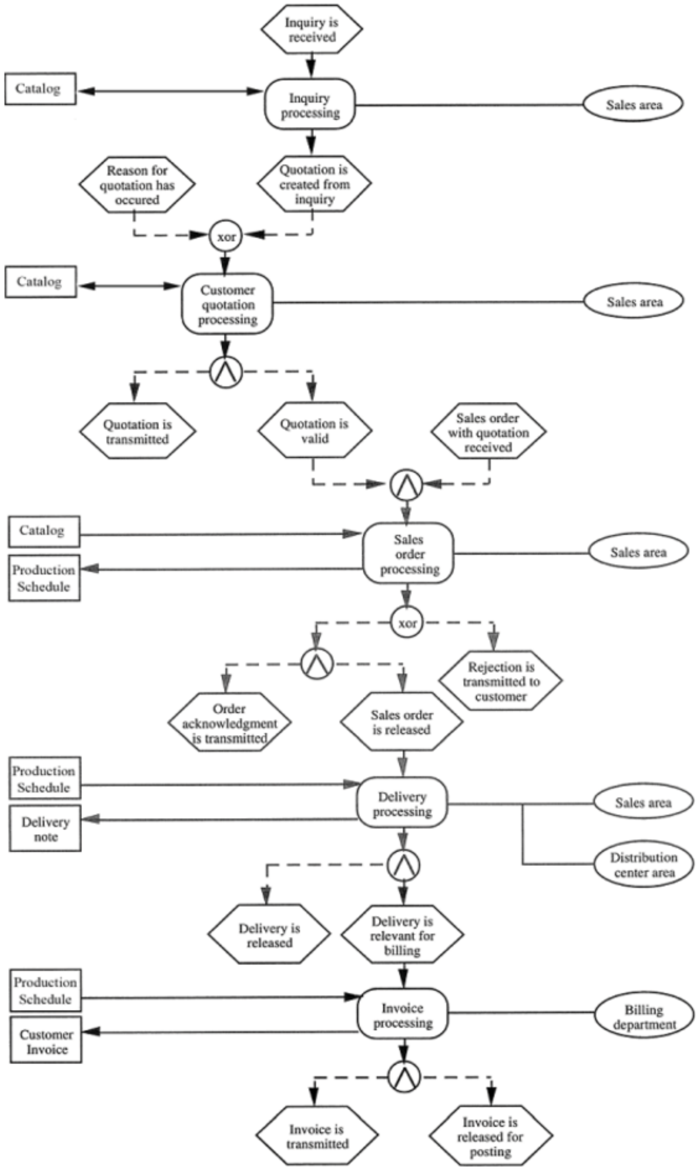

Figure 3.12a. *Aris diagram of a new car sales process*

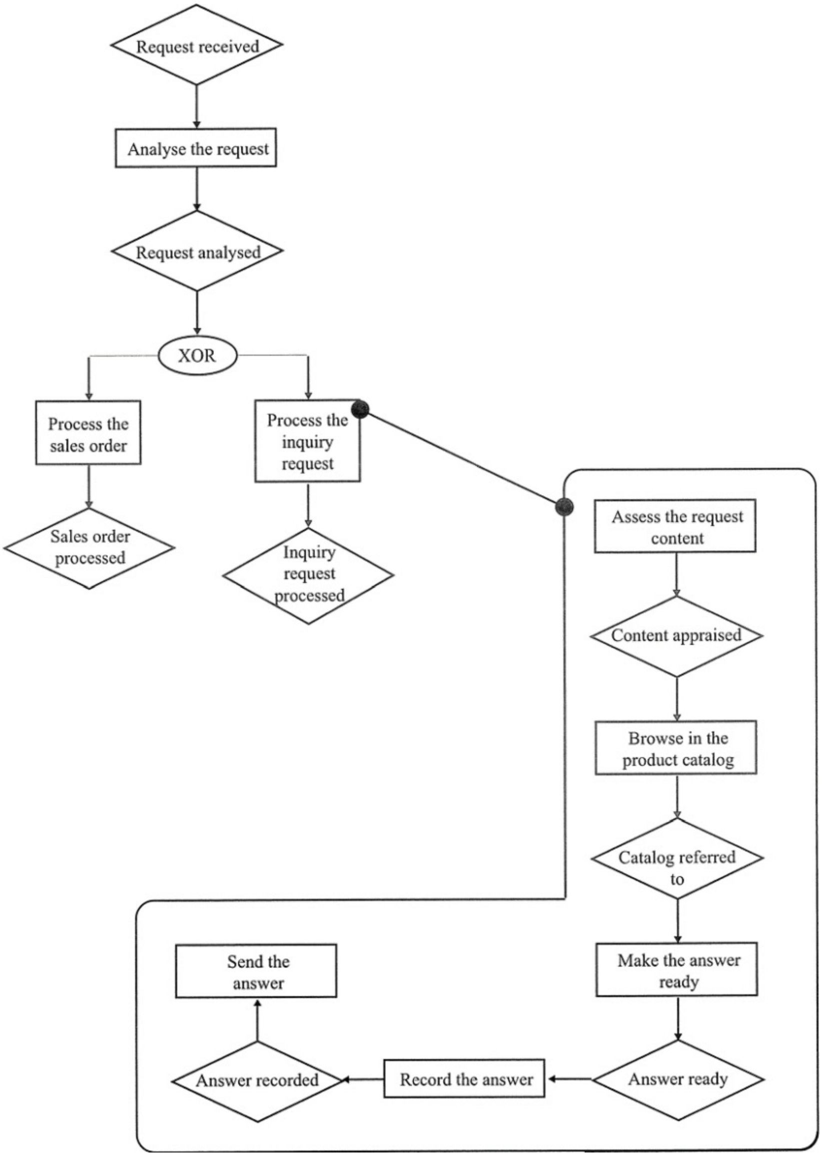

Figure 3.12b. *Detailed description for the inquiry request process*

2) *Elaborate on the contents of the following data repositories: inquiry, production purchase, delivery note, customer invoice.*

3.4. Supply-chain operations reference modeling[1]

3.4.1. *Introduction*

In order to bring and maintain under full control supply-chain operations, it is helpful to make use of reference models. They provide a language for communicating among supply-chain partners. The content of this section is derived from materials produced by the *Supply-Chain Council, Inc.* Figure 3.13 depicts the primary controlling and operational function capabilities engineered by a manufacturing enterprise. They will be elaborated in this section within the framework of the concept of process reference model.

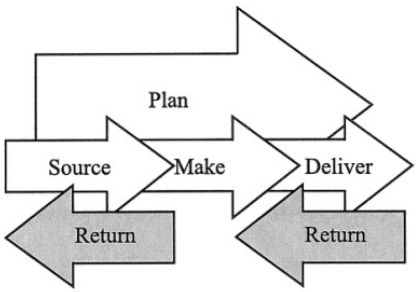

Figure 3.13. *Function capabilities described in reference models*

When a supply-chain from suppliers to end customers is considered cells of function capabilities are interconnected as portrayed in Figure 3.14. Five cells can be identified, i.e. two supplier cells, two customer cells and a central manufacturer covering most possible contexts.

Figure 3.14. *Chain of cellular function capabilities interconnected from suppliers' suppliers to end customers*

1 Supply Chain Council (www.supplychainworld.org).

The issues addressed in this section are:

– What is a process reference model?

– Model scope and structure.

– Applying the model to configurability.

3.4.2. *What is a process reference model?*

The design of process reference models integrates the well-known concepts of business process reengineering, benchmarking and process measurement into a cross-functional framework as shown in Figure 3.15.

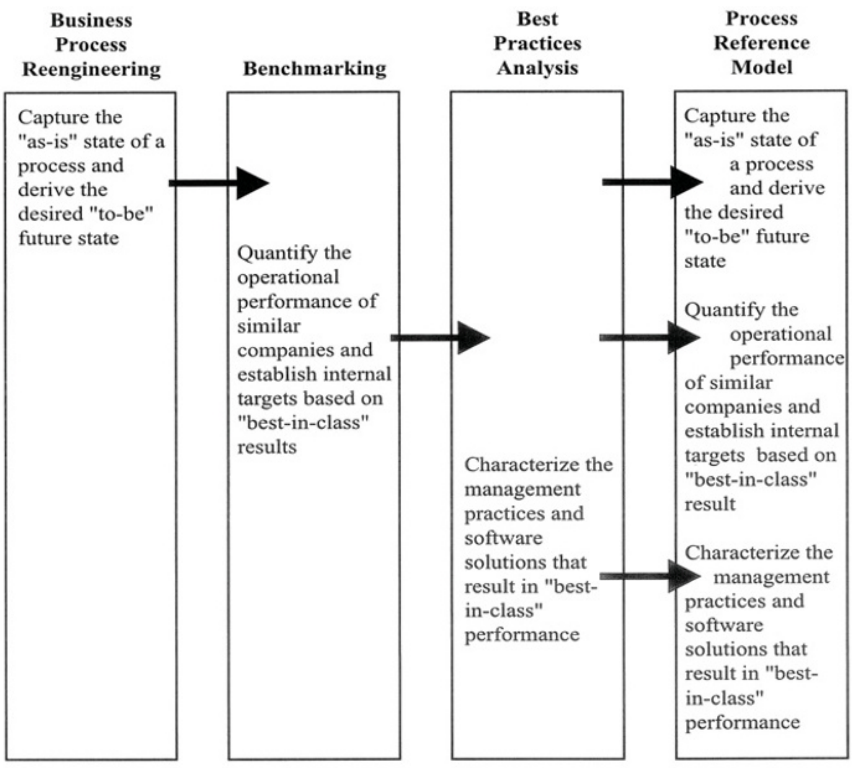

Figure 3.15. *Concepts integrated in the design of process reference model*

A process reference model contains:

– standard descriptions of management processes;

– a framework of relationship among the standard processes;

– standard metrics to measure process performance;

– management practices that produce best-in-class performance;

– standard alignment to features and functionality.

Once a complex management process is captured in standard process reference model form, it can be:

– implemented purposefully to achieve set objectives;

– described unambiguously and communicated;

– brought under control;

– tuned and re-tuned to match the evolving objectives.

3.4.2.1. *The boundaries of any model must be carefully defined*

A model describes:

– all customer interactions, from order entry through paid invoice;

– all product (physical material and service) transactions, from company supplier's suppliers to company customer's customers, including equipment, supplies, spare parts, bulk product, software, etc;

– all market interactions, from the understanding of aggregate demand to the fulfillment of each order.

A reference model should not attempt to describe every business process or activity, including:

– sales and marketing (demand generation);

– research and technology development;

– product development;

– some elements of post-delivery customer support.

But links can be made to processes not included within the model's scope, when and where it is appropriate.

A reference model does not explicitly address:

– Training.

– Quality management.

– Information Technology (IT).

– Administration (non Supply Chain Management).

3.4.3. *Model scope and structure*

The scope and structure of the Plan, Source, Make, Deliver and Return processes within the paradigm of process reference model have to be developed and implemented for the whole supply chain to secure good orchestration of all activities along the chain of stakeholders. They are described as follows in terms of objectives and missions:

– *Plan: demand/supply forecasting and activity planning*

Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing production and delivery requirements with the main missions:

- balance resources with forecast requirements and establish/communicate plans to ensure a smooth and efficient collaboration between all the stakeholders of the chain;

- collect data to derive performance indicators on the basis of managed business rules;

- align the supply chain unit plan with the financial plan.

– *Source: provision of stocked, make-to-order, engineer-to-order products.*

Processes that procure goods and services to meet planned or actual demand with the main missions:

- schedule deliveries from suppliers and authorize supplier payments;

- identify and select supply resources;

- manage supplier agreements and assess supplier performance (quality and reliability);

- manage inventory.

– Make: make-to-stock, make-to-order, engineer-to-order production execution

Processes that transform raw materials or semi-finished product to a final state to meet planned or actual demand with the main missions:

- schedule production activities;
- release product to deliver (compliance with specifications);
- manage the fulfillment of delivery commitments;
- manage inventory of work in progress.

– Deliver: order, warehouse transportation management for stocked, make-to-stock, make-to-order and engineer-to-order products

Processes that provide finished goods and services to meet planned or actual demand, including order management, transportation and distribution management with the main missions:

- process delivery orders;
- select carriers;
- schedule distribution routes;
- assess carrier reliability and customer satisfaction.

– Return: return of raw materials to suppliers and receipt of returns of finished products from customers

Processes associated with returning or receiving returned products for any reason and extending into post-delivery customer support with the main missions:

- schedule defective products return to suppliers;
- receive return products from customers;
- manage the in-house flow of return products from suppliers.

The process reference model described here is based on these five core management processes. These process types consist of three process categories, i.e. planning, execution and enable for supporting planning and execution. The process types are used to define the scope and content for the supply chain reference model. At this level, the performance targets are set in terms of reliability, responsiveness, flexibility and cost. From process categories, a company's supply chain can be "configured-to-order". Companies' operations strategies are implemented through the configuration they choose for their supply chain. To be able to "fine tune", their operations companies have to decompose their categorized processes into process elements. They are characterized by:

– their definition;

– their information inputs and outputs;

– their performance metrics;

– their best practices, when and where applicable;

– their capabilities to perform or support best practices;

– their ability to adjust to changes.

3.4.4. *Applying the reference model to configurability*

The concept of "configurability" refers to the mode of arrangement of resources relative to an operational system. A supply-chain configuration is driven by:

– *Plan* levels of aggregation and information sources.

– *Source* locations and products.

– *Make* production sites and methods.

– *Deliver* channels, inventory deployment and products.

– *Return* locations and methods.

A reference model must accurately reflect how a supply-chain's configuration impacts management processes and practices when changes are introduced.

Each basic supply chain cell is a "Chain" of Source, Make, and Deliver execution processes as depicted in Figure 3.16.

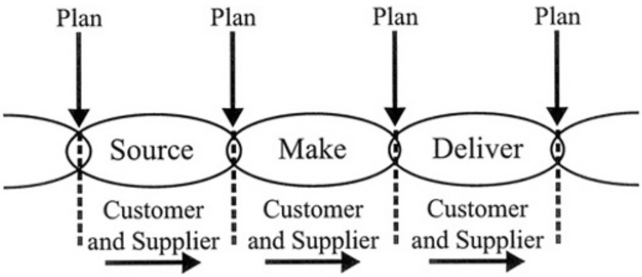

Figure 3.16. *Decomposition of a basic supply chain cell into execution processes*

Each intersection of two execution processes (Source-Make-Deliver) forms a "link" in the supply-chain whose reliability is critical to ensure continuous throughput:

– execution processes transform or transport materials and/or products;

– each process is a customer of the previous process and a supplier to the next so that delivery specifications have to be agreed upon to avoid disruption in the goods flow.

Planning processes manage these customer–supplier interfaces as follows:

– planning processes thus "balance" the supply chain;

– every link *requires* an occurrence of a plan process category.

Figure 3.17 shows how the reference model logic, we have described, can support phased horizontal process integration. In a first phase, the planning protocol of Source, Make, Deliver and Return processes is implemented by backward proceeding from customers to suppliers. The second phase refers to triggering execution processes by order or plan signals.

This reference model can be instrumental in detailing the customer order decoupling point (CODP) concept explained in Chapter 4.

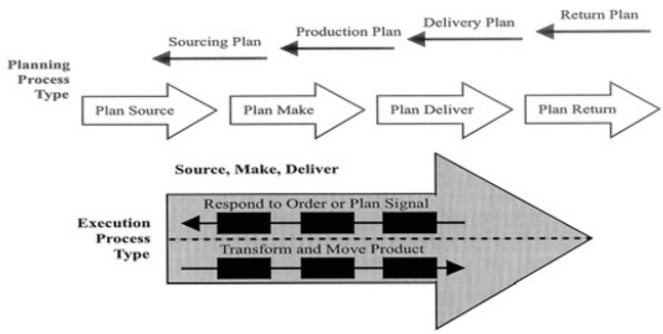

Figure 3.17. *The diagram of reference model logic showing planning and execution activities along a supply chain*

PART 2

Managerial Concepts and Software Packages in Perspective

4

From Materials Requirement Planning (MRP) to Enterprise Resource Planning (ERP) Concepts and the Associated Software Packages (PICS and COPICS of IBM to ERP-Labeled Packages)

4.1. From MRP to ERP concepts

4.1.1. *Overview of the evolution of management thinking*

Inventory management has always received much attention in the business arena. It is concerned with achieving an optimum balance between two competing objectives. The objectives are, first, minimizing the resources directly and indirectly invested in inventory and, second, maximizing the service level to the firm's customer and its operating departments. Resources involved are not earning a return. They are, on the contrary, costing the firm money both in the opportunity sense in that other profitable uses of funds are foregone and in the same sense that they represent funds that have to be paid for. In addition to the inventory itself, other resources are required to have it available, i.e. buildings, handling equipment, personnel, data processing facilities, etc. All the control concepts developed when computers became available for management purposes are aiming at the same target.

E-Enabled Operations Management, First Edition. Jean-Pierre Briffaut.
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4.1.1.1. *Up to the 1950s*

Inventory is a business asset subject to depreciation and cost. Inventory holding cost results from the consumption of physical resources required for having stocks at disposal and from the choice made to buy stocks in the opportunity sense. Even without the help of computer system, inventory management was the focused concern of business managers in spite of the efforts required in terms of labor for physical inspection and clerical work.

Accountants endeavored to lower the inventory level in order to reduce risks of depreciation and costs with a simple replenishment model. By "simple", it is meant a limited number of parameters to control (depletion rate, replenishment lead time, threshold stock and reorder quantity).

Along the goods flow from suppliers to customers, three types of stocks can be identified in a manufacturing company, i.e. raw materials, semi-finished products and finished products, as shown in Figure 4.1.

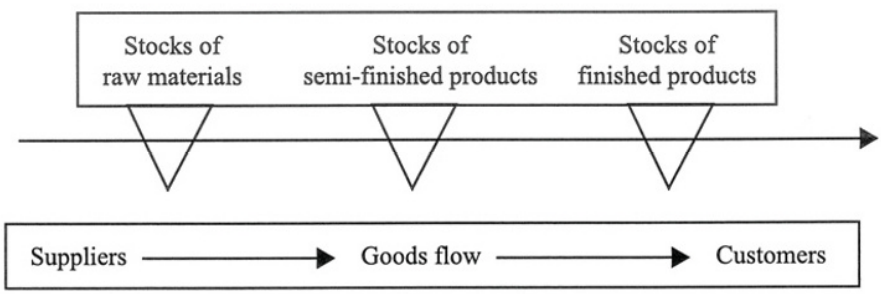


Figure 4.1. *Different types of stocks along the goods flow in a manufacturing company*

Activities up-stream each type of stock are triggered when on-hand inventory comes to a threshold level. The replenishment quantity to order minimizes costs; that is why it is called economic order quantity (EOQ). This control model will be extensively analyzed later in this chapter.

4.1.1.2. *In the 1960s*

Materials requirement planning (MRP I) is a management concept developed by Orlicky, Plossl and Wight, and implemented with software packages. MRP I can be described as a planning tool for deriving a supply schedule from a manufacturing scheduling and product structures describing what for materials have to be supplied to fulfill the manufacturing schedule under consideration.

The basic idea behind this concept is to reduce the inventory levels of supplies by planning their deliveries when they are required (just-in-time) to meet the committed due dates for delivering finished products to the sales department.

4.1.1.3. *In the 1970s*

Manufacturing resource planning (MRP II) is an enhancement of MRP I.

It is a two-stage planning tool:

– stage 1: making realistic manufacturing plans in line with the available capacities of needed resources (mainly manufacturing resources in terms of labor and equipment)/the data items required – routings of products (manufacturing specifications) and rough-cut capacities;

– stage 2: combining the determined manufacturing schedule, the detailed capacity requirements and product structure data for planning the delivery of materials when required (just-in-time) to meet the manufacturing schedule while minimizing the inventory level.

Figure 4.2 shows the roles of MRP I and MRP II in the unfolding of manufacturing-centered business plans.

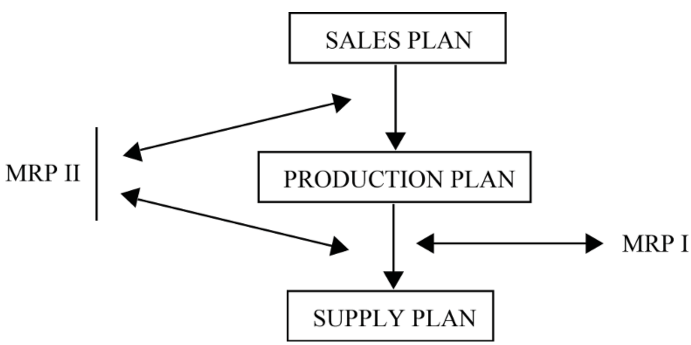


Figure 4.2. *Respective contribution of MRP I and MRP IIto planning manufacturing-related activities*

4.1.1.4. *In the 1990s*

Enterprise resource planning (ERP):

– the ERP concept is a holistic approach for planning all the enterprise resources (labor, equipment, finance and inventory) required to meet the market demand as shown in Figure 4.3;

– an ERP software should be able to derive from a sales plan the precalculated result account and the balance sheet.

As a consequence, an ERP software should encompass financial systems (invoicing, accounts payable, accounts receivable, asset management, costing, general ledger, etc.), operational systems (demand management, inventory management, product structure and routing management, manufacturing management, logistics management, etc.) and organizational systems (human resources management).

ERP packages are run with database management systems (DBMS), ensuring the integration of all applications. The label "ERP" first appeared when relational DBMS became operational in the 1990s.

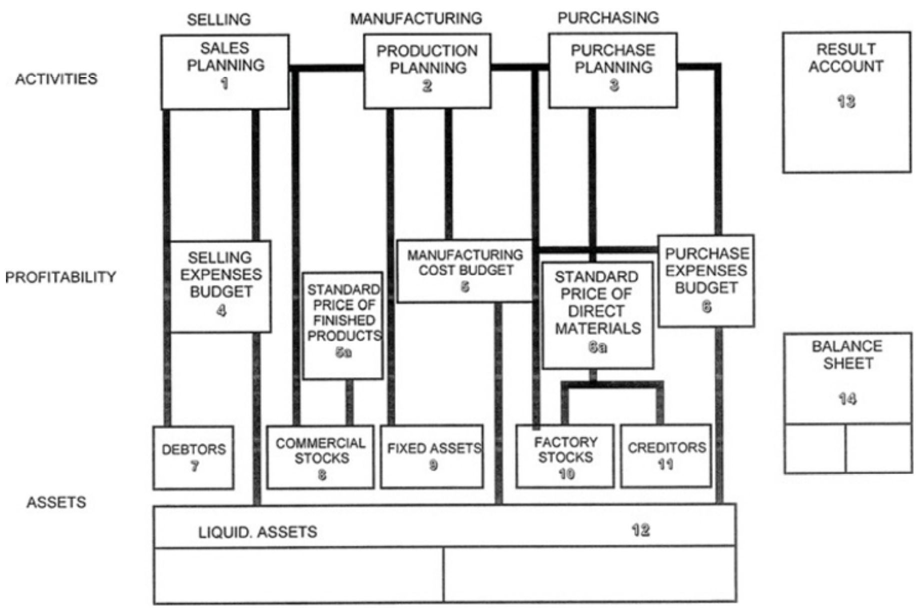


Figure 4.3. *The 14 planning steps from sales to balance sheet*

4.1.2. *Correlation between management thinking and DBMS*

The MRP I and MRP II concepts were developed before software programs were written. In fact, the software packages called production and inventory control system (PICS) and customer-oriented PICS (COPICS) brought in the market place by IBM are the software implementation of the two concepts. In the mid-1970s, a concept called computer-integrated manufacturing (CIM) was discussed in the technical literature. The concept is strongly integration-laden. The idea was to memorize in one database (integration!) all the data items needed to manage and control the business operations of a manufacturing company. It emerged when the early versions of computer-aided design (CAD) and computer-aided manufacturing (CAM) systems were put in the market place. In practice, no software package fulfilling this specification was made available. A very plausible explanation is the lack of performing DBMS at this time.

When reliable relational DBMS became commercially available, ERP-labeled software packages appeared in the market place. This event did not occur by coincidence but is in direct relationship with the properties of relational DBMS. A major technical feature of this type of DBMS is its capability to build data structures for any software program. This means that all data items can be stored in one database and made available in the right format for any software program. The dream of data integration has come true. The underlying concept of ERP-labeled packages was never made explicit for software vendors. It can be concluded that the function capabilities of DBMS play a critical role in providing new tools to develop new types of software systems. The deployment of software packages along with DBMS is summarized chronologically in Figure 4.4.

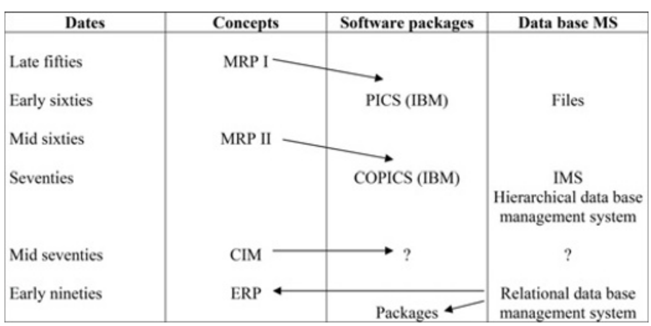


Figure 4.4. *Correlation between the development of management concepts and DBMS*

4.1.3. *Styles of manufacturing*

According to the type of products, three basic styles of manufacturing can be identified.

Engineer-to-order (ETO)

For this type of manufacturing, a major portion of the product is designed to meet the specific requirements of a customer. The product is highly customized and might never be manufactured again. Volumes are low and products are complex in terms of design and manufacturing.

Products falling into this category include airplanes, defense equipment, telecommunication satellites, machine tools, etc.

Assemble-to-order (ATO)/make-to-order

For this type of manufacturing organization, products are assembled on demand from a set of standard components or subassemblies. Customer requirements are translated into certain configurations of parts held in storage at the ready so that an order can be fulfilled on a reasonably short notice.

The whole production organization must be adapted from design to manufacturing. Modular design and flexible manufacturing layout are prerequisites to implement this organizational pattern. On the contrary, a control system with a decoupling point, a storage activity desynchronizing the components flow from the customer-order-driven flow, is necessary to make this manufacturing style instrumental.

Products failing into this category are personal computers, workstations, automobiles, windows and doors, and an increasing number of consumer goods.

Make-to-stock (MTS)

The customer has no impact on the final configuration of products and end items are shipped “off the shelf”. A limited variety of products are offered to customers.

Typical products falling into this category are furniture, file cabinets, garments, shoes and household materials.

4.2. Inventory control system

4.2.1. *Basic model: reorder quantity*

The analysis begins with the classical static model for a single-product inventory in which three types of cost are considered: procurement costs (purchasing or manufacturing and, if relevant, transportation costs), ordering costs and inventory-holding costs. Inventory-holding costs are time dependent, and as such they are proportional to the number of unit periods of stock (one item held for two unit periods plus two items held for one unit period equal four unit periods of stock). Demand is at a constant rate.

The reason why three types of cost are taken into account can be understood when a system description of the situation is given. A flow of products is stored in a storage unit. The in-coming flow is triggered by a control function, purchase when products are delivered by suppliers or manufacturing scheduling when in-house manufactured. When costing an activity, both the costs of the very activity and its control function have to be included in the computation because any activity is always controlled in one way or the other. Figure 4.5 sketches the situation.

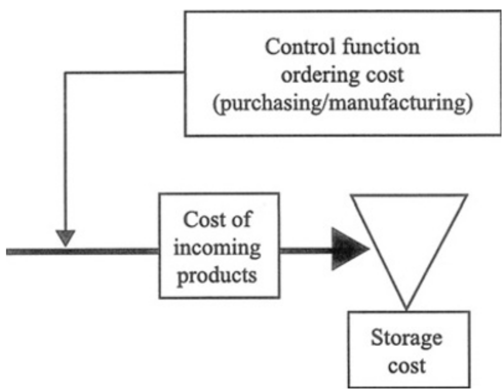


Figure 4.5. *The three types of cost involved in costing stored materials*

In the "classical" model, delivery is assumed to be instantaneous. Figure 4.6 shows the resulting "saw-tooth" time path of inventory.

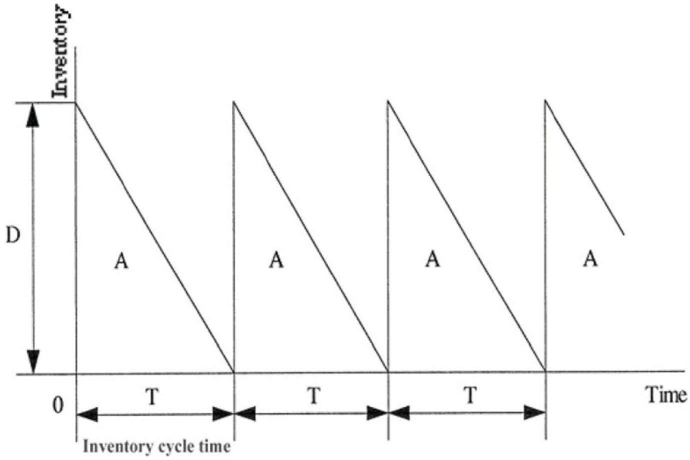


Figure 4.6. *Inventory profile when demand is stable and supply deliveries are periodic*

In the above figure, D is the quantity (order size) to be optimized, T is the inventory cycle time and A is the number of unit periods of stock per cycle.

Total cost per cycle is the sum of the three types of cost mentioned above:

Procurement cost ↓ (Du); Ordering cost ↙ (Cs)

$$TC = Du + Cs + Ch\,A \qquad [4.1]$$

↑ Inventory-holding cost (time dependent) (Ch A)

where u = cost price of one item (purchased or manufactured)

Cs = fixed ordering cost

Ch = cost of holding one item of stock for one unit period of time

A = number of unit periods of stock = $T \times \dfrac{D}{2}$

At time t = 0, an amount D is delivered and constitutes the starting inventory which is run down at a rate of d items per time unit so that the stock D will last for T = D/d. When stock is zero, another batch is delivered. We can now substitute D/d for T into the expression of A.

The expression [4.1] of TC is transformed into

$$TC = Du + Cs + Ch\,D^2 /2d$$

As the inventory-holding cost is time dependent, it is the average cost per item (TC/D) over the cycle time that has to be minimized:

$$TC/D = u + Cs\,D^{-1} + ChD/2d \qquad [4.2]$$

Differentiating equation [4.2] with respect to D and equating to zero give us:

$$(TC)' = - CsD^{-2} + Ch/2d = 0 \qquad [4.3]$$

Therefore, the optimum value of $\overline{D}$, called EOQ, is deduced from [4.3]:

$$\bar{D} = \{2dCs / Ch\}^{1/2} \qquad \text{(square root rule) [4.4]}$$

This result is coherent with an intuitive reasoning seeking for an optimum balance between average replenishment cost per cycle (declining with increase in the quantity ordered) and average holding cost per cycle (rising with increase in the quantity ordered). This is illustrated in Figure 4.7 showing the two curves as functions of D. In this simple model, a minimum of average cost per cycle requires that D is set at such a level that average holding cost per cycle is equal to average replenishment cost per cycle (area OABC in Figure 4.7).

4.2.2. *Basic model: lead time and threshold stock*

When an order for replenishment is placed, the delivery is not immediate. It is necessary to take into account the lead time. Lead time is the number of periods lag between the placing of an order and its fulfillment.

If the demand or usage rate is constant, an order has to be placed when the stock falls to a predetermined level called threshold. This stock threshold depends on the demand rate d (demand per time unit) and the lead time (Figure 4.8).

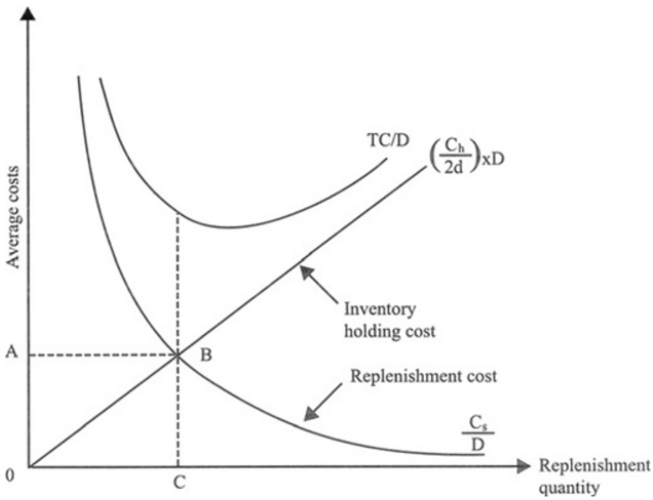


Figure 4.7. *Inventory holding cost and replenishment cost as a function of the replenishment quantity*

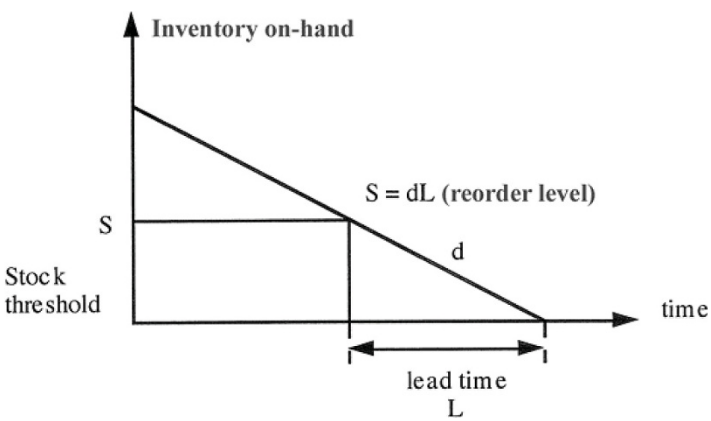


Figure 4.8. *Stock threshold triggering a replenishment order*

The threshold stock S is the stock usage during the lead time.

4.2.3. *Generalization of the basic model*

The basic model can be generalized in many ways. The generalization that will be considered here is the introduction of variable costs. The variable cost prices of purchased goods or variable manufacturing costs can be expressed as a function of D:

$$V= f(D)$$

When f(D) is substituted for Du in equation [4.1], its expression is transformed into:

$$TC= f(D) + Cs + Ch\ A$$

The average cost per item is according to equation [4.2]:

$$TC/D = f(D)/D + Cs/D + Ch\ D/2d$$

Obtaining the EOQ requires the solution of the equation:

$$D\ f''(D) - f(D) - Cs + Ch\ D^2/2d = 0$$

Its solution is analytical only when D f''(D) – f(D) is expressed in terms of D. Otherwise, a numerical solution has to be worked out.

4.2.4. *Probabilistic situation: service levels and safety stock*

When there is some uncertainty in the demand rate and/or in the time between the placing of a replenishment order and the delivery it becomes necessary to make use of some safety or buffer stock to avoid a stockout situation.

Risk is incurred during the delivery lead time. That is why the safety stock is determined by the level of protection chosen against uncertainty in usage during the delivery lead time. This level of protection is often expressed in terms of “service level”. It can be defined as the proportion of items delivered to customers compared with the total required over the lead time period.

The required safety stock can be computed as follows to meet a chosen service level:

Step 1: obtain the parameters of the stochastic distribution of demand during lead time.

Demand rate and lead time can be random variables with joint distribution. Recording data for statistical analysis of their joint distribution is not an easy task. That is why it appears more convenient to collect demand-per-day and lead time data, which are more easily available, and derive the parameters of their separate probability distribution. There are arguments to assume that they are independent variables with Gaussian distribution.

These distribution parameters of the random variables are:

– for the demand-per-day d: mean value $\bar{d}$ and standard deviation σ_d;

– for the lead time L: mean value $\bar{L}$ and standard deviation σ_L.

Step 2: adjust the distribution parameters of the demand-during-lead time (DDLT) variable from random variables considered in step 1.

The DDLT variable can be expressed as the sum of two stochastically independent variables:

– demand during the average lead time $D = \sum_{i=1}^{\bar{L}} d_i$ with the mean value $\bar{L}\,\bar{d} = \bar{D}$ and standard deviation $\left\{\bar{L} \times \sigma_d^2\right\}^{1/2}$;

– variation in demand due to lead time distribution with the mean value 0 and the standard deviation $\bar{d} \times \sigma_L$.

Step 3: Determine the safety stock in terms of service level to the customer.

It turns out that DDLT is the sum of two stochastically independent variables with assumed Gaussian distribution. As a consequence, DDLT is a normally distributed variable with a mean of $\bar{L} \times \bar{d} = D$ and a standard deviation of $\left\{L\, \sigma_d^2 + \bar{d}^2 \sigma_L^2\right\}^{1/2} = \sigma_{\overline{Ld}}$

The re-order level is set at R, given by $R = \bar{D} + z\, \sigma_{\overline{Ld}}$.

The service level is a function of z: its value can be obtained from a table of areas under the standard normal curve up to z. For instance, if z = 1, the probability of stockout during lead time is 15.87%, and if z = 2 this probability is 2.28%. Figure 4.9 shows the probability distribution of DDLT and the meaning of the safety stock.

Stockout situations are the consequence of either stochastic demand rate or replenishment lead time or a combination of both. They are shown in Figure 4.10.

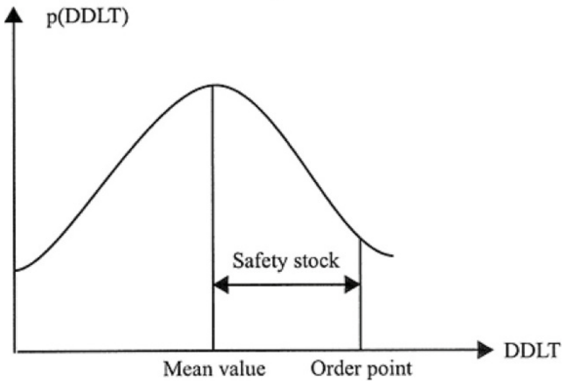


Figure 4.9. *Probability distribution of demand-during-lead-time (DDLT)*

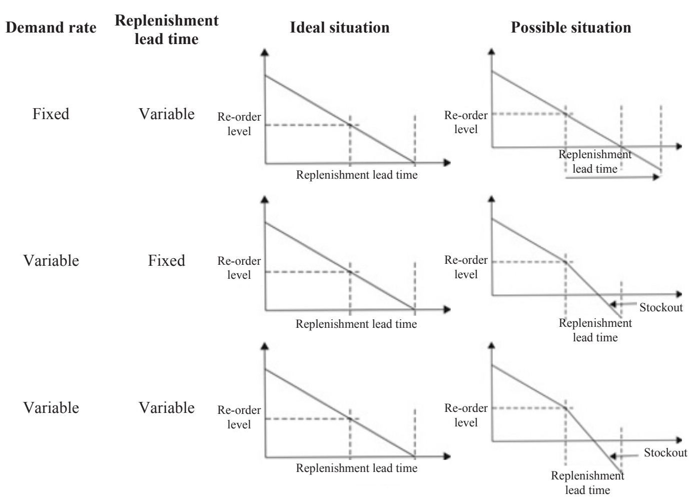


Figure 4.10. *Possible stockout situations*

To counterbalance uncertainty, the reorder level is established according to the following expression:

Reorder level = U (average lead time usage) +

SS (safety stock determined to cover a given risk of stockout)

4.2.5. *Delivering into stock over time: economic manufacturing quantity (EMQ)*

Items are manufactured by batch and are delivered to the market place continuously throughout the manufacturing process periods. When the manufacturing rate *p* is higher than the demand rate *d*, a stockpile builds up to a maximum inventory reached when a batch is completed as shown in Figure 4.11.

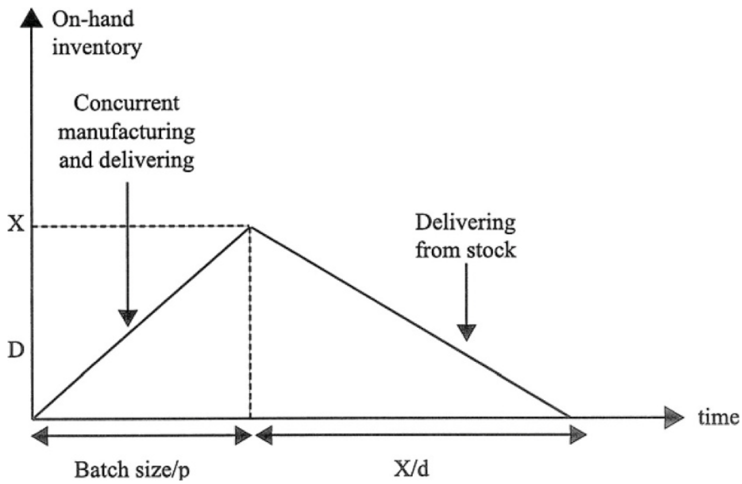


Figure 4.11. *Building-up of on-hand inventory when the production rate is higher than the demand rate*

At each moment, the amount of on-hand inventory is the difference between cumulated production and cumulated deliveries. Figure 4.12 depicts how the stockpile builds up. When production stops, deliveries to the market originate from stock.

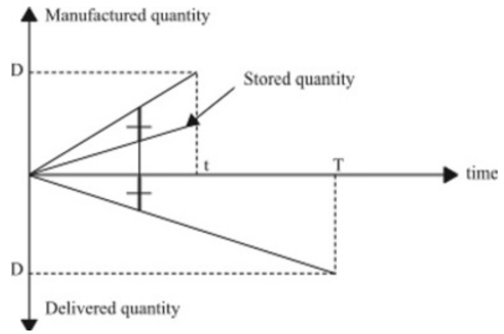


Figure 4.12. *Concurrent mechanisms depicting how the stock pile builds up*

The EMQ minimizing the total cost of setup and inventory holding is:

$$Q^* = \{2d\ Cc/Ch\}^{1/2}\ \{1 - d/p\}^{-1/2}$$

with Cc = setup cost to launch the manufacture of a batch;

p = manufacturing rate of items;

d = demand rate of items;

Ch = inventory-holding cost per item per time unit.

Let us explain how EMQ is derived. The inventory-holding cost is time dependent, which means that the total cost under consideration for computing EMQ must be the sum of costs incurred over a well-defined period of time (for instance, per time unit) or the average cost per item manufactured. In the second case, the time parameter is explicitly offset, but implicitly taken into account because manufacturing a batch of items requires time. Anyway, the two approaches yield the same result.

The various steps to follow for computing EMQ are as follows:

Step 1: obtain the total cost TC per full cycle T (D/d);

It is the sum of three types of cost:

– manufacturing cost Q × u, where Q is the quantity manufactured and u is the manufacturing unit cost;

– setup cost to launch the manufacture of a batch of Q products;

– inventory-holding cost that is Ch (inventory-holding cost per item per time unit) × X_m (average on-hand inventory over the cycle time) × T (cycle time);

X is the maximum quantity of on-hand inventory (Figure 4.11). It is reached when the batch size is complete. At this time, the cumulated manufactured quantity is Q = pt and the cumulated delivered quantity is dt. The value of X is pt-dt = (p-d)t = (p-d) Q/p. The average value of on-hand inventory over the cycle time T is X_m = X/2. This results from elementary geometrical considerations or from application of the formal formula of the average value of a function.

The expression of TC is Qu + Cc + ½ [Ch x (p-d) Q/p x T].

Step 2: derive the total cost TC per time unit and the average cost per item;

The total cost per time unit is TC/ T = Qu/T + Cc/T + ½ [Ch x (p-d) x Q/p]

As Q = pt = dT, the previous expression is transformed into:

ud + Cc d/Q + ½ [Ch x (p-d) x Q/p] [4.5]

The average cost per item TC/Q is

u + Cc /Q + ½ [Ch x (p-d) Q/(p d)] [4.6]

Step 3: differentiate the total cost TC per time unit or the average cost per item with respect to Q.

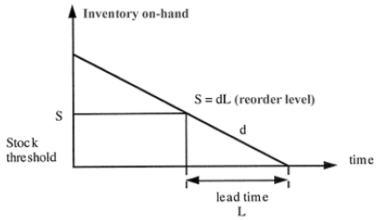
Equating to zero, the derivatives of [4.5] and [4.6] with respect to Q yield the same result.

$$Q^* = \{2d\ Cc/Ch\}^{1/2}\ \{1 - d/p\}^{-1/2}$$

If p is much greater than d (p >> d), then d/p becomes negligible with respect to 1 and Q^* is written as {2d Cc/Ch}1/2, which is precisely the expression derived in section 2.1. Is it surprising? No, because in this case the manufacturing time of a batch is so short that the whole batch is stored before delivering products to market customers.

SCOPE OF THE RE-ORDER LEVEL MODEL

Basis of many more advanced models



BASIC ASSUMPTIONS:

a) the depletion profile of stored materials can be modelled by a linear function

b) the depletion rate is constant or can be described by a stochastic function (average and standard deviation) whose characteristics are stationary, i.e. stable over time.

ISSUES TO BE ADDRESSED:

WHEN to place an order?

HOW MUCH to order ?

WHEN TO RELEASE A REPLENISMENT ORDER? : MODEL PARAMETERS

Replenisment lead time L

Depletion rate d

→ Reorder level = L x d

HOW MUCH TO ORDER ? : MODEL PARAMETERS

Ch = Inventory-holding cost per item and per time unit

Cs = ordering unit cost

→ Economic Order Quantity $\sqrt{2d\ Cs / Ch}$

APPROACH TO UNCERTAINTY

When the depletion rate and/or replenishment lead time are random variables possible stock-out situations can happen.

The counter measure to deal with this context is to have a safety stock securing a chosen service level.

A service level is defined by the probability of being able to fulfil an order from stock during a certain period of time, here replenishment lead time.

APPROACH TO REDUCING AVERAGE UNIT COST

Split deliveries :

One order → One delivery

One order → Many deliveries

4.3. Manufacturing resource planning

4.3.1. *Defining planning and scheduling*

Planning is the managerial process of deciding in advance what is to be done and how it is to be done. Planning is not an end in itself; its primary purpose is to organize action to make the best economical use of resources. All resources required to conduct business operations are costly because they are scarce. Their consumption must be made optimal, i.e. economical, by means of good management practice and control.

Planning is done on both a formal and informal basis from information sources internal and external to the firm. Because planning deals with future action, it is derived from forecasting. Forecasting is always associated with uncertainty. This means that flexibility must be incorporated into plans. Even when there is considerable uncertainty, plans give direction and purpose to a firm. Without plans, any organization is rudderless.

In the literature on planning, a wide variety of terms are used, not always consistently. For clarity, the terms used in this book are defined below:

Objectives: statement of aims and goals to be achieved;

Plan: statement of specific actions and/or outcomes to achieve objectives;

Schedule: detailed description of how to fulfill the requirement of a plan.

Thus, *objectives* are ends, *plans* are means and *schedules* are implements.

Scheduling is the process of transforming a plan into operational guidelines.

4.3.2. *General description of the MRP technique*

MRP II is a computational technique establishing a realistic master schedule for serving the forecast market demand, on the one hand, and converting the master schedule for end products into a detailed schedule for the supply of raw materials and components used in the end products, on the other hand. The detailed schedule identifies the quantities and the supply and/or processing lead times of each raw material and component item required to fulfill the master schedule.

Although MRP II is an effective tool for minimizing unnecessary inventories (raw materials, work in progress, finished products, etc.), it relies on a master schedule that is the core engine triggering the release of supply orders and manufacturing orders. The concept is rather straightforward. The master schedule provides the overall timetable for end products in terms of time-period-by-time-period availability requirements. This allows the sales department to issue shipping orders. The master schedule is the implement ensuring collaboration between the various departments involved (procurement, manufacturing and sales).

In order to compute the component requirements for end products listed in the master schedule, the product structure must be known. This is specified by the bill of materials (BOM), which is a listing of components and subassemblies making up each end product. In the MRP II vernacular, end products are called independent-demand items and the components are called dependent-demand items. The demand of components is derived from that of end products by means of the product structure or the BOM.

In terms of inventory management, the purpose is to make inventories available only at specified due dates derived from the master schedule through the BOM. Inventories are monitored as a collection of dependent-demand items.

The main building blocks of the MRP technique and their multiple interplays are described in Figure 4.13.

Master activity planning

Master activity planning is a top management responsibility. It provides guidelines and constraints within manufacturing that is expected to operate. The master activity plan follows from balanced agreements between three business functions (marketing, finance and manufacturing) as to what, in aggregated terms, will be produced and made available for sales to the market place per large periods of time. The span of these periods of time depends on the type of products manufactured and the market behavior. Master activity planning is the key driving force of future business operations.

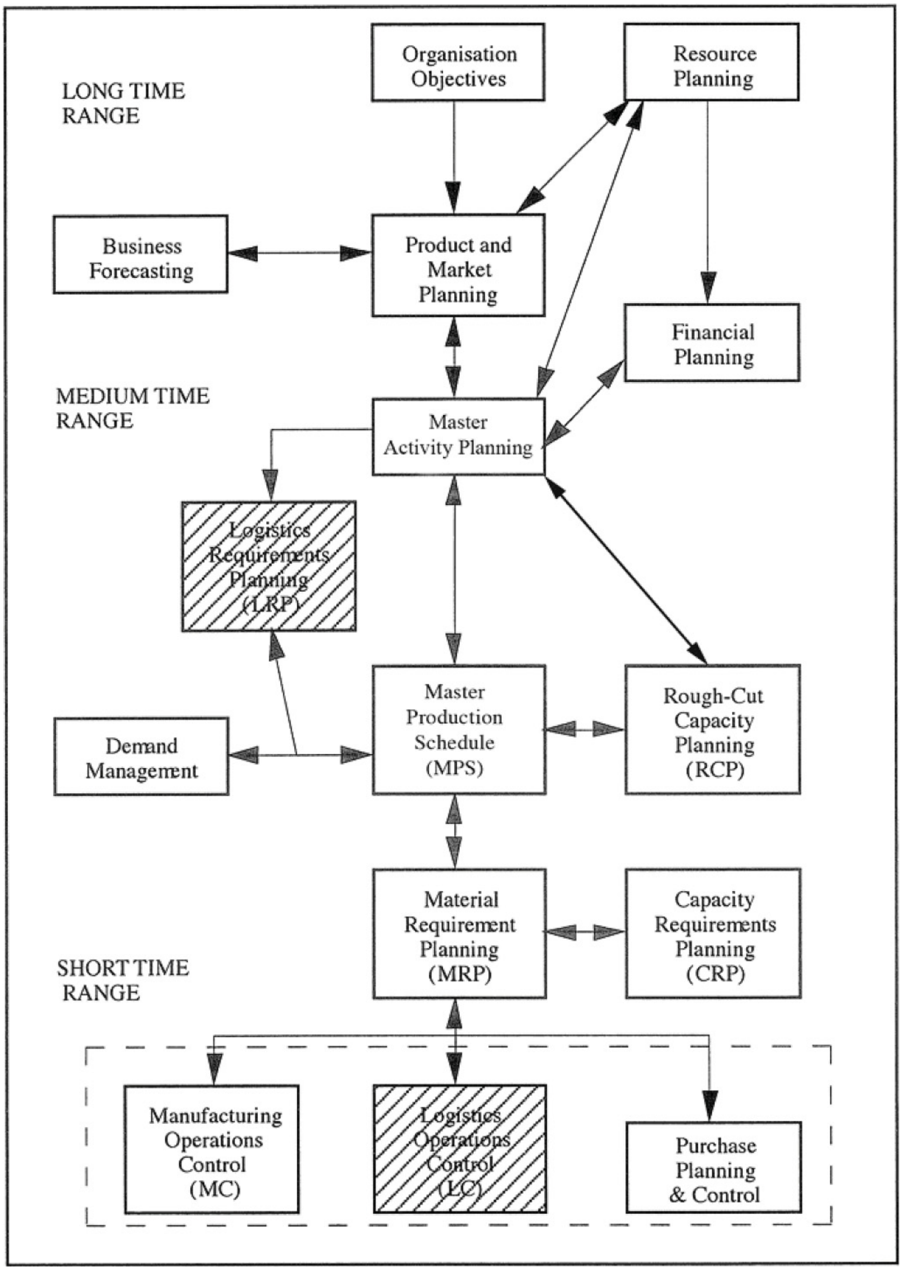


Figure 4.13. *Main building blocks of the MRP technique and their interactions*

Master activity planning results in long-range plans describing the rough-cut capacities of resources required by activity-based processes to produce determined aggregate output quantities by large time periods with a long planning horizon. It is a part of the global strategy of an enterprise, along with product and market planning, financial planning and resource (other than finance) planning. It is derived from long-range forecasts.

Logistics requirements planning

Logistics requirement planning refers to the planning of key resources so that warehouse spaces, workforce and transport are provided in right quantities in line with customer demand and the process plan.

Demand management

Demand management consists of recognizing and managing all of the demands for products/services in order to ensure that they are included in the master process schedule. It covers the activities of short-term forecasting, order entry and branch warehouse requirements.

Rough-cut capacity planning

The rough-cut capacity planning is purposely targeted to identify the existence of critical manufacturing and supply resources that are potential bottlenecks in the production flow, and to help check whether their capacities meet the requirements of the master schedule. It reflects the basic objectives of keeping the master schedule realistic in terms of available resource capacities.

There is also a link to the master activity planning box to secure the long-term resource capacities in line with the long-range activity plans.

Master production schedule (MPS)

A master schedule is a short-range plan describing the quantity and detailed timing of the process output (goods/services). When a business process plan is translated into a master process schedule, logistics requirements and supply capacities have to be accounted for to yield "realistic" scheduling.

The MPS is a commitment assigned to and accepted by the manufacturing department to deliver to the sales department per time buckets the quantities of products put in the schedule. In this way, the sales department knows the type and the quantity of products per time period it has to sell.

Material requirements planning

Material requirement planning converts a manufacturing schedule into a supply plan with the help of data describing product structures (what has to be ordered with time-phased supply) to fulfill the master schedule at due dates.

Manufacturing and logistics operations control

Performance indicators for both types of operations are required to yield a full control of the activity chain form suppliers to customers.

4.3.3. *MRP-related concepts in action*

4.3.3.1. *MRP mechanism*

When it comes to practically use the MRP technique, two phases need to be distinguished: the preparation phase and the implementation phase (see Figure 4.14). During the preparation phase, input data from the market (customer order servicing, demand forecasting) are combined with support data, characterizing the manufacturing capacities of the enterprise, the product structures and its current inventories (on-hand quantities of raw materials, semi-finished and finished products have not to be supplied or manufactured) to produce a master production schedule (MPS). This MPS is a collaborative tool orchestrating and triggering the activities of the enterprise so that all tasks are completed on time to fulfill the objectives of the MPS.

Four operational objectives to meet the MPS requirements *per time bucket* can be identified:

– quantity of products manufactured;

– agreed level of quality;

– cost aimed at;

– delivery due dates committed.

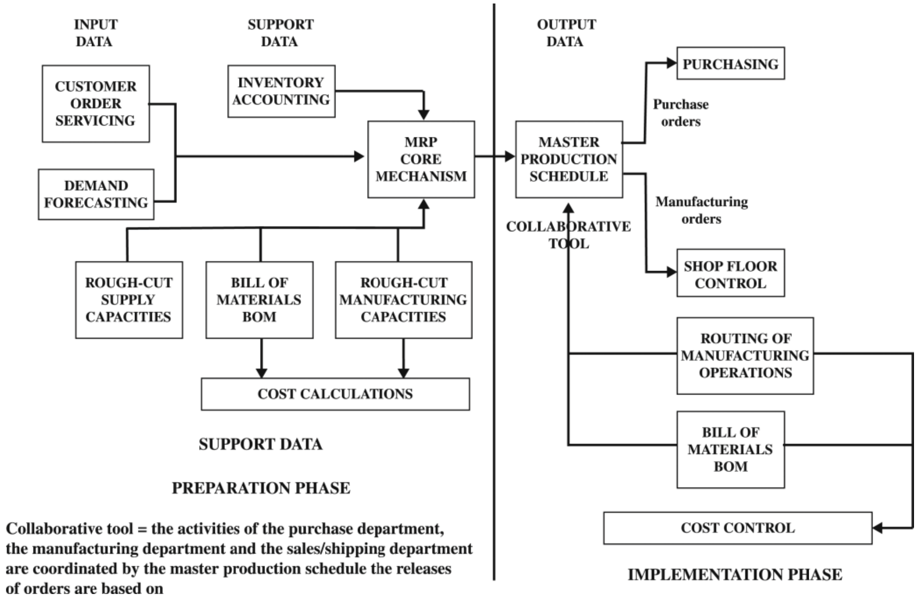


Figure 4.14. *Preparation and implementation phases of the MRP mechanism*

The underlying idea behind these targets is that all the resources required to fulfill the MPS have to be made available "on time" so that customer orders are delivered on time and that the consumption of resources and, as a consequence, costs are brought under full control. One notion that is central to MRP is the notion of the optimized usage of resources due to demand forecasting to yield overall efficiency within the framework of the Taylor's tenet.

Some other issues have to be considered to reach a full-fledged description and to make use of the MRP technique, i.e. the time horizon of the MPS, the items to lodge in the MPS and the data requirements of the information system supporting the MRP concept.

4.3.3.2. *Time horizon of the MPS*

The stakeholders involved in establishing an MPS are the sales department that can be considered as the embodiment of the market place inside the enterprise, the manufacturing department that is the critical kingpin for working out the MPS and the purchase department that stands proxy for the suppliers of raw materials. These are interdependent key partners because, without the availability of supplies, the manufacturing department cannot fulfill the MPS commitments.

After all the stakeholders have come to an agreement concerning the MPS, it is “frozen” over a well-defined horizon. This means that, in fact, the MPS concept implies the decoupling of the manufacturing activities from the market place over a certain time horizon. This approach is on the fringe of economic unrealism when market demands have turned global.

There is no general rule to decide on an appropriate time horizon. It depends on the type of industry under consideration and the market behavior. A technique often used to counterbalance the volatile demand which can be seasonal or cyclical is rolling MPS split into two parts. It offers appropriate means to deal with market uncertainties.

The first section of the MPS is “frozen”, i.e. nothing can be changed in terms of manufacturing and supply orders. The second section is considered “flexible” and partly committed, i.e. can be adapted according to the changing backdrop.

The idea of “rolling” MPS is to update an existing MPS before it has reached its final limit. Figure 4.15 illustrates the technique.

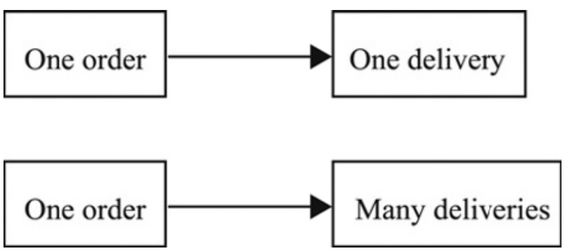


Figure 4.15. *The technique of rolling plans*

4.3.3.3. *Independent demand items versus dependent demand items*

A relevant question raised when developing a master schedule function is: what for products to include in the processing function? The primary basis for this determination is the nature of the products' BOM structure. The BOM is the product structure of the item to manufacture. It is a top-down hierarchical description of the item. As an example, the product structure for the final assembly of a personal computer (PC) is given in Figure 4.16.

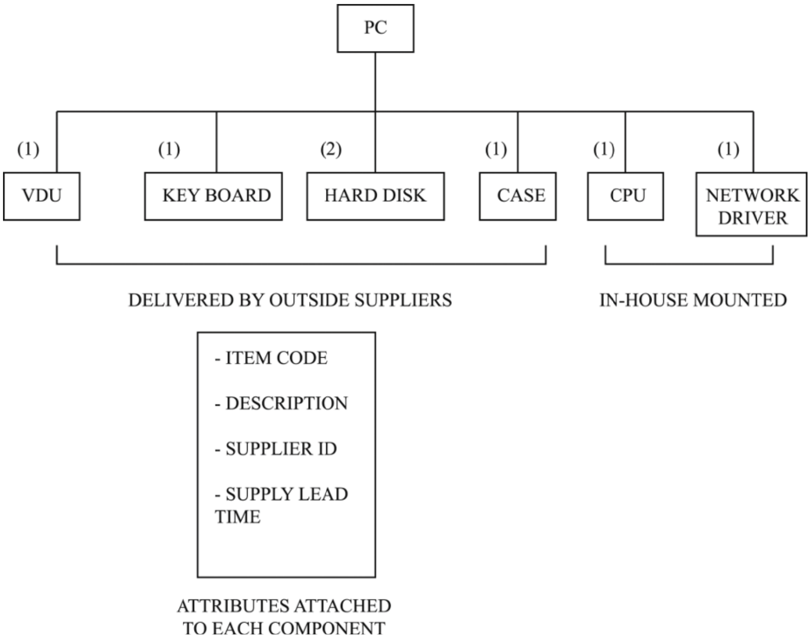


Figure 4.16. *Relationships between product structure, operations and resources required for manufacturing an assembled finished product*

The configurations of BOMs tend to fall into one of the three categories as shown in Figure 4.17.

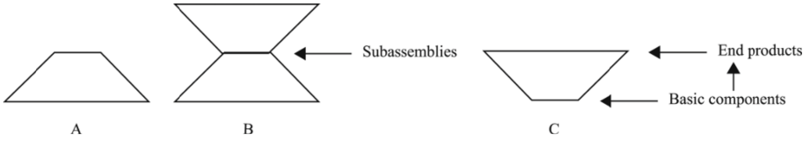


Figure 4.17. *Bill of materials structures*

The shape of each category symbol is intended to give an impression of the evolving number of compound components along the manufacturing process.

The structure represented by category A is a BOM in which many components are combined to manufacture a lesser number of end products. Category B represents a bill in which many components are required to produce a limited number of subassemblies that are then used in various combinations to deliver many end products. Category C represents an inverted bill structure in which a few raw material components are transformed by the production process in many ways to deliver a large number of end products.

It is generally accepted that the proper level to schedule in each category is the section of the structure with the most restricted width, and, therefore, with the fewest parts.

Category B refers to a situation where products are designed and manufactured on a modular basis: subassemblies are configured to fulfill customer orders on demand.

Requirements of dependent demand items are derived from their usages in independent demand items through the definitions of product structures. This calculation is performed by an algorithm called material requirements planning. Figure 4.18 shows how the MRP algorithm works. Requirements for assembly A come from parent assemblies X and Y, as well as a service requirement of 30 pieces. Item B, which is dependent on A, is planned on the basis of scheduled receipts and on-hand inventory. The planned order release of 12 A's has been offset by lead time (and lot-sized to a minimum order quantity of 50). The requirement of 50 is "exploded" to its components B and C using the BOM. Components B and C are assumed to be available when planned orders are released. Minimum order quantities result from economic considerations for minimizing overall costs.

4.3.3.4. *Information system supporting the MRP technique*

Calculations required by the MRP technique are not sophisticated, but the volume of data involved cannot be dealt with without the support of computer technology. It makes possible to perform the calculations necessary to work out the appropriate attributes of manufacturing and supply orders (quantity and due date).

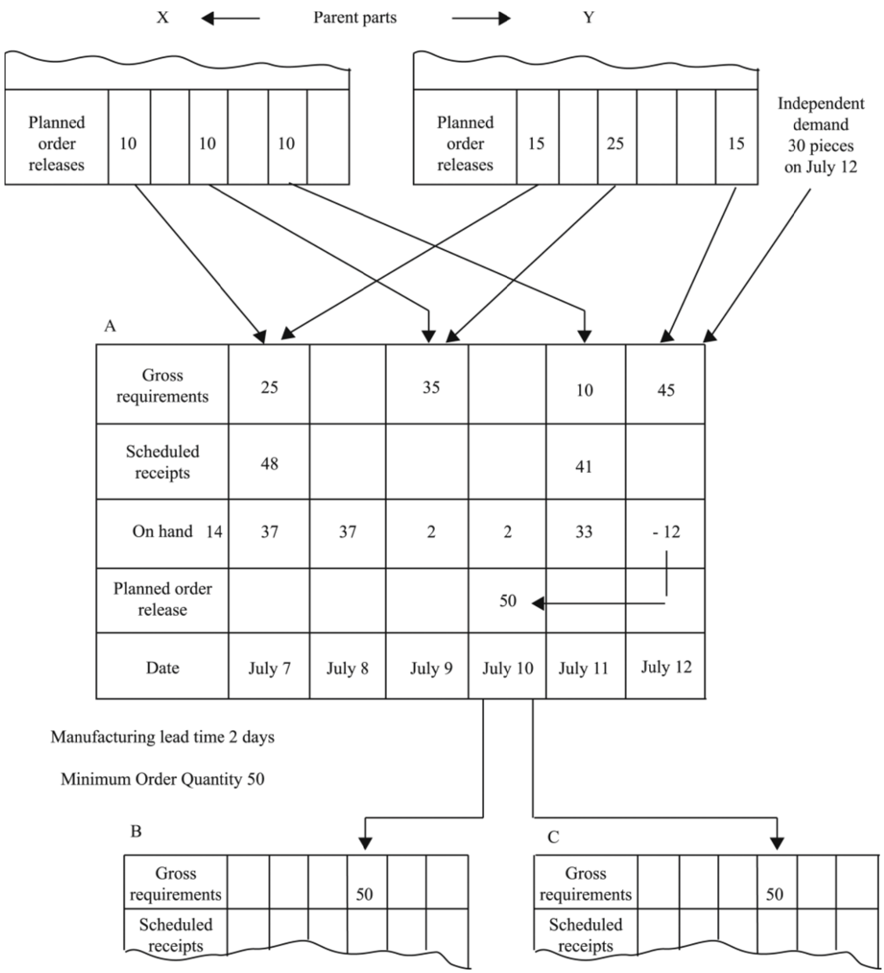


Figure 4.18. *MRP algorithm for deriving order releases*

The data requirements refer to product structures, descriptions of operations and resources. Product structures (also called BOM) identify end products to manufacture and their components in a hierarchical form. Descriptions of operations explain the sequences of operations engineered to manufacture specified products. Resources are something that are necessary in terms of equipment and manpower to carry out manufacturing operations.

The three blocks of data are interrelated. Figure 4.19 portrays the situation found in all software packages offered by vendors.

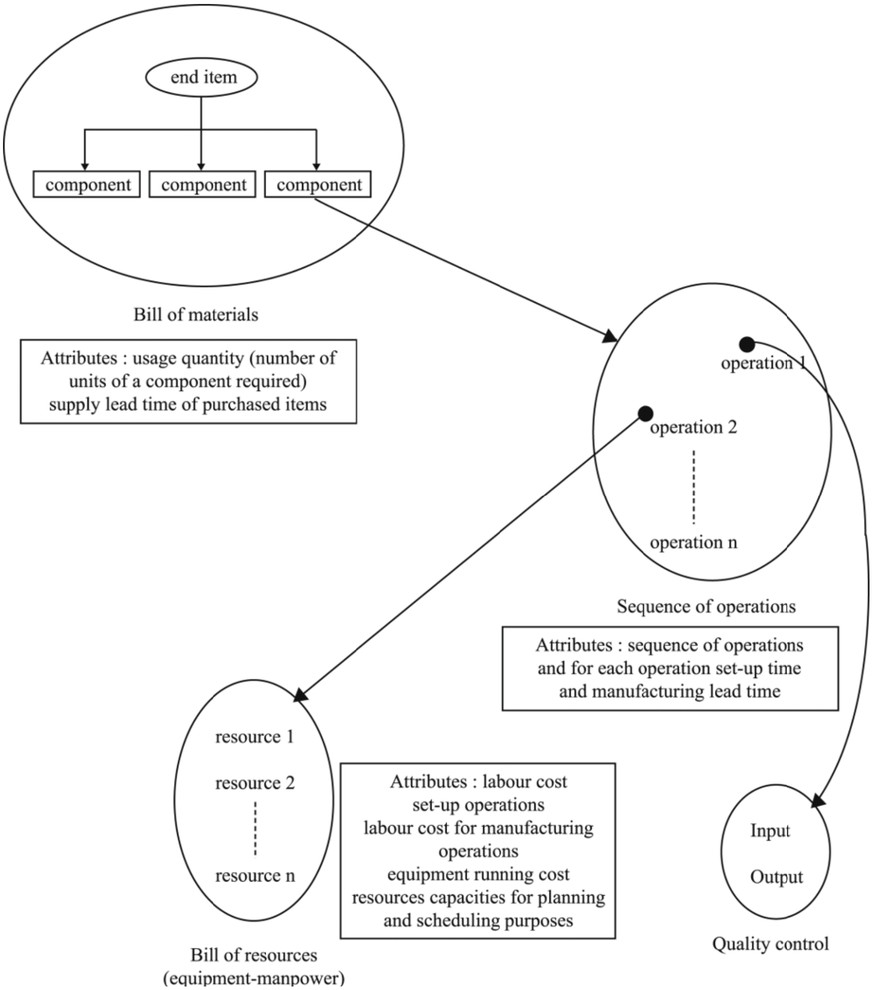


Figure 4.19. *Relationships between product structure, operations and resources required for manufacturing a product*

Lead times that are attributes of operations and product structures for purchased items are the key variables for backward scheduling, the releases of manufacturing and supply orders from delivery due dates, so that the products lodged in the MPS are delivered on time.

Remember that once an MPS has been agreed on, it becomes a sales plan for the sales department. Commercial people know, by time interval, what quantities of products will be made available by the manufacturing department which is committed to fulfilling the MPS.

The way sales plan, manufacturing and supply schedules are articulated is shown in Figure 4.20.

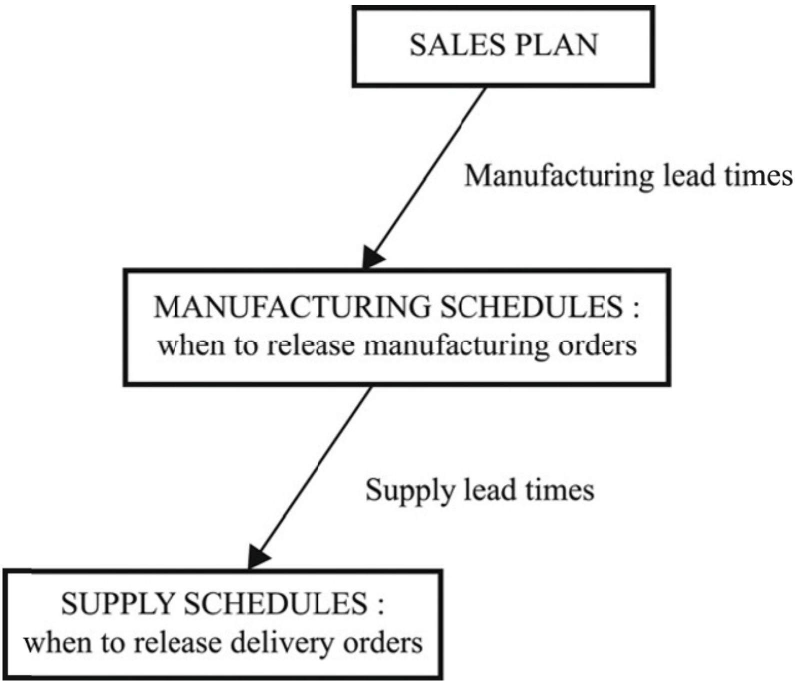


Figure 4.20. *Relationships between sales plan, manufacturing and supply schedules to derive the releases of manufacturing and supply orders*

In order to give a detailed insight into the MRP dynamics, Figures 4.21 and 4.22 show how a manufacturing schedule is derived from a sales plan.

Converting a sales plan into a manufacturing schedule requires two types of data items: end products structures and manufacturing lead times.

Time buckets → / Product types quantity ↓	n-2	n-1	n	n+1	n+2
A			100	120	90
B			1000	1200	900

Figure 4.21. *Sales plan committed to be supplied by the manufacturing department*

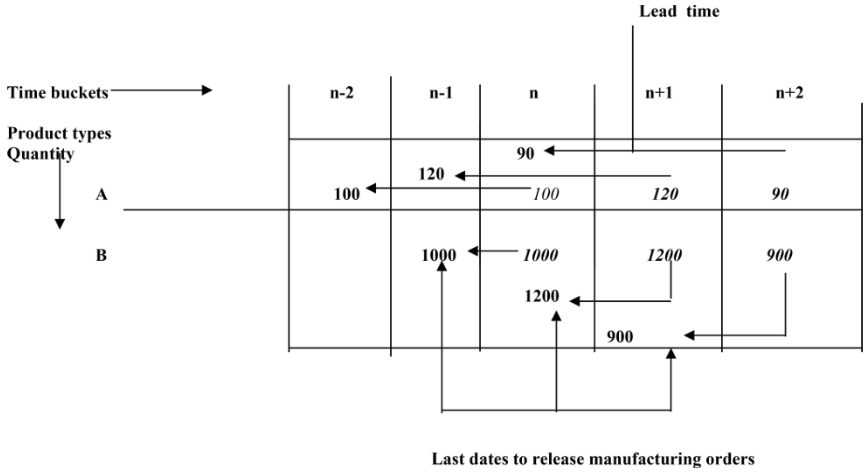


Figure 4.22. *Manufacturing schedule*

Delivery schedules of purchased items can be derived from the manufacturing schedule by taking account of the various lead times.

4.3.4. *Implementation of MRP-related concepts in the maintenance field*

4.3.4.1. *Introduction*

Maintenance has turned to be an important issue in the manufacturing industry. First, all manufacturing control systems assume that equipment units are available when needed. This means that down times have to be reduced to a minimum. As increasingly automation devices are in operation, preventive maintenance has become prevalent and has to be scheduled to shun down times and make the best use of expensive highly skilled labor.

MRP-related concepts can be advantageously applied to maintenance activities. The types of data required are precisely those described in Figure 4.16.

The equipment unit structure describes the unit from the point of view of maintenance in terms of systems to be serviced and spare parts to supply. Figure 4.23 shows the structure of an equipment unit M, the systems S_1 and S_2 which have to be serviced by changing parts C_{11}, C_{12}, C_{13}, C_{21} and C_{22}.

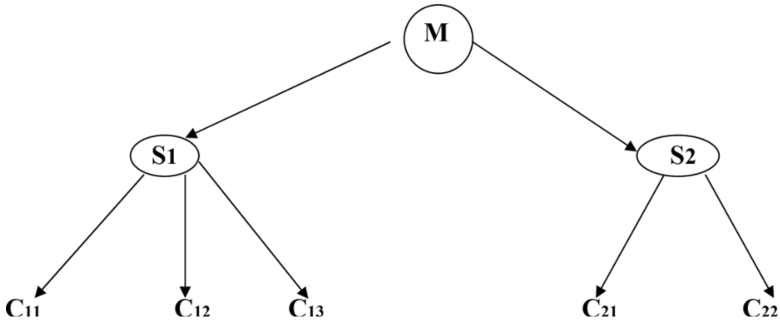


Figure 4.23. *Equipment unit structure*

A schedule of maintenance activities can be evolved as a Gantt chart by backward scheduling. This means that scheduling is engineered backwards starting from the due date of maintenance completion on the basis of the lead times of maintenance operations and spare parts supply. From this Gantt chart, it is deduced at the latest dates maintenance orders and supply orders of spare parts have to be released so that the due dates of the maintenance schedule are met. Figure 4.24 presents an example of backward scheduling of the maintenance of an equipment unit made up of two systems to be serviced.

4.3.4.2. *Exercise in maintenance resources planning*

The best way to make concepts understandable is to give a straightforward example implying active participation with some thinking and self-discovery of solutions. Most problems in business environments have to be solved under incompatible constraints using common sense. One best solution is rarely found. A full solution of the exercise will not be developed, leaving the readers imagining solutions.

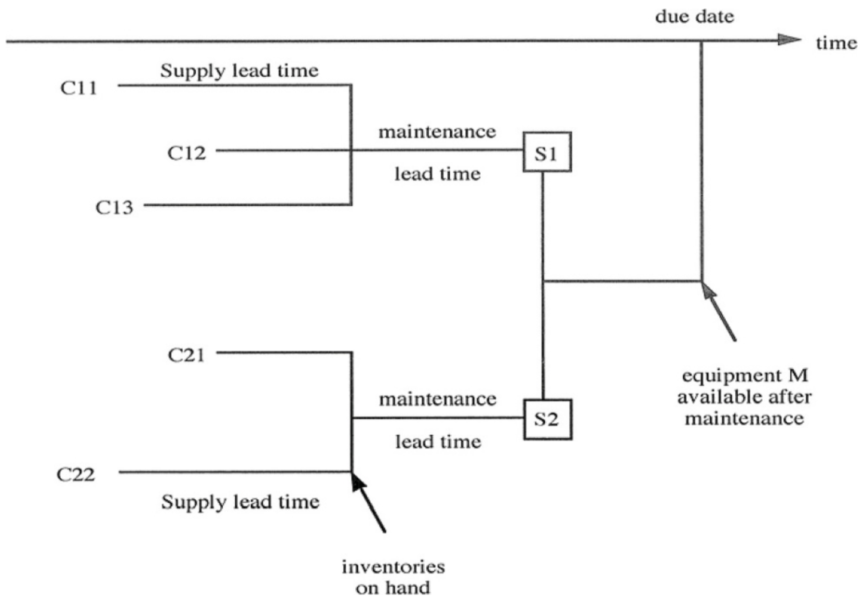


Figure 4.24. *Backward scheduling of maintenance activities to determine the latest dates when maintenance and supply orders have to be released*

Two equipment units have to be maintained. Their structures for maintenance purposes are described in Figure 4.25.

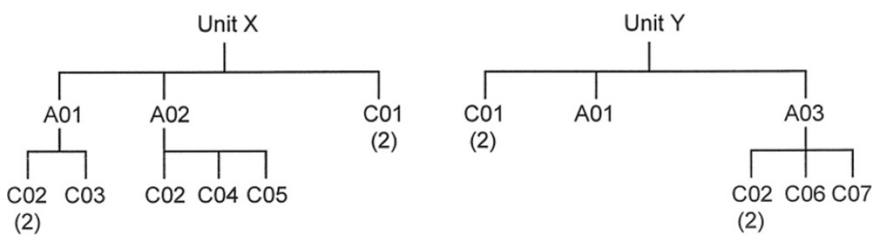


Figure 4.25. *Equipment unit structures*

The numbers between brackets in Figure 4.25 are the usage quantities: two CO_2 parts are in AO_1 as well as in AO_3. The delivery lead time of part CO_2 is two time units.

Time requirements for maintaining the equipment units X and Y are:

– Equipment Unit X: 8 h;

– Equipment Unit Y: 7 h.

A maintenance shift works for 15 h, which is taken as a time bucket for maintenance scheduling. For work efficiency, any equipment unit must be maintained only within one time bucket, and no overlapping is allowed.

A planned maintenance schedule is given in Table 4.1.

Time buckets	2	3	4	5	6	7	8	9
Unit X	1		1		1		1	
Unit Y		4		3		2		4

Table 4.1. *Planned maintenance schedule*

QUESTIONS.–

– *Is this maintenance schedule realistic? If not, make the relevant changes.*

Realistic means that all the required resources will be available. In this case, the resource taken into consideration is the workforce equivalent to 15 h per time bucket.

Smoothing the workload is the technique used to make a schedule realistic by trials and errors. The maintenance of a unit can be moved upstream or downstream the planned time bucket.

– *Calculate the requirements for component CO_2 by time buckets to match the maintenance schedule.*

Component CO_2 requirements are deduced from the maintenance schedule through the equipment unit structures. They are called “gross part requirements”. In a second step, the available balance of components per time bucket has to be taken into account. It is the quantity of components that is projected to be on-hand considering the quantity already on-hand and the supply orders previously released the delivery of which has been confirmed.

Gross requirements subtracted from available balance return net requirements (see Chapter 7, section 7.2, for detailed explicitness). Before calculating a new available balance schedule, it is critical to receive confirmation from the suppliers that they are in a position to supply the quantities you need. Without this essential step, the new available balance is uncertainty-stricken and cannot be considered as a reliable management tool.

Another parameter is lot sizing. Lot for lot means that the quantity required can be ordered whereas when a lot size is imposed by the supplier, a fixed quantity has to be ordered even if your requirement is lower than the lot size. This constraint incurs higher inventory levels.

– Determine when call-off orders have to be released to suppliers to make the deliveries in line with the requirements.

Tables 4.2 and 4.3 are given as templates to work out the exercise for part CO_2.

Time buckets		0	1	2	3	4	5	6	7	8	9	10	11
Resources requirement													
Smoothing													
Maintenance schedule													

Table 4.2. *Template for evolving a realistic maintenance schedule through smoothing out the workload*

Delivery lead time: 2 time units — Part identification

Lot sizing: lot for lot — CO_2

Time buckets		0	1	2	3	4	5	6	7	8	9	10	11
Gross part requirement													
Available balance													

Net requirement													
Confirmed orders													
Call-off orders													
New available balance													

Delivery lead time: 2 time units — Part identification

Lot sizing: 5 — CO_2

Time buckets		0	1	2	3	4	5	6	7	8	9	10	11
Gross part requirement													
Available balance													
Net requirement													
Confirmed orders													
Call-off orders													
New available balance													

Table 4.3. *Template for deriving part requirements plans (lot sizing: lot for lot and 5)*

4.4. The just-in-time concept

4.4.1. *Introduction*

Another concept for controlling manufacturing processes emerged in the 1970 in Japan. It was developed by companies, notably Toyota, within a manufacturing context. It has become a most advocated, copied and popular manufacturing philosophy. However, just-in-time (JIT) is a general approach having far-reaching implications for the full range of business operations. The JIT principles are introductory in nature and provide foundations on which each business function can be (re)organized and linked up together to yield an optimized workflow.

Within the manufacturing framework, JIT has been defined as involving "the production of the necessary items in the necessary quantities at the necessary time". With this approach, the entire manufacturing system is pulled by demand: the need to serve/supply a customer triggers activities along the operating system. This organizational situation contrasts significantly with practice in many systems which depend on substantial inventories. Two important features of JIT refer to rapid throughputs and reduced inventories to cut costs. This seemingly simple idea is applied to enable efficient operation flow to be established in many segments of business activities outside manufacturing.

In spite of the fact that the JIT concept is presented mainly as an organizational concept (reduce throughput time, cut lot size, etc.), its *stricto sensu* implementation requires planning resource capacities and using them as managing and controlling tools.

4.4.2. *Core features of the just-in-time concept*

Gaining a full understanding of the MRP II and just-in-time concepts requires to clearly distinguish between planning and accomplishing activities.

Planning can be described by the following four-step approach:

– *Understand the pattern of the market demand and its volatility*

Such appropriate questions should be addressed:

– which products are most variable/difficult to forecast or cause the most production problems if the forecast is low?

– which products have only a few customers?

– which customers require the shortest lead time? What problems is this causing in the supply chain?

– which products are most profitable?

– how can shipment history be used most effectively for statistical forecasting and at what level of aggregation?

– *Analyze inventory and position it to support demand*

A full inventory visibility allows for addressing the following issues:

– the average number of days in supply per stock-keeping unit;

– levels of safety stocks per location;

– inventory management processes to keep inventories at established target levels and reexamine them on a regular basis.

– *Create a collaborative demand planning process*

Data inputs come from different sources (sales, marketing, inventory management, purchasing). The purchasing department ensures visibility on the supply market. Each input, including the statistical forecast, should be maintained separately, so that the accuracy of each can be measured. In addition, there must be a mechanism for determining a consensus forecast.

– *Create a quantitative framework for balancing demand with supply*

Optimizing a complex manufacturing plan requires the processing of many related factors, such as manufacturing capacities, sourcing alternatives, desired inventory per location, supply and distribution logistics capacities.

A model that closely reflects the business reality is needed. It can be used to produce several alternate scenarios. The choice between scenarios must result from consensus between all the stakeholders (operations manager, shop floor supervisor, master scheduler, purchasing manager and transportation manager).

Contrasting MRP II and JIT as control concepts leads to the view that resource capacities are used to support MRP II master production scheduling and to control JIT-driven activities directly, as shown in Figure 4.26.

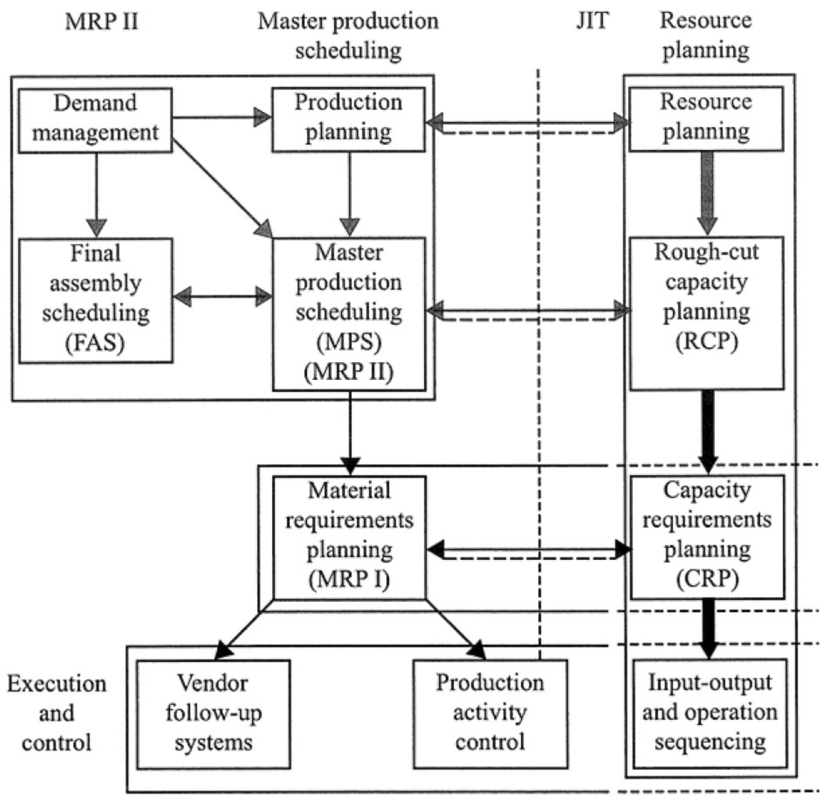


Figure 4.26. *Contrasting MRP II and just-in-time concepts*

JIT-controlled activities are not schedule-driven but customer-order-driven by means of control of resource capacities. A JIT-oriented information system must be able to answer customer requests for a product in terms of quantity and delivery rate. In practice, some short-term scheduling of activities cannot be avoided because a production line cannot be stopped and restarted overnight. A full stop-and-go system is not workable.

4.4.3. *JIT and inventory management*

Two principles of JIT management influence directly the inventory management. They include:

– cut lot size;

– cut safety stock.

Switching to JIT inventory management means cutting large-lot size into smaller quantities. This is called split delivery.

When using the equations of the basic inventory model, the JIT/EOQ can be computed. Assuming that a replenishment order is fulfilled by *n* deliveries, the JIT/EOQ is given by:

$$\overline{D}\,(JIT) = \overline{D}\sqrt{n} \text{ where } \overline{D} \text{ refers to the one order-one delivery case}$$

The logical consequence is a reduced average inventory and reduced carrying costs. This generates a cost saving in using the split-delivery system. It amounts per item to:

$$C^* - C^*_{jit} = (1 - 1/\sqrt{n}\,)\left(\frac{2\,C_s\,C_h}{d}\right)^{1/2}$$

C^* = minimized unit cost when the delivery quantity is the economic order quantity.

C^*_{jit} = minimized unit cost when economic order quantity is split into n deliveries.

This expression is valid as long as the unit cost of an item does not depend on *n*: this assumption does not hold true in practice when *n* becomes large. It can be shown in this case that the cost saving as a function of *n* is bell-shaped. This means that the cost saving is maximum for a given value of *n* (see box).

Split deliveries and shortened lead times reduce the time period during which a stockout may occur. It can be easily proved that the shorter the time period under risk, the lower is the safety stock providing a set service level.

4.4.4. *JIT and resources capacities*

In JIT philosophy, the drastic decrease in the elapsed time of the order-to-deliver cycle has displaced the objective of 100% capacity usage of resources. It requires higher capacities of available resources to diminish lead times or to satisfy unexpected demand within an upper limit. An example of a simple queuing illustrates best the situation in Figure 4.27.

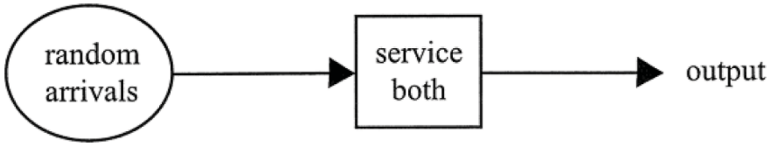


Figure 4.27. *Simple queuing system*

Assuming that λ is the average arrival rate of a Poisson distribution and μ μ μ is the average service rate of an exponential distribution, it can be shown that:

$$Lq = \text{average number of units in queue} = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

$$Wq = \text{average time spent in queue} = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

$$W = \text{average time spent in system (queue + service)} = \frac{1}{\mu - \lambda}$$

A service operation is wanted which will reduce its lead time (queue + service) from 12 days to 4 days. Jobs arrive at an average rate of 12 per day and the service operation can handle an average of 12.083 jobs per day. What new service rate would allow for a lead time of 4 days? How much would the jobs queue be reduced with the new service rate?

The new service rate is given by the equation:

$$W = \frac{1}{\mu - \lambda} = \frac{1}{\mu - 12} = 4$$

from which μ = 12.25 jobs/day is derived.

By increasing the average service rate from 12.083 to 12.35 jobs per day, the lead time is reduced from 12 to 4 days.

The job queue contains an average number Lq of $\frac{\lambda^2}{\mu(\mu-\lambda)}$ units.

When μ = 12.083, then Lq = 143.5 jobs;

When μ = 12.25, then Lq = 47.0 jobs.

This reduction in the jobs queue induces reduced work in progress (WIP) inventory and can justify an increased investment in equipment.

4.4.5. *JIT and kanban*

Kanban and JIT are often associated in the literature. The simplest kanban system utilizes pairs of cards (kanban in Japanese) for triggering operations and movements between operations in flow systems. Along the flow line, end items are manufactured in small batches step by step on processing stations where operations are carried out.

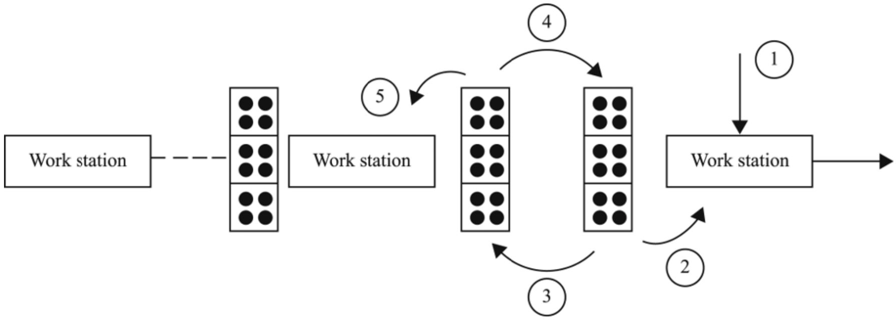
Items in manufacturing progress are held in stock in containers. A kanban is attached to each container: either a movement kanban or a processing kanban. Each workstation has downstream containers of processed products and upstream containers of products to be processed. When a downstream container is removed by a neighboring station, a manufacturing kanban is left behind and triggers its replacement by taking an upstream container for processing. The movement kanban of this upstream container is used for triggering replenishment from the previous processing station. The protocol for making use of kanabans is shown in Figure 4.28.

In practice, this system can be engineered with a software package interfaced to management information system modules.

The number of kanban card sets (one of each type per container) is:

$$k = \frac{\text{Average demand during lead time plus safety stock}}{\text{Size of container}}$$

$$= \frac{d\,(\overline{\varpi} + \overline{p})\,(1 + \alpha)}{c}$$



1. A work order is received by the final work station
2. A container of components manufactured by the previous work station is taken to fulfil the order
3. A supply kanban is transferred to the previous work station
4. A container with a supply kanban is dispatched to the final work station
5. A manufacturing kanban triggers the production of the amount of components dispatched

Figure 4.28. *Protocol for making use of kanbans*

where k = number of production-order/withdrawal card sets for a given part;

d = expected daily demand for the part, in units;

$\bar{\omega}$ = average waiting time during the production process plus materials handling time per container in fractions of a day;

$\bar{p}$ = average processing time per container in fractions of a day;

c = quantity in a standard container of the part;

α = a policy variable that reflects the efficiency of the workstations producing and using the part (Toyota uses a value not more than 10%).

The kanban system allows management to fine-tune the flow of materials in the system in a straightforward manner. For example, removing card sets from the system reduces the number of authorized containers of the part, which results in reducing the inventory of the part.

The container quantity c and the efficiency factor α are also variables that management can use to control inventory. Adjusting c changes the lot sizes, and adjusting α changes the amount of safety stock. The kanban system is actually a special form of the base-stock system. In this case, the stocking level is $d(\overline{\omega}+\overline{p})(1+\overline{\alpha})$ and the order quantity is fixed at c units. Each time a container of parts is removed from the base stock, authorization is given to replace it.

SPLIT DELIVERIES

When an order triggers one delivery total costs per cycle are

$$\mathbf{TC = Du + Cs + Ch\ D2\ /2d}$$

It is the average cost per item (TC/D) that has to be minimised:

$$\mathbf{TC/D = u + Cs\ D^{-1} + ChD/2d}$$

Differentiating this expression with respect to D and equating to zero give

$$\mathbf{(TC)' = -\ CsD^{-2} + Ch/2d = 0}$$

Therefore the EOQ $\mathbf{\overline{D}\ (1)}$ is $\mathbf{\{2d\ Cs/Ch\}^{1/2}}$

The average cost per item when the EOQ is ordered is:

$$\mathbf{C^* = u + Cs\ \overline{D}\ (1)^{-1} + Ch\overline{D}\ (1)/2d}$$

When an order triggers n deliveries total costs per cycle are

$$\mathbf{TC = Du + Cs + Ch\ D^2/\ (2\ dn)}$$

It is the average cost per item (TC/D) that has to be minimised:

$$\mathbf{TC/D = u + Cs\ D^{-1} + ChD\ /\ (2\ dn)}$$

Differentiating this expression with respect to D and equating to zero give

$$\mathbf{(TC)' = -\ CsD^{-2} + Ch/2d = 0}$$

Therefore the EOQ $\mathbf{\overline{D}\ (n)}$ is $\mathbf{\{2d\ n\ Cs/Ch\}}$ $\quad \mathbf{= \overline{D}(1)\sqrt{n}}$

The average cost per item when the EOQ is ordered is:

$$\mathbf{C^*_{jit} = u + Cs\ \overline{D}\ (n)^{-1} + Ch\ \overline{D}\ (n)\ /\ 2d}$$

Using the split-delivery system generates a cost saving per item amounting to

$$C^* - C^*_{jit} = (1 - 1/\sqrt{n})\left(\frac{2\,C_s C_h}{d}\right)^{1/2}$$

This model does not enable to obtain an optimal value for n. The cost saving per item tends to $\left(\frac{2\,C_s C_h}{d}\right)^{1/2}$ as n increases indefinitely and does not show any minimum.

In fact the model has to be made more realistic by considering that u, the cost price of one item, depends on n. When u(n) is substituted with u x n in the expression of C^*_{jit} the cost saving per item yields

$$\mathbf{u - u(n)} + (1 - 1/\sqrt{n})\left(\frac{2\,C_s C_h}{d}\right)^{1/2}$$

Assuming that n is a continuous variable the optimum value of n is given by equating to zero the derivative with respect to n of the cost saving per item.

4.5. Customer order decoupling point

4.5.1. *Description*

The customer order decoupling point (CODP) is the point in the manufacturing process where planning ceased to be based on forecast demand and starts to depend on customer orders. When manufacturing activities are depicted as a chain of activities, activities upstream from the decoupling point are controlled by scheduling whereas activities downstream from the decoupling point are controlled by market demand. The decoupling point is always a storage activity desynchronizing the upstream goods flow from the downstream goods flow.

As shown in Figure 4.29, five CODP positions can be identified in the goods flow according to the type of manufacturing organization chosen by the management. The DP3 point is the organizational structure targeted by all companies assembling mass products (automotive industry, electronic industry, etc.). Components and subsystems are produced on the basis of forecast-driven production schedules. The final product is manufactured when customer orders are received. This implies that product design is appropriate, i.e. modular, and the shop floor layout enables flexibility.

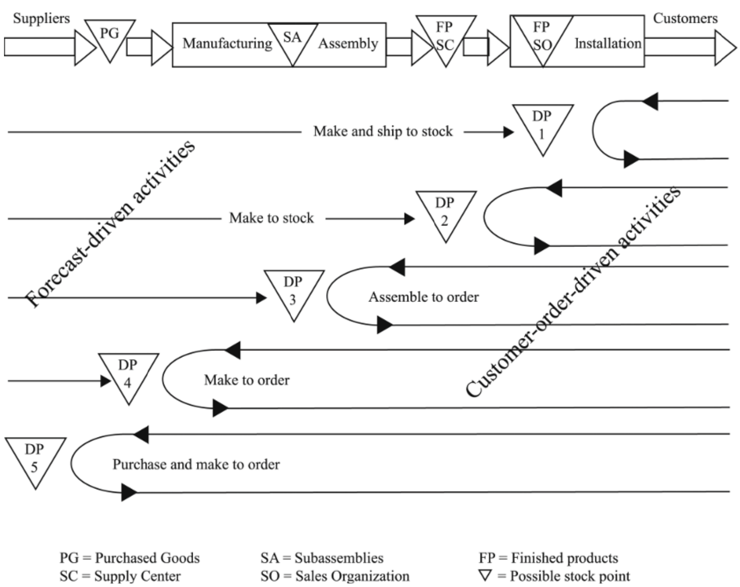


Figure 4.29. *Five DP positions representing five logistics structures*

4.5.2. *Deploying an MPS within a CODP context*

Let us assume that the customized products manufactured by a company are assembled from components supplied by subcontractors. In order to take account of the spectrum of options offered to customers, the final assembly of products is triggered by customer orders.

After an MPS and its associated supply schedules have been evolved on the basis of forecasts as shown in Figure 4.31, the supply schedules are fulfilled to have on-hand the components/subsystems required when needed.

On the contrary, the MPS is locked and is not utilized for releasing manufacturing orders that trigger shop floor activities. Releasing manufacturing orders is triggered by customer orders with the mindset of avoiding inventories of finished products. It has to be born in mind that the manufacturing capacity is limited by the availability of forecast resources (manufacturing and supply).

Figure 4.30 depicts the whole situation.

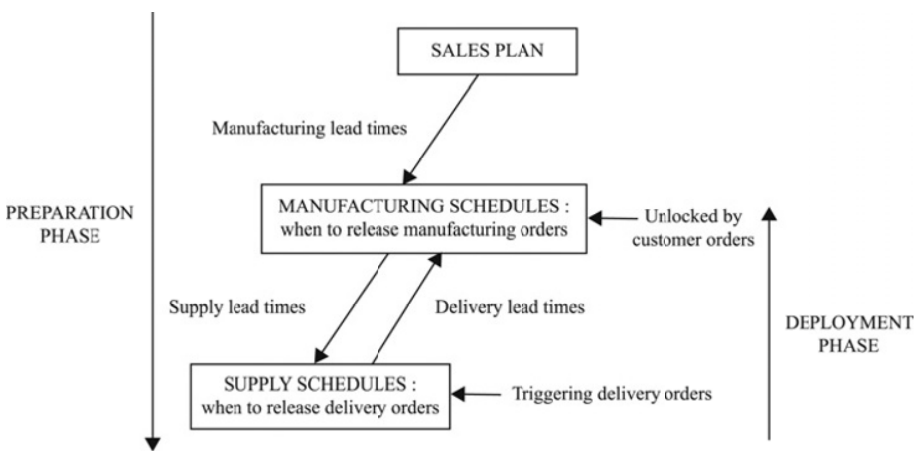


Figure 4.30. *Deploying the MRP concept within a CODP backdrop*

4.6. Contrasting the various control concepts

The main features of the various control models in terms of triggering mechanisms and data requirements are summarized in Table 4.4.

	Mechanisms triggering business activities	Data requirements	
		Internal sources	External sources (demand/suppliers)
ICS	Inventory levels	Replenishment lead times	Supply lead times Market demand rate
MRP	Manufacturing schedule	– Bill of materials – Sequence of operations – Manufacturing lead times (dates to release manufacturing orders/ stock requisitions)	– Demand forecast for deriving realistic manufacturing schedules – Supply lead times
JIT	Customer orders	Real-time Resources capacities (Response times to customer orders)	– Demand forecast for deriving resources capacities – Suppliers' capacities

Table 4.4. *Main features of ICS, MRP and JIT control models*

The various control models have to be considered as tools to be used in a pragmatic way according to the management stakes. The inventory control system (ICS) control model is the simplest in terms of data requirements and calculations. It does not provide insights into the instantaneous states of resources but can prove to be sufficiently relevant in specific cases. It is not required that all sections of a company should be controlled with a monolithic model.

It should be clear that the implementation of MRP and JIT control models requires deploying and maintaining software packages because of the large volumes of data to be handled, which incurs costs not always easy to bring and keep under full control. Remember that capturing and processing data consume energy, which is not free of charge. In fact, when business information systems are scrutinized, it often appears that business managers endeavor to run their operations with minimized data items and processing.

Procedures associated with scheduled manufacturing and JIT manufacturing monitored by kanbans are displayed in Figure 4.31. They are explained hereafter.

Scheduled manufacturing (MPS)

1-Delivery orders sent to suppliers

2-Notification of goods shipment

3-Goods received

4-Goods stored

5-Notification of availability

6-Phased production orders released to fulfill MPS requirements

7-Shop-floor control phase 1

8-Work-in-progress control

9-Shop-floor control phase 2

10-Work-in-progress control

11-Shop-floor control phase 3

12-Work-in-progress control

13-Shop-floor control phase n

14-Inspection

15-Delivery

Just-in-time manufacturing

1-Blanket delivery schedule sent to suppliers

2-Customer order processing

3-Final production phase n

4-delivery to customers

5-Manufacturing kanban sent to the previous production phase

5a-Supplying kanban to suppliers

5b-Goods delivery

6-Production phase 3

7-Manufacturing kanban sent to the previous production phase 2

7a-Supplying kanban to suppliers

7b-Goods delivery

8-Production phase 2

9-Manufacturing kanban sent to the previous production phase 1

9a-Manufacturing kanban sent to the previous production phase

9b-Goods delivery

10-production phase 1

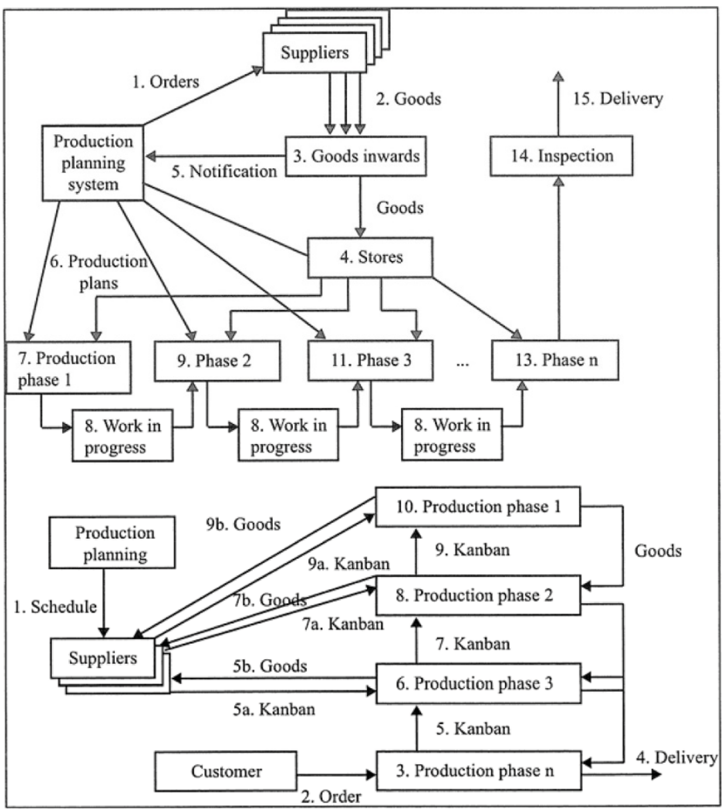


Figure 4.31. *Synopsis of procedures associated with scheduled manufacturing and just-in- time manufacturing*

5

Specific Features of ERP Packages

5.1. Featuring ERP philosophy of software packages

Right from the inception of data processing systems for management purposes in the late 1950s and early 1960s, data integration has haunted the centralization dreams of many managers, i.e. having an easy and secure access to all business data items stored in one repository. That function capability gives the illusive impression of having brought all business activities under full control. In the deep unconscious of many decision-makers, "managing by numbers" remains a strong appeal.

In the late 1980s and early 1990s, software vendors came into the marketplace with a strong argument to quench the thirst of business managers for data integration, i.e. relational database management system. The decisive features' characteristics of this database management system are its capability to format stored data easily for any application program. On this occasion, they refurbished their software packages under the heading "enterprise resource planning" (ERP).

Instead of presenting piecemeal offerings in the marketplace, software vendors provided "integrated" solutions integrating all business processes seamless. That explains the two types of arguments developed to sell ERP-labeled packages:

– full integration within a "reasonable" time span on a limited budget; when several databases have to be interfaced development and maintenance costs are significantly high;

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– software modules support “best-of-breed” business processes, called reference models.

It has to be acknowledged that these two aspects are relevant contributions to better information management in businesses.

> – Customer-Oriented Production and Inventory Control System (COPICS) is the architectural basis all ERP software packages were developed upon.
>
> – Reference models are purposed.
>
> – To help firms analyze their structural and organizational patterns.
>
> – To speed up the implementation of information system project by aligning current business processes and reference models.
>
> – The issue of architectural flexibility has to be raised to secure organizational evolution of business operations when e-enabled operations are engineered.

A reference model is a comprehensive description of all processes and their relationships required to plan, execute and control business operations with the best practices in terms of functions, organization, procedures, data and data processing.

5.2. ERP-tagged software packages for managing business processes available in the marketplace

ERP-tagged software packages for managing business operations are composed of modules covering the main business processes deployed to run a manufacturing company. They are listed in Figure 5.1.

5.3. Function capabilities of the SAP CRM package

5.3.1. *Why CRM?*

It has been felt for a long time by many companies that markets are saturated on the one hand, and on the other hand that differences in price and product function capabilities have become increasingly negligible.

Something other than these two characteristics must be found by companies to attract customers and retain their loyalty.

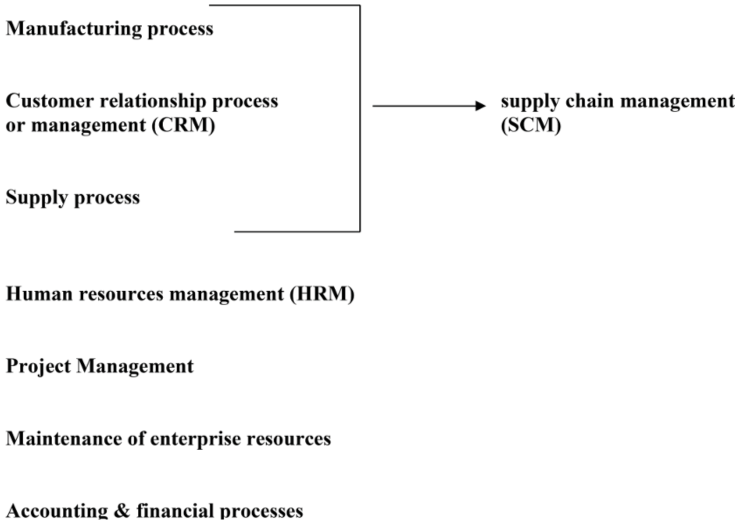


Figure 5.1. *List of modules available in ERP-tagged software packages*

Markets that have switched from sellers' markets to buyers' markets are open to intensified competition and compressed cycle times. To match this challenge, companies have developed the concept of product service. Within that perspective, a car is no more considered as a product in itself but as a transportation service. This service must address the individual needs and priorities of customers all along the product lifetime. Customer care after sales has become a key issue. That explains why customer-oriented approaches and customer focus are nowadays the main pillars for competitive business models. These viewpoints lead to establishing and deepening long-lasting relationships with profitable customers from a lifetime perspective.

The falling costs for computing power and the arrival of new software tools (data warehouses, reporting systems) for capturing and analyzing mass data have provided the decisive thrust behind the increasing importance of analytical solutions. Software vendors have brought systems into the market to support knowledge of customers. One of them called customer relationship management (CRM) facilitates sell-side connections to customers. At the same time, CRM is a management concept aiming at personalizing communication with customers through meaningful trustful business transactions. It is best described by the function capabilities of software packages such as those explained in the following section.

5.3.2. *Function capabilities of CRM software systems*

CRM that is one of the most widely vaunted management concept in customer understanding customer satisfaction and financial returns encompasses four continuous patterns:

– engage: recognizing potential customers and converting them into (first-time) buyers;

– transact: getting the customer to make a purchase;

– fulfil: delivering the product;

– service: providing customer care and support across all channels.

All these features are embedded in the function capabilities of SAP software systems and can be described as follows:

MARKETING PLANNING.– marketing approach to suspects, prospects and clients sales forecasting.

CUSTOMER CARE.–

– catalog of products/services;

– delivery lead time management;

– help desk;

– maintenance services.

ORDER SUPPORT.–

– quotation;

– order entry;

– order status.

CUSTOMER PROFILE MANAGEMENT.–

– one-to-one customer relationship;

– customized offering of products/services.

5.4. Reference control model of a manufacturing firm

In this section, the modules of a reference control model of a manufacturing firm are described in terms of procedures and information system requirements. They are intended to explain what for data items and processing are to be made available to use such a control model.

Figure 5.2 provides an overview of the whole system with the monitoring functions and the modules directly controlling the goods flow.

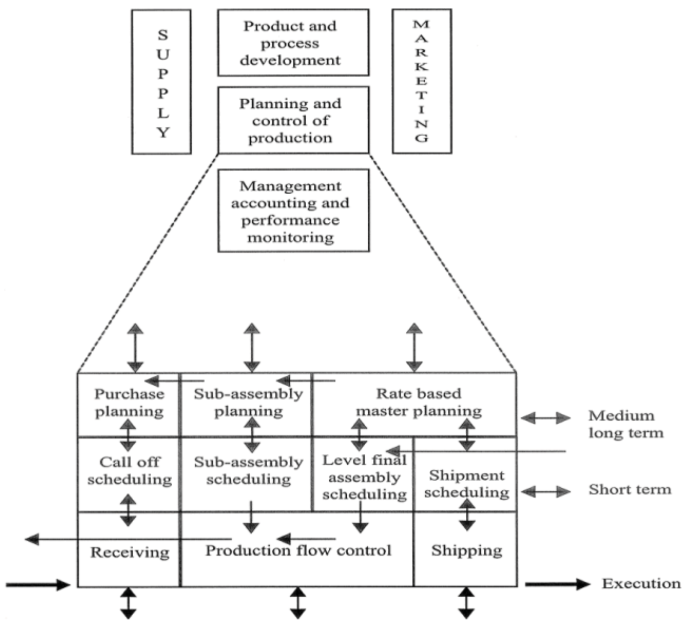
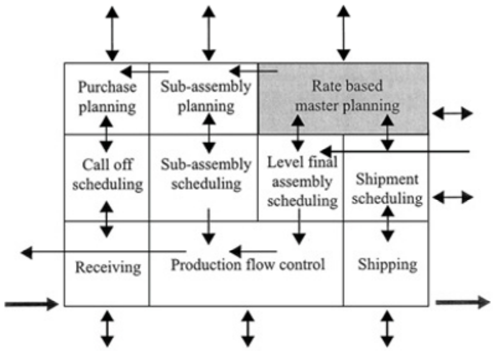


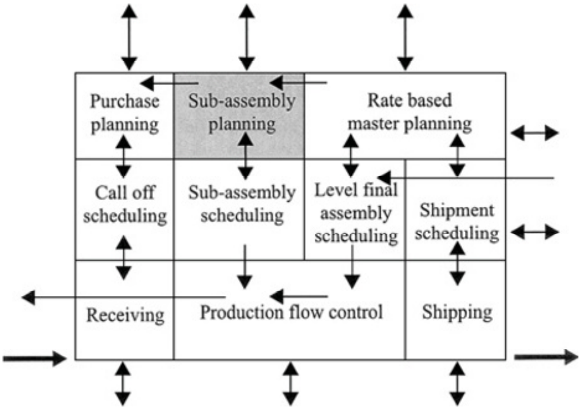
Figure 5.2. *Overview of software modules required for controlling manufacturing operations*

Each software module of Figure 5.2 is described in terms of procedures and information system needs in Figures 5.3–5.12.



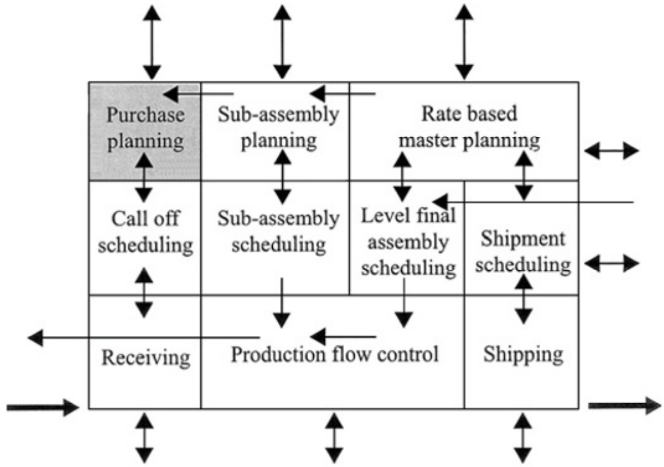
Rate-based master planning	
Procedures – Forecast and actual demand by time period loaded as far as necessary to make orientations for supplier capacity and internal capacity possible. Capacity is expressed as flow rate and is consistent with achievable goals (long term).	Information system needs – Load forecasts and orders (long term) and calculate flow rates based on demand, taking into account time fences, cumulative lead times and compare this with achievable flow rates. – Provide information to support the ordering of long lead time (specific) items (possibly including overplanning). – Balance operations, simulating the final assembly area possibilities, taking into account equipment, tools, men and preventive maintenance schedules. – Confirmation message sent to the master scheduler.
– Acceptance of short-term plan	– Load forecast and orders by time period (short term) to enable an analysis of achievability against flow rate. – Transfer master production schedule (MPS) and requirements schedule (summarized in daily buckets) to subassembly planning.

Figure 5.3. *Procedures and information system needs for controlling rate-based master planning*



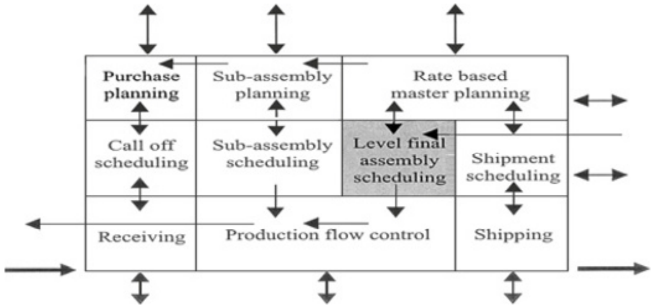
Subassembly planning	
Procedures	Information system needs
– Break down finished product planning into subassembly plans and schedules.	– Bills of materials and explosion mechanism to break down finished products plans and schedules into subassembly requirements, netting where necessary against stock and offsetting where appropriate with lead times
– Balance the capacity (equipment, tools and men) to meet the plans in the medium to long term; inconsistencies and non-achievable plans to be fed back to the master scheduler.	– Calculate flow rates per time period. – Balance operations, simulating shop floor possibilities, taking into account equipment, tools and men and preventive maintenance schedules. – Confirmation message or otherwise to be sent to master scheduler. – Transfer long-, medium- and short-term material plans and schedules to purchase planning. – Transfer short-term subassembly schedules to subassembly scheduling.

Figure 5.4. *Procedures and information system needs for controlling subassembly planning*



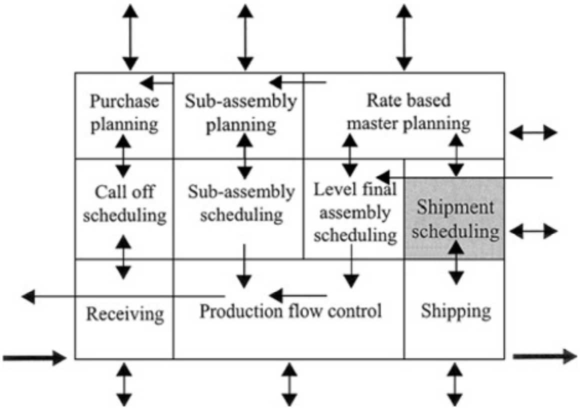
Purchase planning	
Procedures	Information system needs
– Break down finished product plans and subassembly schedules to give purchase plan and schedules.	– Bills of materials and explosion mechanism to break down finished product and subassembly schedules into purchase requirements, netting where necessary against outstanding purchase orders and offsetting where appropriate with lead times
– Negotiate long-term contracts (price, quality and delivery reliability) with supplier.	– Supplier performance and statistics.
– Give supplier visibility of likely demand per time period (necessary for supplier to meet call-off schedules).	– Prepare purchase plans (orientations) per supplier, per product or capacity group and per time period. – Transfer short-term (frozen) schedules to call-off scheduling.

Figure 5.5. *Procedures and information system needs for controlling purchase planning*



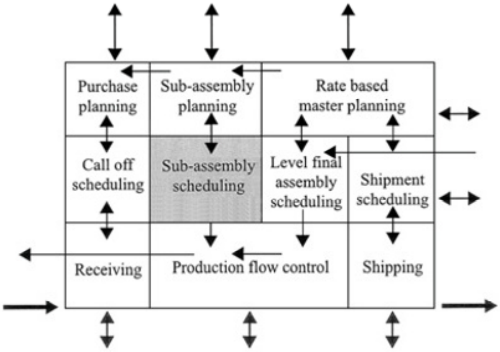
Level final assembly scheduling	
Procedures	Information system needs
– Accept demand schedules and load within permitted flow rate (volume and mix).	– Load demand within the overall permitted flow rates (volume and mix) by time period.
– Fix schedule and calculate overall flow rate: supervision will use the rate to make minor changes to labor and machines to meet the schedule in the most efficient way.	– Calculate flow rates for fixed schedule. Simulation may be required. If so, some operation and routing data will be necessary.
– Smooth and sequence final assembly schedule per line. All models made each day within the immediate planning horizon.	– Calculate an optimum sequence of production per final assembly line based on flow rates, taking into account preferred sequence of type changes and firm shipment dates.
– Release smoothed final assembly schedule to the MPS for the following period.	– Transfer the smoothed fixed final assembly schedule in daily buckets to the MPS for the following period.
– Plan work-in-progress levels in terms of standard containers needed to support the plan and the volumes in the pipeline between work centers	– Calculate the necessary work-in-progress levels to support the following periods of the final assembly schedule.
– Release daily dispatch list.	– Provide a sequenced list of all finished-product requirements per final assembly line for the day.
– Take action where exception conditions occur.	– Exception signals from flow control.

Figure 5.6. *Procedures and information needs for scheduling final assembly*



Shipment scheduling	
Procedures – Derive shipment schedules from the final assembly schedule, taking into account firm transport schedules (especially overseas).	Information system needs – Calculate daily shipments, giving product types, quantities, destinations, means of transport, etc. – Generate packing instructions.

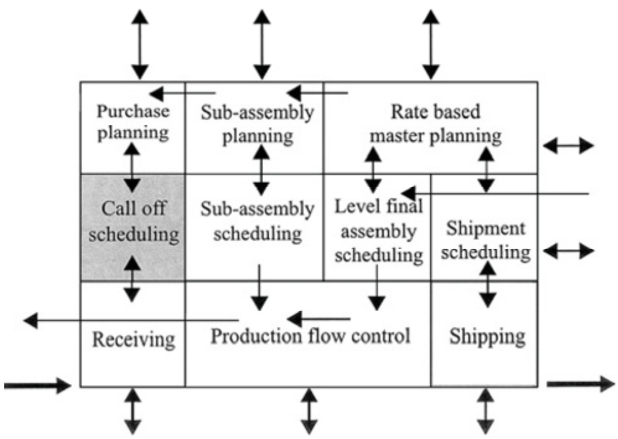
Figure 5.7. *Procedures and information system needs for controlling shipment scheduling*



Subassembly scheduling	
Procedures – Calculate the overall flow rate for the next period: supervision will use this rate to make minor changes to labor and machines to meet the schedule in the most efficient way.	Information system needs – Calculate flow rates (simulation of shop floor may be required). If so, some operation and routing data will be required.

– Plan work-in-progress levels needed to support the subassembly schedule in terms of standard containers and the volumes in the pipeline between the work centers.	– Calculate the necessary work-in-progress levels to support the following periods of the subassembly schedule.
– Release the subassembly schedule for either PUSH signals for start-up and stopping production (changeovers between schedule periods, engineering changes or types produced on a low frequency) or authorization to be linked with a PULL signal in a synchro-MRP environment.	– Release orders for start-ups and non-flow work centers. Maintain the cumulative plan.
– Take action where exception conditions occur.	– Exception signals from flow control.

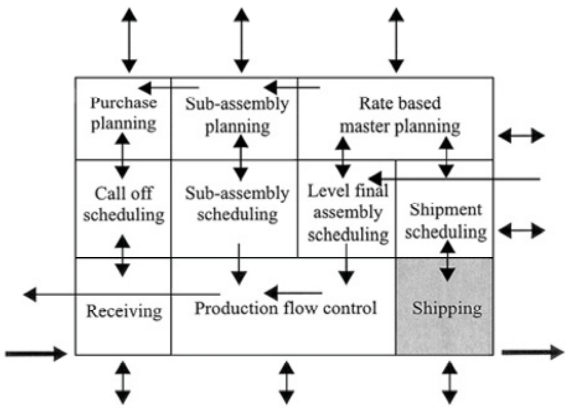
Figure 5.8. *Procedures and information system needs for controlling subassembly scheduling*



Call-off scheduling	
Procedures	Information system needs
– Break down the short-term master plan to give purchase call-off schedules per supplier.	– Bills of materials and explosion mechanism to break down finished product and subassembly schedules into short-term purchase call-off schedules, offsetting where appropriate with lead times.

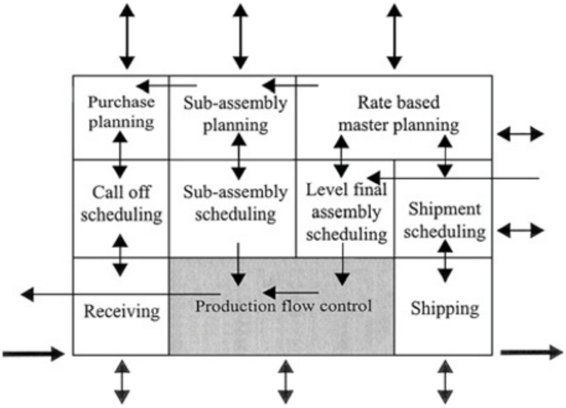
– Send supplier firm plans for delivery in the next period. – Delivery schedules showing daily what product to ship, packed in standard containers (short term).	– Show per supplier and on daily basis the requirements per item, in terms of the number of complete standard containers to supply, delivery date and the physical location that the containers are to be delivered to.

Figure 5.9. *Procedures and information system needs for controlling call-off scheduling*



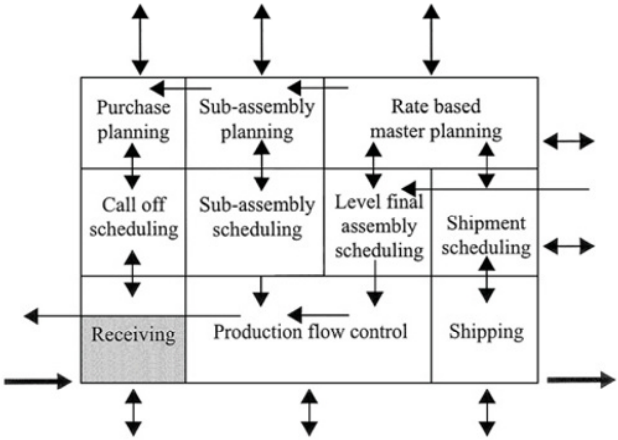
Shipping	
Procedures – Pack and label according to the shipment schedule.	Information system needs – Packing and destination data.
– Move to shipping bay.	– Routing data.
– Form shipments.	– Transport, volume and destination data.
– Raise shipping and invoice documentation.	– Customs, transport, destination customer data. Generate messages.
– Signal that products have been shipped.	– Update shipping schedule. Inform customer via standard messages.

Figure 5.10. *Procedures and information system needs for controlling shipping*



Production flow control	
Procedures – Assemble or fabricate when authorized by pull dispatch list, pull signal or work-in-progress planning.	Information system needs – Release schedule. – Pull signal. – CAM interface. – Manufacturing instructions.
– Pull material from previous operation, stock point, supplier, via a pull signal when required.	– Pull signal (physical or electrical). – Routing data. – CAM interface.
– Where appropriate, report completion against schedule.	– CAM interface. – Report completion (data, capture devices) and update cum figures. – Broadcast deviations from schedule. – Backflush the consumption of the components.
– Indicate when there is a quality problem.	– Broadcast quality problem. – CAM interface.
– Indicate when there is a machine fault.	– Broadcast machine breakdown. – CAM interface.
– Indicate when material is not available from the previous operation.	– Broadcast lack of material. – CAM interface.

Figure 5.11. *Procedures and information system needs for controlling the production flow*



Receiving	
Procedures – Receive goods in standard containers from vendors.	Information system needs – Record receipt using appropriate data capture device, by supplier and item number, update cumulative receipts and compare with total period quantity.
– Take action where exception conditions occur.	– Determine inspection instructions (e.g. 100% or sampling) based on supplier's quality statistics.
– Inspect goods if supplier is uncertified.	– Record results of inspection, update supplier statistics.
– Determine internal destination.	– From delivery documentation, identify where parts are to be delivered to.
– Pass accepted receipts to accounting for authorization of payment.	– Routing information. – Interface to accounting function.

Figure 5.12. *Procedures and information system needs for controlling receiving goods from suppliers*

5.5. Finance reference control model

As explained in Chapter 3 (section 3.3), one of the reasons for deploying the MRP concept is cost control. It is therefore logical to interface operations reference models with a finance reference model to yield a fully fledged business control system. Figure 5.13 stylizes such a model.

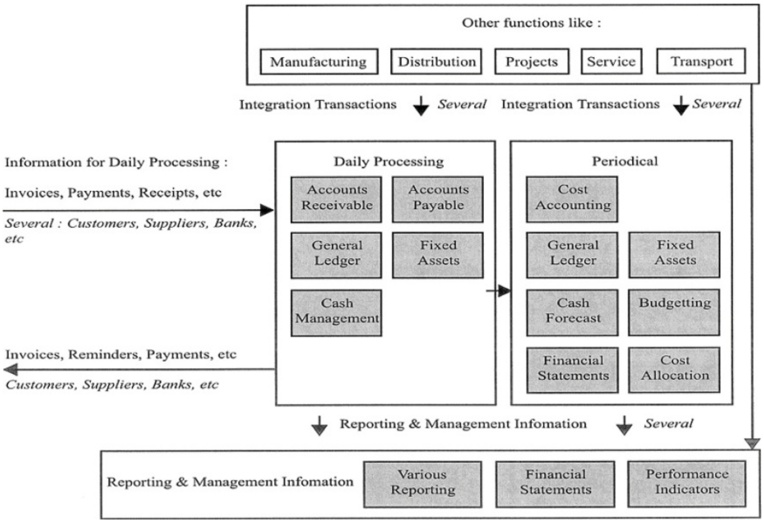


Figure 5.13. *Reference model for controlling finance and costs*

PART 3

Beyond ERP Packages: the E-Enabled Enterprise

6

Change in Business Processes Induced by E-Commerce and E-Business

6.1. General considerations for approaching the digital economy

Information technologies (ITs) cause a change in the techno-economic paradigm as a pervasive source of interleaved innovations in technologies and organizational, behavioral practice. This changes the way industrial sectors are organized and as a result, businesses are run.

ITs and especially telecommunications impact into three dimensions of the usual operational continuum of businesses:

– *space*: production becomes less dependent on the location of raw materials. Networks displace market centers. Data processing and software developments are no longer bound to the nearby availability of computing facilities;

– *time*: time management monitors goods management. The just-in-time manufacturing concept designed in Japan is by now scattered over all the areas of industrial life;

– *scale*: the trend toward the globalization of business markets adds more actors and volatility. Institutional forms and societal structures are affected by enlarged fields of action and induced complexity: as an example, the imbalance between swift movements of capital and the slow movement of people has become a critical issue in present international relations.

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The economy is shifting to an information-based pattern: sector groups are emerging on grounds of task division and/or task sharing due to telecommunication-aided services.

Globalization is a complex of interrelated processes rather than an end-state. It is essential to distinguish between two distinct processes:

– internationalizing processes involving the simple extension of economic activities across national boundaries;

– globalizing processes involving not merely cross-border processes but also – and more importantly – the functional integration of internationally dispersed activities.

Some claim that the world economy was at least as open before 1914 as it is today. In fact, the nature of integration was different. At this time, the world economy was characterized by closed free-trade zones conducting commercial transactions between them supporting import taxes. The main closed free-trade zones were the European colonial empires (UK, France, The Netherlands, Belgium and Portugal) and large political zones (USA, Russia and Austro-Hungarian empire) protecting their markets by import taxes. International trade was open between these entities under the control of nation states. Today, decision centers are distributed all over the world and operations are controlled by transnational companies through a network of data processing facilities out of the grip of nation states. Powerful globalizing forces are at work and implemented by information and communication technology tools. These tools transform the way business operations are conducted and brought under control.

Co-makership as a substitute for subcontracting was engineered by Japanese firms hitherto within closed circles. The idea was to weave links of partnership in a framework of common interest. Western firms embraced the concept with an openness approach. This resulted in the setting up of joint ventures between competitors to share the manufacturing of parts. This practice is common in Europe in the car industry. Telecommunication services make this style of management instrumental; if reference is made to a specific telecommunication service, electronic data interchange (EDI) has been the major contributor up to now.

6.2. Change in business structures

Because national boundaries no longer "contain" production and distribution processes in the way they once did it, a new vision has to be found to break out of "national spheres" to understand what is going on in the economic world. One way of doing this is to use the concepts of network and agent: they lead to processes connecting agents into relational structures at different organizational and geographical scales. This forces us to think in terms of connections of activities through the flows of both material and immaterial phenomena and of the power relationships through which networks are structured and coordinated by design.

Within the framework of the "classical" approach, the production of any good and service is conceived as a production chain, that is a transactionally linked sequence of functions in which each stage adds value to the process of delivering goods and services. In this context, a production chain is essentially linear. Figure 6.1 represents the stripped version of a simplified supply chain centered on the transformation step, its core operation.

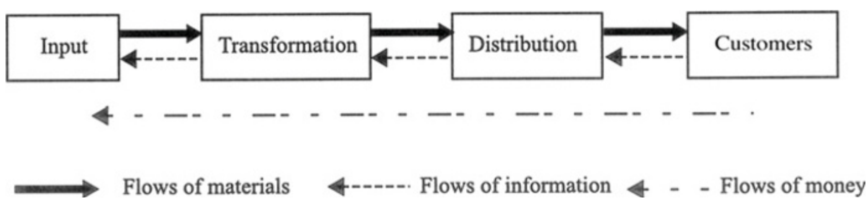


Figure 6.1. *Simplified version of a supply chain*

Three kinds of flow can be identified:

– flows of materials from suppliers to customers;

– flows of information from customers in the way of orders to suppliers in the way of call off delivery orders;

– flows of money from clients paying for the deliverables they are provided with, to all the chain stakeholders for their contributions.

Globalization has allowed or even led to new types of economic organization and firms to emerge. The driving factors are time and space shrinking. On the one hand, there is a shift from production chains to production networks and on the other hand, a new organizational structure of corporations departing from what was called multinationals has developed. This structure is called “transnational corporation”.

The networked version of a supply chain is depicted in Figure 6.2 when the transformation unit (manufacturer) is the hub of the network supplying products to clients.

The networked version of a supply chain is depicted in figure 6.2. when the transformation unit (manufacturer) is the hub of the network supplying products to clients.

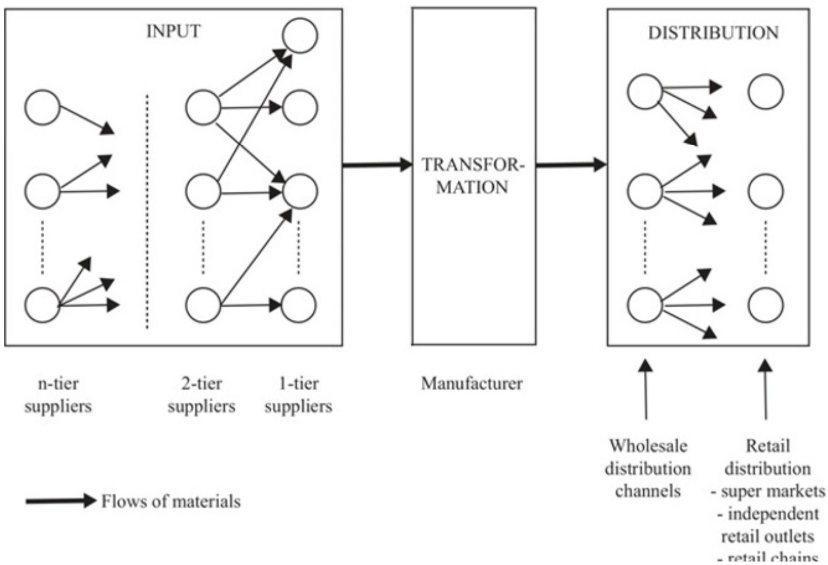


Figure 6.2. *Manufacturer-controlled supply network*

A transnational corporation is a firm that has the power to coordinate and control operations in more than one country, even if it does not own them. It is typically involved in a spider’s web of collaborative relationships with other legally independent firms across the globe.

A telling example of this organizational configuration is found in supply networks controlled by “fabless” distributors. A distributor places online orders to a group of manufacturers delivering single products or a range of products on demand according to their manufacturing resource capacities and the retail locations involved. In this case, the distributor is the monitoring agent of the activities of the whole supply chain. Figure 6.3 portrays the situation.

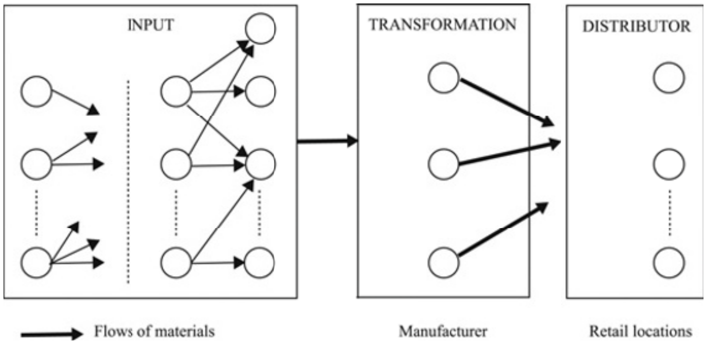


Figure 6.3. *Distributor-controlled supply network*

The ways activities are conducted in companies are affected by ITs which make already a major contribution to:

– the cost and quality of goods manufacturing;

– the marketing of goods and services;

– business administration;

– research and development;

– the provision of services (some of which could not exist otherwise);

– the location of activities.

Patterns of organizational behavior are changing with the support of IT. A telling insight into the evolving working environment in businesses is given by groupware. Groupware is a generic term for specialized computer aids designed and operated to meet the requirements of business teams in relation to software and hardware services. This trend toward business team approach can be ascribed to a lot of driving forces. A hidden cause which is of paramount importance is the implementation of ISO 9000 standards to achieve total quality management (TQM). Their essence is business modeling by activities and specifying client–supplier relationships between these activities. This means that the contents of relationships must be clearly defined and made reliable. In fact, relationships are converted into transactions conveying contracts made up of data and procedural processing. Other reasons can be put forward to explain the momentum gained by team work: distant working, shift to knowledge-based working, performance enhancement, etc.

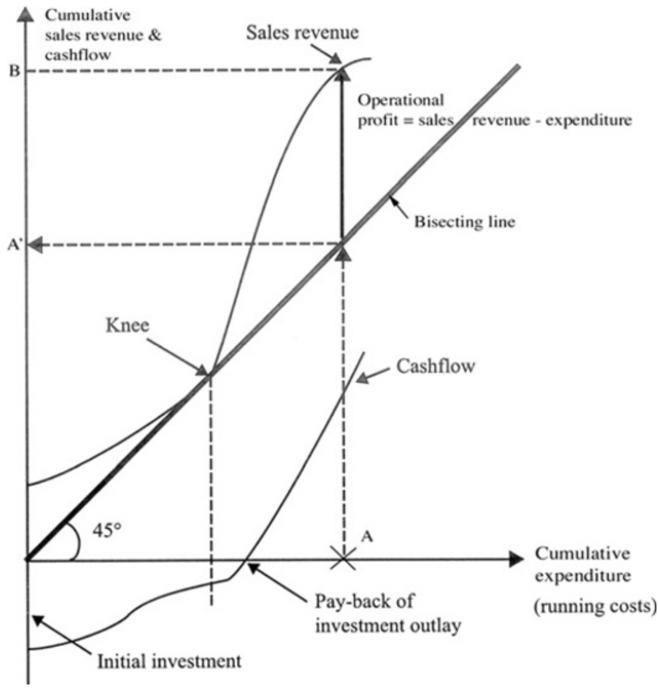


Figure 6.4. *Sales revenue through e-commerce and profit as a function of expenditure*

6.3. Microeconomic approach to the digital economy

Companies launching e-commerce can expect it to have a lifecycle similar to that of most new products. Sales through this channel vary with expenditure according to an S-shaped curve. During the early stages of development, large expenditure (initial investments and running costs) may be vital before returns, if any, are forthcoming. After a certain point, successive increments in e-commerce expenditure (running costs) will produce more than proportionate increments in sales. When the *knee* of the sales curve is reached, sales accelerate as a function of expenditure size-a turning point that corresponds to the critical mass of market acceptance. After another point, the sales curve will move out of this phase, diminishing returns will set in and while the sales will continue to rise they will do so less than proportionately. This situation can be ascribed to fixity in size of the target market. From the sales revenue curve, profit curve can be derived as shown in Figure 6.4. When the cumulative expenditure has come to a point A, the cumulative sales revenue is B. When the point A is transferred to point A' of the cumulative sales revenue axis via the bisecting line, the two segments OA and OA' are equal. Then, the operational profit is measured by the segment A'B.

The outlay of the initial investment is redeemed by the cumulative operational profits (sales revenue – running costs), gained in progressive stages. This is measured by the cash flow balance between cumulative outflows (initial investment + running costs) and cumulative inflows (sales revenue of money).

Profitability of an investment can be characterized by two parameters, i.e. the rate of return on investment (ROI) and the pay-back period of time.

The rate of return includes forecasting the earnings resulting from the investment, the earnings being calculated on an accrual basis of accounting. This means that depreciation is deduced each year. Depreciation measures how the value of investment is gradually eroded over time. It can be taken at book-value or market value. If book-value is considered, ROI measures the profitability of the recorded capital. On the other hand, if market value is taken, ROI measures the profitability of effective capital.

The earnings each year net of depreciation and taxation are expressed as a percentage of the capital invested in the project to determine a rate of return. The general expression of the rate of return is:

$$\frac{\text{Annual earnings net of depreciation and taxation}}{\text{Value of the investment capital}}$$

The rate of return might not be the same in each year because annual earnings are variable and the value of the investment on capital is gradually dwindling. Usually, the average annual profits and the average value of investment {1/2 (opening investment + closing investment)} are used as a base. In this case, "the average annual rate of return" is obtained. The payback criterion simply states the time required to return back the capital outlay by means of profits. It is a safety-first criterion intended to avoid risk.

Whatever technique is used, costs and benefits have to be calculated. A number of situations have to be considered:

1) e-commerce/e-business systems are priced too highly, i.e. their costs exceed their benefits;

2) it is impossible to quantify the costs and benefits with sufficient precision and hence, the level of risk associated with the investments is too high;

3) the preconditions, facilitating factors, infrastructure and environments necessary to support the success of adoption and integration are not preset.

6.4. E-commerce

6.4.1. *Distinction between e-commerce and e-business*

E-commerce can be defined as the conduct of business transactions using information in electronic form with the help of a man–machine interface as outlined in Figure 6.5. It includes an online delivery of digital products and services.

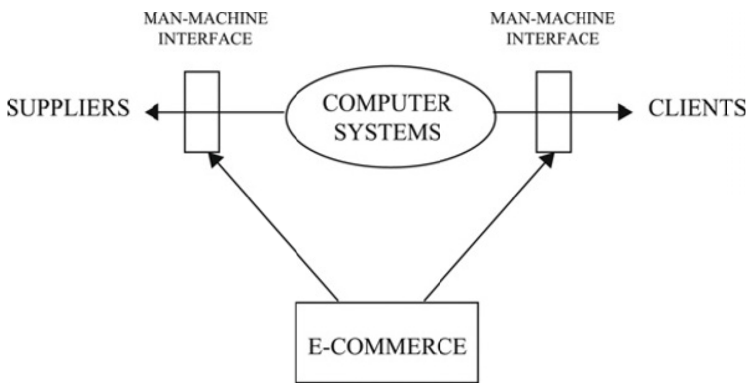


Figure 6.5. *Man–machine interfaces in e-commerce*

The e-commerce market is conventionally divided into business-to-business (B2B) and business-to-customer (B2C) segments as shown in Figure 6.6.

E-business can be defined as the conduct of business operations using data in electronic form exchanged between computer systems without human intervention.

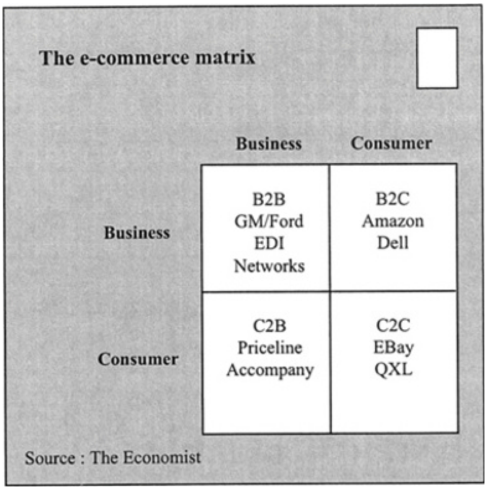


Figure 6.6. *E-commerce segmentation*

EDI as a telecommunication-enabled coordination service is implemented between data processing systems of businesses and as such is named B-to-B e-business. The Internet has opened a new communication channel between businesses themselves and between businesses and individual customers, called B-to-B or B-to-C e-commerce accordingly.

6.4.2. *E-commerce from different perspectives*

Describing how e-commerce is viewed from different perspectives is an indirect way to explain what practically e-commerce is. Two perspectives are envisaged, i.e. the customer perspective and the merchant perspective.

Customer perspective (buy side)

From a customer perspective, the purpose of e-commerce is to enable customers to locate, choose and purchase a desired good or service without visiting a host of shops. E-commerce is a cheap and quick means to do home shopping by accessing virtual stores worldwide.

Merchant perspective (sell side)

From a merchant perspective, e-commerce is above all a communication tool. The core reason to deploy such a tool is the prospect of increased revenues at low cost. E-commerce allows a worldwide reach to global markets from a simple web server. Any start-up company can afford them. This context justifies the need to change the traditional marketing practices because, among other reasons, direct negotiations are carried out with end customers without retailing intermediaries. Multi-market segmentation can be easily implemented. Customer relationships are deeply altered by capturing real-time data about the profiles of cybercustomers. The response time to market changes can be drastically reduced. Online maintenance is an important support to win customers' loyalty. Physical distribution channels, i.e. logistics, are a key success factor for e-commerce.

According to the type of products manufactured by a company (generic or specific), different targets can be sought after as displayed in Figure 6.7.

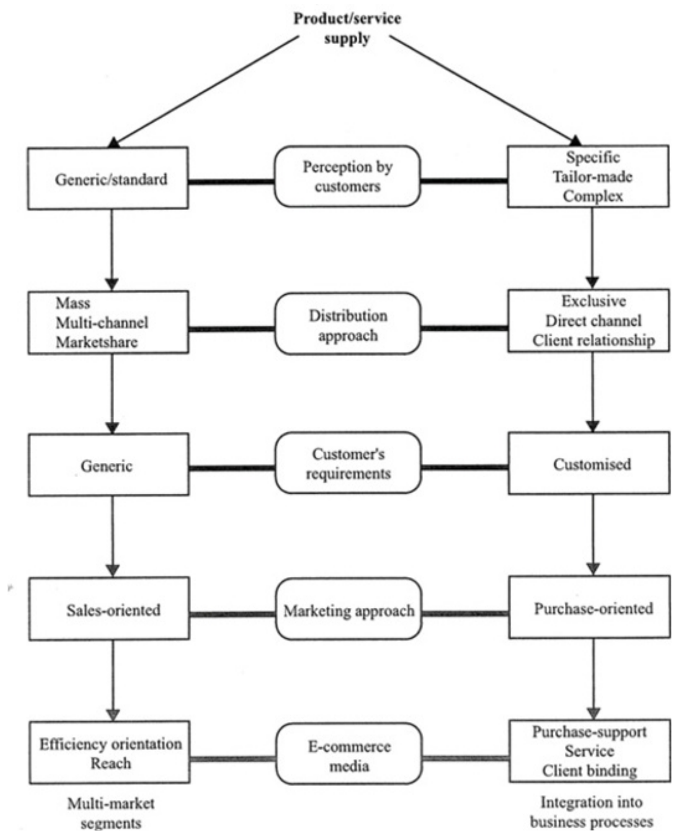


Figure 6.7. *Uses of e-commerce media according to the types of product and market involved*

6.4.3. *Business models for e-commerce exchanges*

Many analysts consider e-commerce-labeled exchanges as being focused on vertical or horizontal markets, such as auctions, information hubs or trading. However, it is becoming increasing difficult to force them into single categories. Exchanges increasingly offer multiple transaction mechanisms and serve both economic verticals and cross-sector markets.

It appears more relevant to classify exchanges by their ownership, distinguishing between those run by third-parties, private companies and industry consortia. The three primary business models for online exchanges are described in Table 6.1.

	Description	Examples
Third-party exchange	Exchange is owned and operated by a third-party not considered as a trading partner	Hosted web sites Internet service providers
Private exchange	Exchange is owned and operated by a single large firm	Distribution companies
Consortia-led exchange	Exchange ownership is shared by market leaders	Purchasing pools

Table 6.1. *Primary business models for online exchanges*

6.5. Changes in business processes induced by e-enabled business operations

Business processes are changed when humans are substituted for server-enabled activities: upstream and downstream activities have to be adapted accordingly. As a result, information systems have to be modified to meet the requirements of e-customers and e-employees.

A logistics revolution is brought about by the technological development (mainly, the Internet and electronic data interchange technology). Logistics has become a key business function (supply and distribution). Distribution patterns are dramatically changed by the impact of technological innovation on three criteria dominating the distribution industries: speed, flexibility and reliability.

Related to the perception that e-enabled business transactions spell the end for the traditional intermediary organizations is the idea that the traditional physical infrastructures will be displaced by the new technological forms. This perception has to be mitigated by scrutinizing the actual situation. The upheaval has not reached the extent expected. New types of intermediaries have emerged. As they rely mainly on IT, they are called "infomediaries".

In fact, e-commerce can be understood as a paperless version of mail shopping. A virtual catalog is hosted by a server and browsed from afar. Purchase orders are electronically processed without human intervention. Shipments are scheduled with the help of software packages. Even physical distribution can be traced by satellite telecommunication systems so that a control center is able to inform waiting clients in real time about the status of their deliveries.

Several ways of fulfilling e-commerce orders have been developed according to business strategy and existent organizational structures.

6.5.1. *Dell business model and its evolution*

6.5.1.1. *Assumptions made by Mike DELL*

Dell is a well-known personal computer (PC) manufacturer. When Mike Dell started his business in 1984, he simply wanted to assemble and sell computers out of his university dormitory. This was possible because a PC-clone industry had just emerged in the wake of IBM's first machine, complete with an explosion of suppliers. Computer companies no longer needed their own research and manufacturing operations. Instead, they could focus on assembly and marketing.

Right from the outset, its strategy and organization were conducive to flexibility. Basic assumptions were made as follows:

– mail shopping will be a good cost-effective distribution channel: it will not entail customer satisfaction and loyalty;

– PC's will become a commodity;

– PC's will be assembled from industry-standard components easily available in the market place and customized with a limited number of features, if any;

– customer orders activate the supply chain from suppliers to customers through the nexus of manufacturing. The organizational structure is designed accordingly.

6.5.1.2. *Why is this model difficult to copy?*

Several reasons can be put forward to elaborate why this streamlined direct-sales model is difficult to copy:

Strong hurdles to switch from a distribution pattern to a new pattern

Established companies are usually far too wary of undermining their existing businesses and sales channels to push direct buying particularly hard. In addition, this (r)evolution cannot avoid significant changes in the structure of manufacturing operations to reap the full benefits of direct buying. Change management in businesses is not at all a sheer lure made instru-mental by consultants for gaining contracts. In many cases, it turns out to be a critical issue.

Use of specific tailor-made components

Many industry sectors make a wide use of microprocessor-embedded parts for taking advantage of their function capabilities in terms of automation. These parts are either commissioned to and designed by chip makers or designed in-house and manufactured by third-parties. In general, they contain custom features intended to gain competitive advantages. Orders are placed on forecast and are difficult to adjust in the case of market volatility. This lack of flexibility entails higher levels of inventory.

Protection of manufacturing know-how

Assemble-to-order manufacturing requires a specific shop-floor layout and appropriate control and scheduling systems. This organization may also require the deployment of original processes and/or workmanship. On the other hand, relationships with suppliers have to be organized accordingly. All these features form an immaterial capital to protect.

6.5.1.3. *Dell's model evolution*

Business models are not eternal. The backdrop relative to technology, economy and societal issues changes our ecosystems and results in a dynamic adjustment of all the stakeholders involved.

Up to the 2000s, Dell epitomized the streamlined direct-sales operations, in spite of the fact that Dell made some unsuccessful attempts to sell its products via reseller channels. It is out of the scope of this context to tell its tortuous past development path. It diverged with its first line of products (PCs) by entering into new segments of digital technology (servers, data storage devices, computer software, High Definition TeleVision (HDTV), cameras, audioplayers and printers).

All throughout its lifespan, Dell has retained a reputation as a company that relied on supply chain efficiencies to sell established non-proprietary technologies at low prices. Customizing products and short-term deliveries are two other characteristics attached to the Dell brand image. Localizing factory sites at arm's length of markets and configure-to-order manufacturing organizations underpin that strategy.

6.5.2. *Bricks-and-mortar model*

This type of model typifies an endeavor to combine existent traditional distribution channels, generally retailers, and opportunities offered by Websites. The main purpose is to increase the geographical reach and capture cyberclients. In most cases, retailers are supplied from distribution centers.

A problem with this system is that individual Internet-based orders require the processing of a lot of frequent small-quantity orders, whereas retail orders generally require the processing of large–quantity orders. The bricks-and-mortar organization has to migrate to a JIT functioning, which may turn out to be very difficult.

6.5.3. *Virtual firm model*

This model typifies the infomediary scheme. A virtual firm is fabless and constitutes the front office of manufacturers which have outsourced their sales and distribution functions.

The virtual firm receives an order on its Website, passes the order onto a manufacturer for production and possible delivery direct to the customer. Customer orders are dropped-shipped from the manufacturer. Virtual firms are large retailers, brand-named merchandisers and trading companies playing a pivotal role in setting up decentralized production networks in a variety of exporting countries. In fact, the governance of buyer-driven production networks is far more polymorphic than this definition implies.

The methods of fulfilling e-commerce orders are portrayed in Figure 6.8.

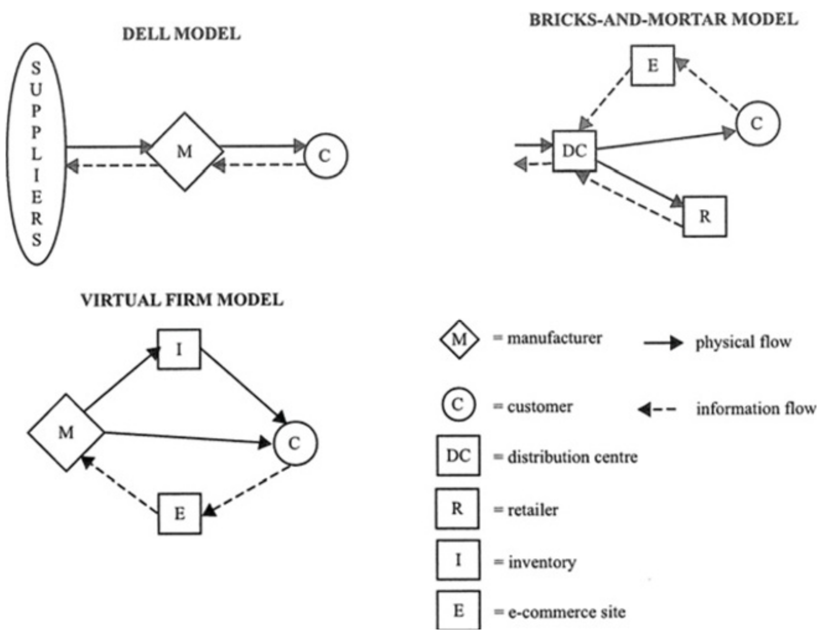


Figure 6.8. *Method of fulfilling e-commerce orders*

6.6. Online auction process

6.6.1. *Introduction*

Auctions are one of the oldest forms of market transactions dating back to at least 500 BC. Today, all sorts of commodities are sold and bought using auctions. The Internet has changed the way auctions are organized and the geographical reach of buyers and sellers.

Auctions are classified by economists as private-value auctions and common-value auctions. In a private-value auction, buyers and sellers give potentially different values to the good in question. The art market typifies this form of auction. In a common-value auction, the good in question is worth essentially the same amount to every bidder, although the bidders may have different estimates of that common value. In the present context, discussion will be restricted to this last case found in B-to-B supply auctions.

The prevalent form of bidding structure is known as a Dutch auction, due to its use in the Netherlands. The auctioneer, the middleman between buyers and sellers, starts with a high price and gradually lowers it step-by-step until someone is willing to buy the item. Today, the "auctioneer'' can be a Website collecting decreasing bids posted by bidders over a limited period of time. Therefore, it is called an online auction.

Another type of auction is a sealed-bid auction. Each bidder writes down a bid on a slip of paper and seals it in an envelope. After being collected, the envelopes are opened and the good is awarded to the person with the highest bid. This technique is electronically implemented by eBay. They are also commonly used for industrial projects such as construction work or manufacturing equipment.

Online Dutch auction processes are now widely used by purchase pools for consumer goods. An example of such a process designed and implemented in a high-tech manufacturing company is described in the following section.

6.6.2. *Online auction process in a high-tech manufacturing company*

Figure 6.9 depicts the chain of subprocesses implemented to carry out an online auction in a high-tech manufacturing company (manufacturer of jet engines).

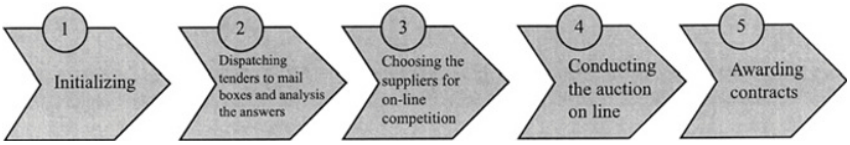


Figure 6.9. *Breakdown of an online auction process into subprocesses*

The procedures and information requirements for completing each subprocess are described in Tables 6.2–6.6 and Figure 6.10.

Procedures	Information Requirements
– Analyze forecasts – Establish itemized procurement needs – Establish purchasing specifications per item – Group items by manufacturing features and defining purchasing lots	– Market demand forecast – Product structure data and quality specification for manufacturing per item

– The more purchasing specifications are stringent, the more the number of suppliers is limited.

– Grouping items by manufacturing features allows for establishing lots to be auctioned and fostering technical economies of scale by untethering cost price for each item of the lots.

Table 6.2. *Procedures and information requirements for initializing the auction process*

Procedures	Information requirements
– Establish e-mail format (financial data/R&D and manufacturing capabilities/compliance with ISO 9000 standards/rough-cut quotations for lots, etc.) – Dispatch tenders to mail boxes –Analyze answers – Set up a merit list	–Profiles of present and prospective suppliers: - Financial status - Offerings - Technical capabilities - Price list - Competitors

– This activity can be viewed as an online market surveying aimed at keeping market intelligence updated.

Table 6.3. *Procedures and information requirements for dispatching tenders to mail boxes and analyzing the answers*

Procedures	Information requirements
– Weigh up the parameters of the merit list against: - The local economic and technical environment - The logistics costs - The quality qualification costs - The currency rate risks. – Derive the equalizing factors of the suppliers' bidding prices – Establish the short list of suppliers for an online competition on the basis of the smoothed-up values of the parameters	– Logistics costs – Cost for granting quality qualification to a new supplier – Exchange rate forecasts – Economic and technical intelligence

Table 6.4. *Procedures and information requirements for choosing the suppliers for an online competition*

Procedures	Information requirements
– Train the bidders – Administer the Website during the auction time – Record the bids	– Bids recorded by each bidder

– Final prices offered by bidders were reduced by about 50% with respect to prices currently paid.

Table 6.5. *Procedures and information requirements for conducting the auction online*

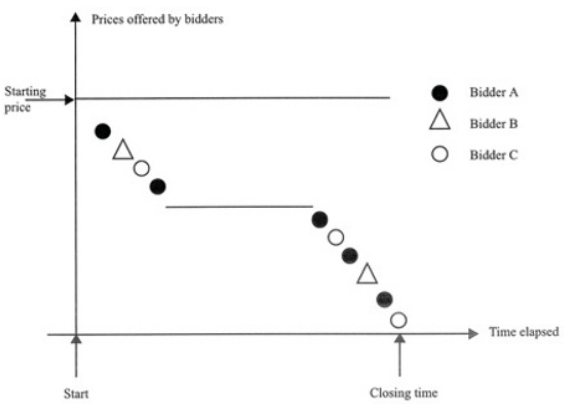


Figure 6.10. *Typical profile of bids during the auction time*

Procedures	Information requirements
– Analyze the features of the auction – Ask for itemized prices of lots – Recommend the “best” supplier (not the cheapest) by weighing up the terms of contracts awarded for a limited period of time against economic and technical risks	– Market demand forecast – Economic and technical intelligence – Price list of items purchased and terms of contracts awarded

– The final decision is based on rational and intuitive arguments built on gained experience and expertise.

Table 6.6. *Procedures and information requirements for awarding contracts*

The relationships between the subprocesses and the aggregated data items required by the subprocess procedures are shown in Figure 6.11.

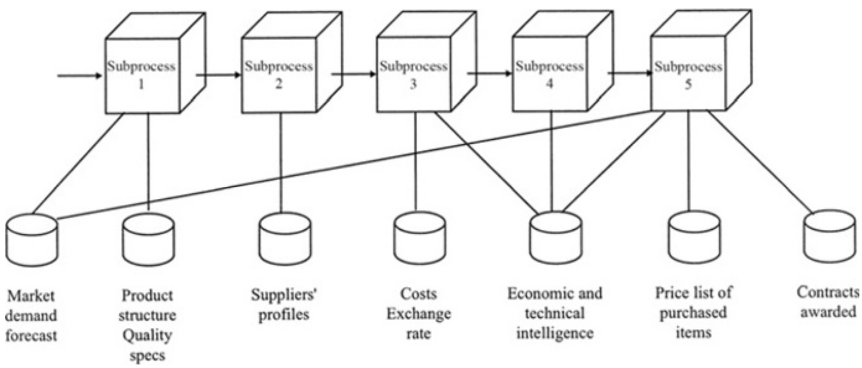


Figure 6.11. *Relationships between subprocesses and aggregated data items*

6.6.3. *Description of the market place COVISINT*

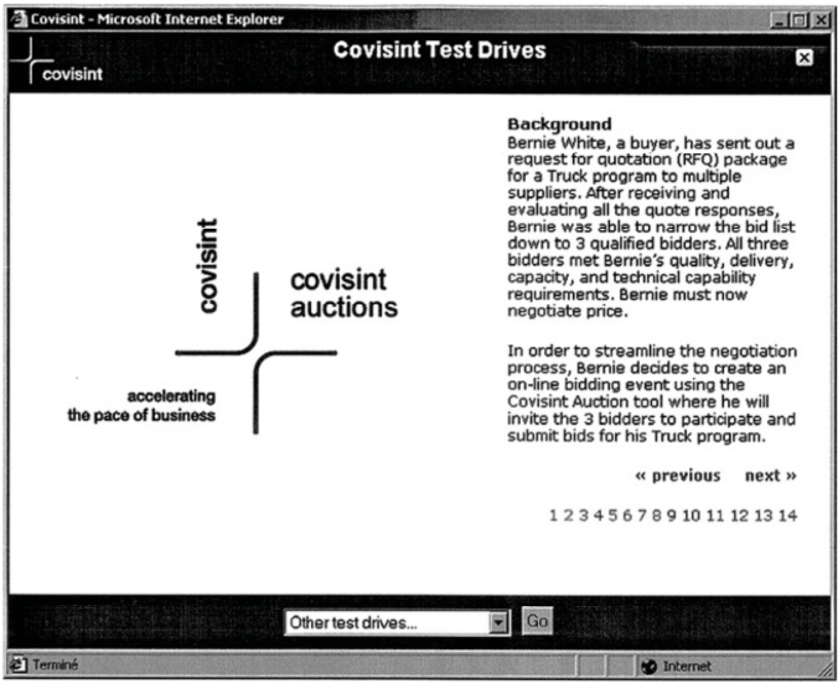
COVISINT was launched by car manufacturers (GM, Ford and Daimler-Chrysler as founding members joined by PSA and Renault-Nissan as late members). The inceptive idea behind COVISINT was to set up an electronic market place for pooling purchases through an online auctioning and obtaining reduced prices. The business model was based on fees paid by purchasers and suppliers taking part in auctions. A cost reduction of US $ 2000/3000 per vehicle was expected associated with bringing delivery lead time from 60 to 15 days.

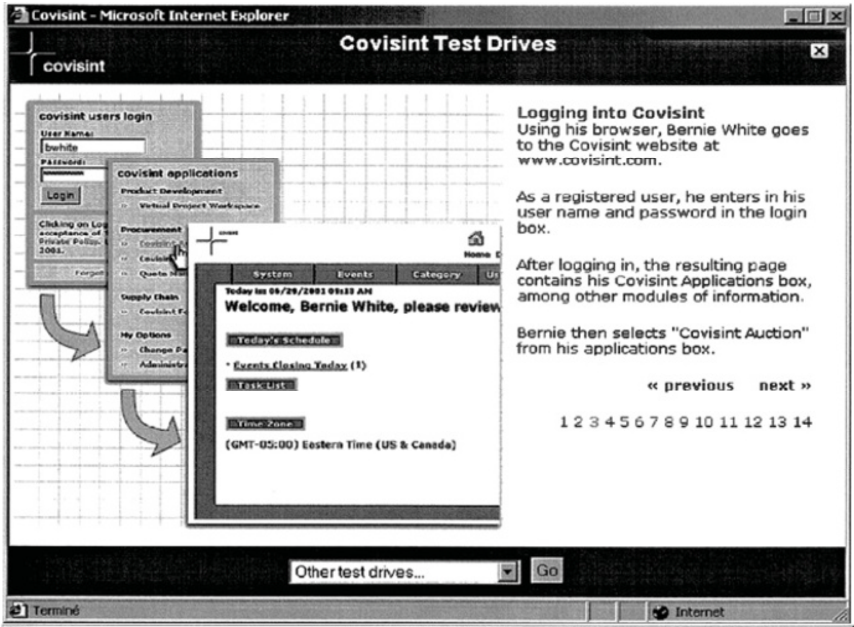
It is now an independent public company offering the services of cloud-based horizontal portal. Gartner defines a portal as a personalized point of access to relevant information, business processes and other people. Enterprise portals support a wide range of business activities and address various audiences, including employees, customers and partners.

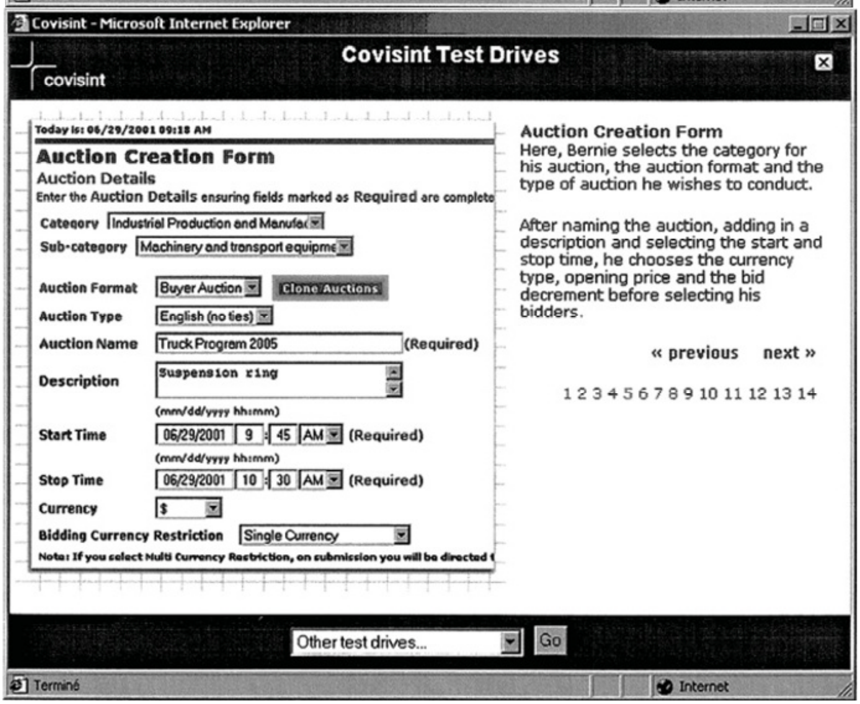
Gartner distinguishes between vertical and horizontal portals. Vertical portals focus on providing access and interaction with specific applications or business functions, whereas horizontal portals integrate and aggregate data from multiple cross-enterprise applications.

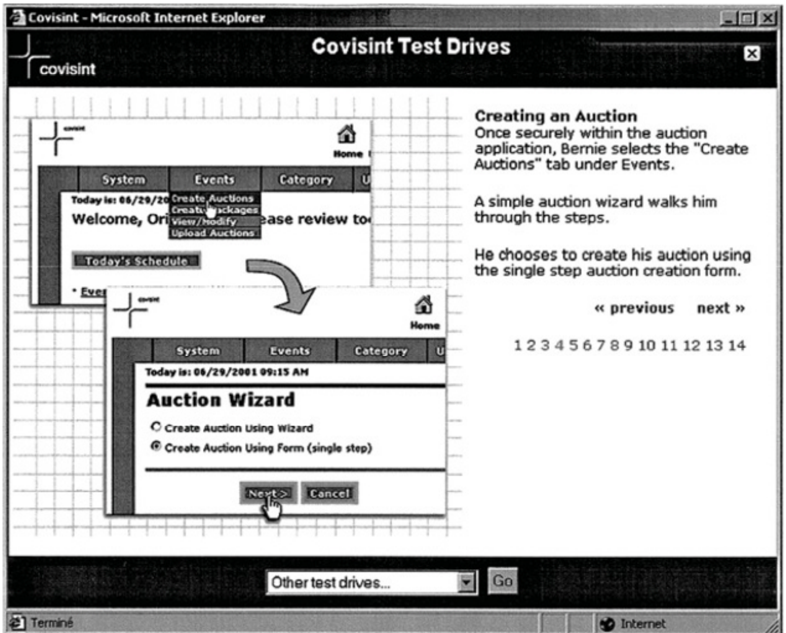
6.6.4. *Exercise*

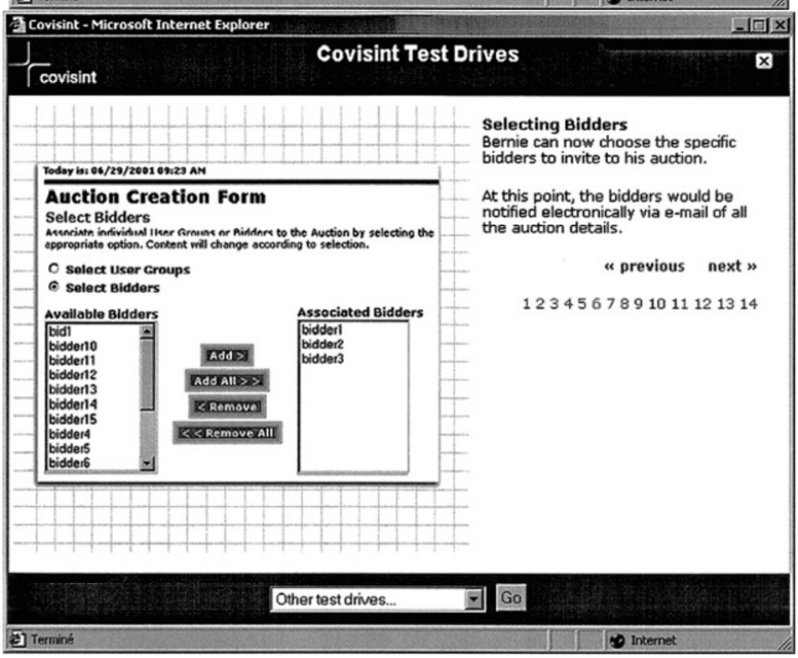
The COVISINT Website provided a demo of auction purchase process. The screenshots of this demo are shown hereafter. Derive an event-driven process mirroring the various steps of the demo.

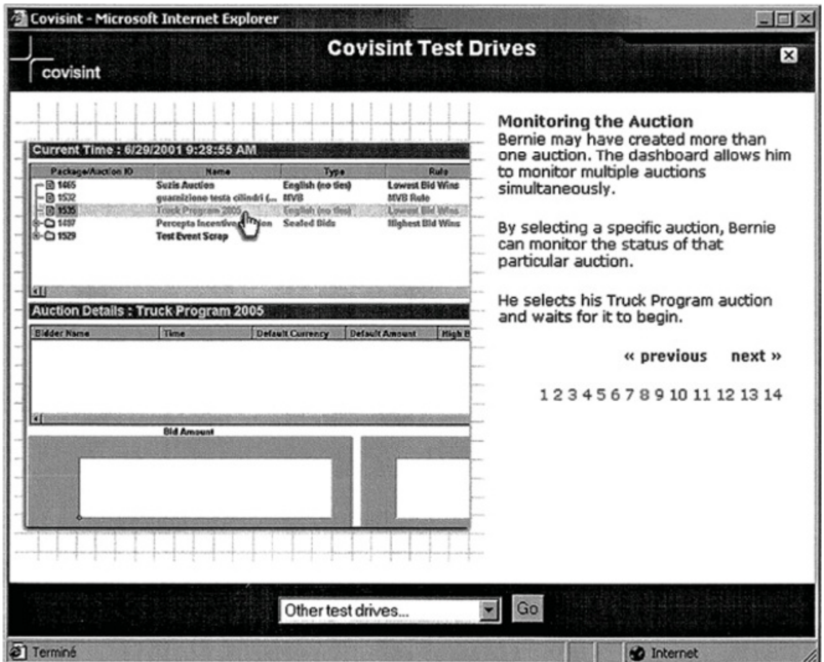


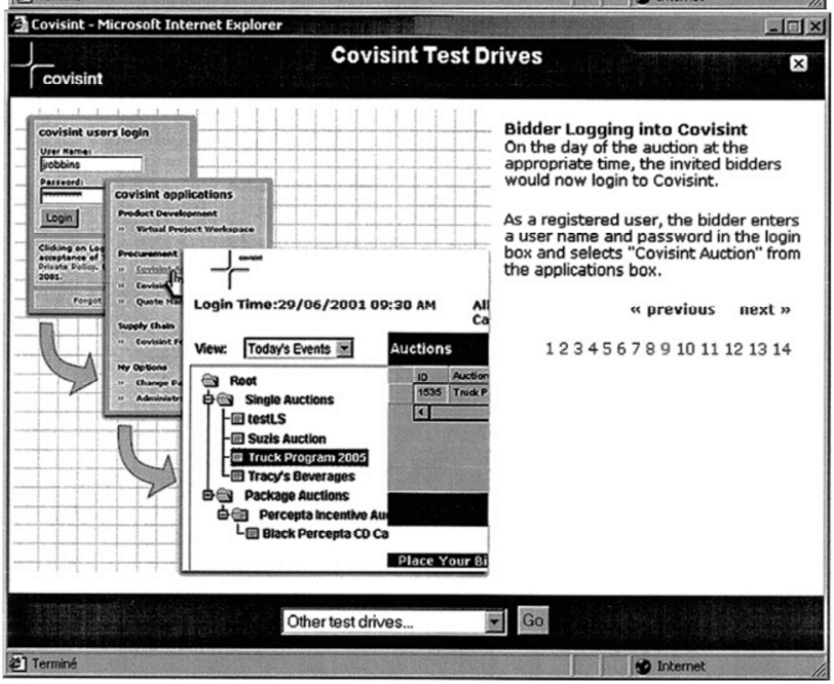

Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
covisint users login
covisint applications
Welcome, Bernie White, please review
(GMT-05:00) Eastern Time (US & Canada)
Logging into Covisint
Using his browser, Bernie White goes to the Covisint website at www.covisint.com.
As a registered user, he enters in his user name and password in the login box.
After logging in, the resulting page contains his Covisint Applications box, among other modules of information.
Bernie then selects "Covisint Auction" from his applications box.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet

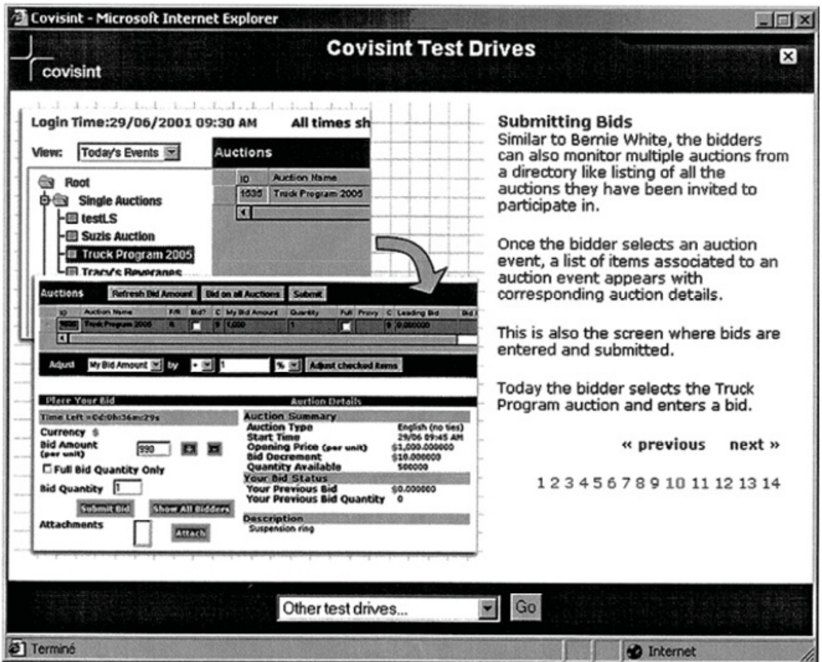

Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
Today is: 06/29/2001 09:18 AM
Auction Creation Form
Auction Details
Category
Industrial Production and Manufac
Sub-category
Machinery and transport equipme
Auction Format
Buyer Auction
Clone Auctions
Auction Type
English (no ties)
Auction Name
Truck Program 2005
(Required)
Description
Suspension ring
(mm/dd/yyyy hh:mm)
Start Time
06/29/2001 9 45 AM
(Required)
Stop Time
06/29/2001 10 30 AM
(Required)
Currency
$
Bidding Currency Restriction
Single Currency
Auction Creation Form
Here, Bernie selects the category for his auction, the auction format and the type of auction he wishes to conduct.
After naming the auction, adding in a description and selecting the start and stop time, he chooses the currency type, opening price and the bid decrement before selecting his bidders.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet

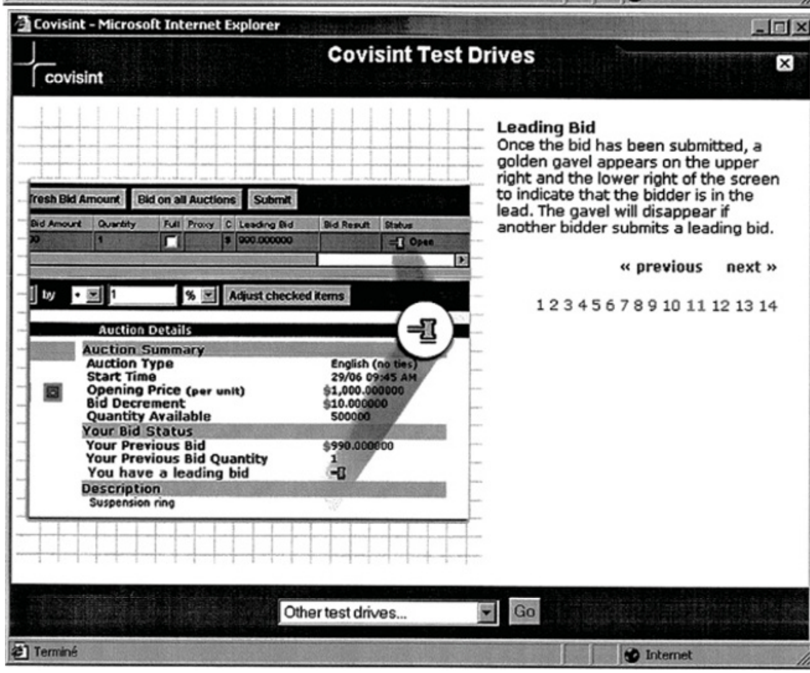

Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
System
Events
Category
Create Auctions
View/Modify
Upload Auctions
Today's Schedule
Home
Today is: 06/29/2001 09:15 AM
Auction Wizard
Create Auction Using Wizard
Create Auction Using Form (single step)
Next >
Cancel
Creating an Auction
Once securely within the auction application, Bernie selects the "Create Auctions" tab under Events.
A simple auction wizard walks him through the steps.
He chooses to create his auction using the single step auction creation form.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet

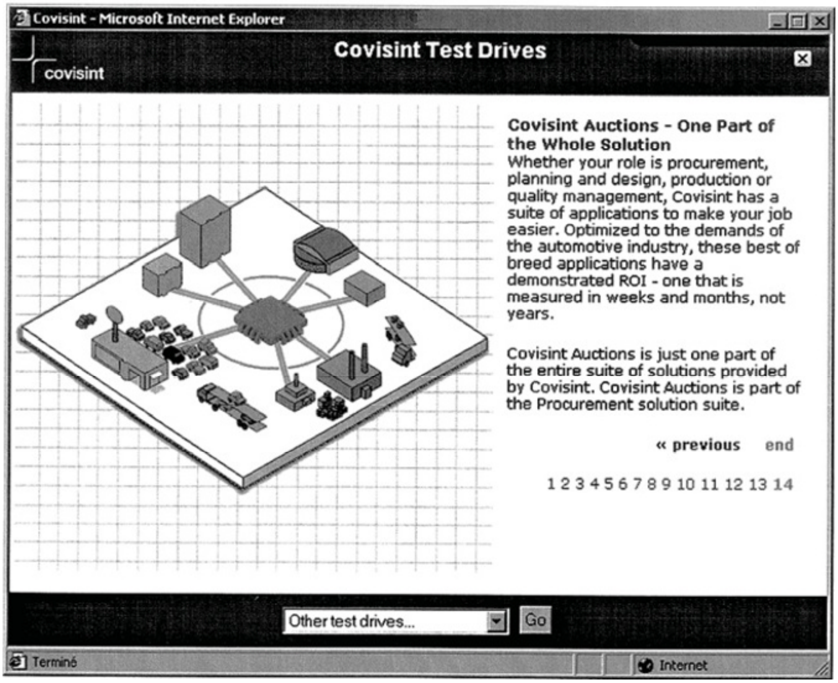

Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
Today is: 06/29/2001 09:23 AM
Auction Creation Form
Select Bidders
Associate individual User Groups or Bidders to the Auction by selecting the appropriate option. Content will change according to selection.
Select User Groups
Select Bidders
Available Bidders
bid1
bidder10
bidder11
bidder12
bidder13
bidder14
bidder15
bidder4
bidder5
bidder6
Add >
Add All > >
< Remove
< < Remove All
Associated Bidders
bidder1
bidder2
bidder3
Selecting Bidders
Bernie can now choose the specific bidders to invite to his auction.
At this point, the bidders would be notified electronically via e-mail of all the auction details.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet


Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
Current Time : 6/29/2001 9:28:55 AM
Auction Details : Truck Program 2005
Monitoring the Auction
Bernie may have created more than one auction. The dashboard allows him to monitor multiple auctions simultaneously.
By selecting a specific auction, Bernie can monitor the status of that particular auction.
He selects his Truck Program auction and waits for it to begin.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet


Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
covisint users login
covisint applications
Login Time:29/06/2001 09:30 AM
View: Today's Events
Auctions
Root
Single Auctions
testLS
Suzis Auction
Truck Program 2005
Tracy's Beverages
Package Auctions
Bidder Logging into Covisint
On the day of the auction at the appropriate time, the invited bidders would now login to Covisint.
As a registered user, the bidder enters a user name and password in the login box and selects "Covisint Auction" from the applications box.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet


Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
Login Time:29/06/2001 09:30 AM
View: Today's Events
Auctions
Root
Single Auctions
testLS
Suzis Auction
Truck Program 2005
Submitting Bids
Similar to Bernie White, the bidders can also monitor multiple auctions from a directory like listing of all the auctions they have been invited to participate in.
Once the bidder selects an auction event, a list of items associated to an auction event appears with corresponding auction details.
This is also the screen where bids are entered and submitted.
Today the bidder selects the Truck Program auction and enters a bid.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet


Covisint - Microsoft Internet Explorer
Covisint Test Drives
covisint
Bid on all Auctions
Submit
Adjust checked items
Auction Details
Auction Summary
Auction Type
Start Time
Opening Price (per unit)
Bid Decrement
Quantity Available
Your Bid Status
Your Previous Bid
Your Previous Bid Quantity
You have a leading bid
Description
Suspension ring
Leading Bid
Once the bid has been submitted, a golden gavel appears on the upper right and the lower right of the screen to indicate that the bidder is in the lead. The gavel will disappear if another bidder submits a leading bid.
« previous next »
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Other test drives...
Go
Terminé
Internet



6.7. E-commerce, sales chains and ROI

6.7.1. *General setting*

After having squeezed costs out of production and delivery systems, many firms are set out to improve their sales process, feeding their production and delivery systems. Whatever a firm's position in a supply network, provider of end products or first-or second-tier supplier, it operates a sales process. The Internet era has heralded a good time to foster faster, cheaper and more efficient processes for sales chains linking all types of suppliers and clients, even for in-house transactions. To elicit the idea, customized needs of clients are intended to be captured more clearly up front and the fulfillment time of a sales order is supposed to be slashed.

When a firm decides to launch an e-commerce project, the following correlated questions have to be addressed:

– Do we want to make money?

– Do we want to provide service to existing clients via the Web?

– Is our Website a marketing vehicle to attract new customers?

– Do we want to advertise or to sell or both?

Critical success factors are often neglected:

– ensuring that the endeavor has clearly articulated and agreed objectives;

– focusing on order fulfillments with special attention to the delivery of goods.

The ability to make a purchase instantly, at one's own convenience, using a computer-based medium, brings with it an increased expectation level regarding not only delivery but also customer care. And, of course, once a company has got it wrong, it loses repeat customers and may find it difficult to recruit new customers as the news spreads.

Anyway, in all cases, invested money must earn profits. This is why it is important to understand how an e-commerce investment can generate profits. In the first place, the sales process must be described. In the second phase, the process activities have to be analyzed to assess how they will be impacted by e-commerce transactions. It appears that some activities will be carried out by the cyberclients. This transfer of work will reduce the consumption of resources by the seller, and this is the very source of cost reduction enabling us to deliver a profit when an investment is implemented.

Figure 6.12 distinguishes between the traditional and digital processes. Some activities of the traditional sales process are carried out by the cyberclients.

Another approach to adjust firm's sales process to e-commerce framework is to deploy a B-to-B proprietary market place. A proprietary e-market place is a catalog of products and services chosen by a firm after assessment in terms of specifications and price and allowed us to be ordered by its staff when needed. The switch from a traditional process to an e-market system is portrayed in Figure 6.13.

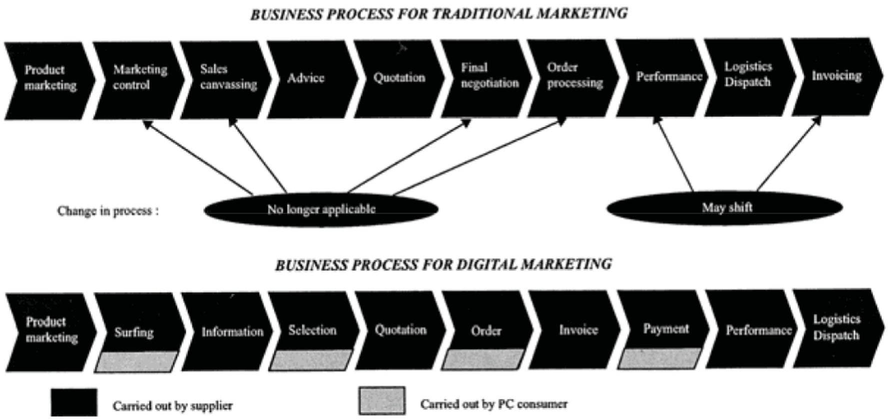


Figure 6.12. *Difference between the traditional and digital sales processes*

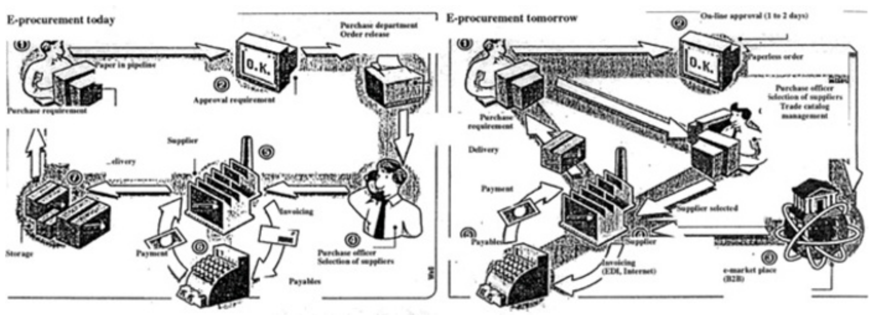


Figure 6.13. *Cash ordering process with and without a market place*

The cash ordering process is described in Figure 6.14 with an event-driven process formalism.

The e-market place can be hosted and operated by a third-party, but the catalog content is created and maintained under the responsibility of the firm. As seen in Figure 6.13, a new mission emerges in the purchasing department, finding and qualifying products and services to be registered in the catalog. When an order is placed, it is sent over the Internet to the supplier's system and the rest of the transaction is electronically performed. The degree of integration with the supplier's system depends on the part of the transaction that is processed automatically without human intervention.

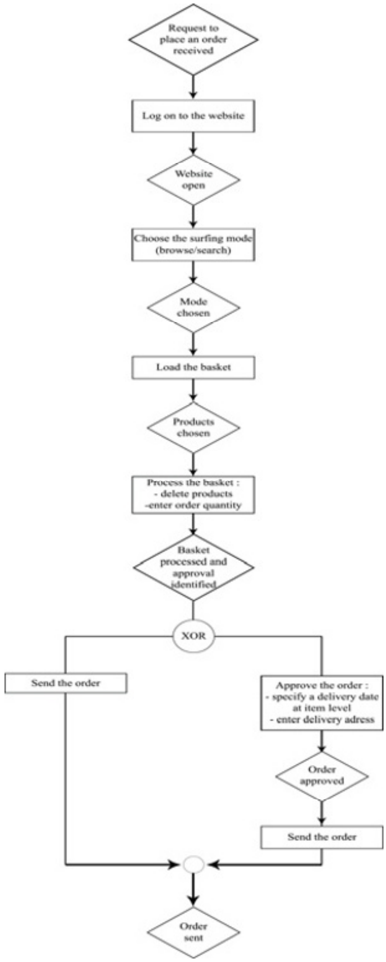


Figure 6.14. *Cash ordering process with a market place*

6.7.2. *ROI of e-commerce in sales chains*

The question raised when assessing an investment project in e-commerce is: what factors in the sales chain are to be considered and analyzed to understand the profitability of the project? The answer is the cost-to-serve a customer order. Quite often, fulfilling a customer order incurs hidden costs, so that understanding the actual cost-to-serve dynamics is a key issue. The drivers of cost-to-serve have to be grasped at the level of an individual item and an individual customer.

The cost-to-serve economics draws on the consumptions of the following resources, i.e. inventory, packaging, shipping and returns processing. Their relative importance with and without e-commerce explains why online sales are successful or not.

Assessing the profitability of a capital outlay implies explicitly or implicitly comparing two situations, i.e. the present situation and the situation after the investment has been deployed. Data describing the present situation are readily accessible from management information systems. The post-investment situation is estimated on the basis of forecasts.

It is tantalizing to invest for the sake of technology. It has to be remembered that business decision makers are always accountable for the consequences of their actions and especially the profitability of investments.

Before applying a technique of a sort to calculate the profitability of an investment on capital, a retinue of data has to be collected or forecast before being processed. The main data requirements are described in Table 6.8.

	Current situation (current costs)	Post-investment situation (forecast costs)
Value of investment and economic lifetime		
Fixed costs (investment depreciation office space, staff, maintenance, etc.)		
Variable costs incurred by transactional activities (phone, fax, advertising, traveling, sponsoring, etc.)		
Variable costs incurred by non-transactional activities (inventory levels, administration and reporting, training, Website servicing, catalog maintenance, etc.)		
Other returns (increased productivity, increased customer satisfaction and loyalty, enhanced geographical reach, competitive advantage, etc.)		

Table 6.7. *Data requirements for assessing the profitability of an investment in e-commerce*

7

Control Parameters for E-Enabled Supply Chain

7.1. Collaborative planning, forecasting and replenishment

One of the main issues in supply chain performance is the lack of visibility into the downstream demand by the chain members. This leads to lost sales and high inventory levels along the supply chain. Most companies forecast future demand on historical data of customer orders or shipment levels and patterns. In fact, actual demand can be very different from the past order stream. Each member of the supply chain observes the demand pattern of its customers and, in turn, produces a set of demand on its suppliers. The decisions made by a supply chain actor in forecasting, setting inventory targets, lot sizing and purchase act to transform and distort the actual picture of market demand.

The further a supply chain actor is “upstream” in the chain, the more distorted is the order stream relative to the actual market demand. This situation can be best visualized as the propagation of a domino effect with uncertainty of a sort added at each step. It could be labeled uncertainty added backward scheduling. This mechanism is portrayed in Figure 7.1.

Market demand is analyzed by the members of the distribution channel and plans of sales forecast are created. On the basis of aggregate sales forecast, the manufacturer evolves a master production schedule (MPS) including some constraints of its own (e.g. lot sizing) and taking account of its own credence in market demand. From this MPS, a master supply schedule is derived and serves as an input to the MPSs of suppliers. In turn,

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the suppliers add their constraints and perception of the market situation. The propagating distortion of the actual final demand is well described by the bullwhip effect and entails suboptimal customer service levels and low return on assets (ROAs).

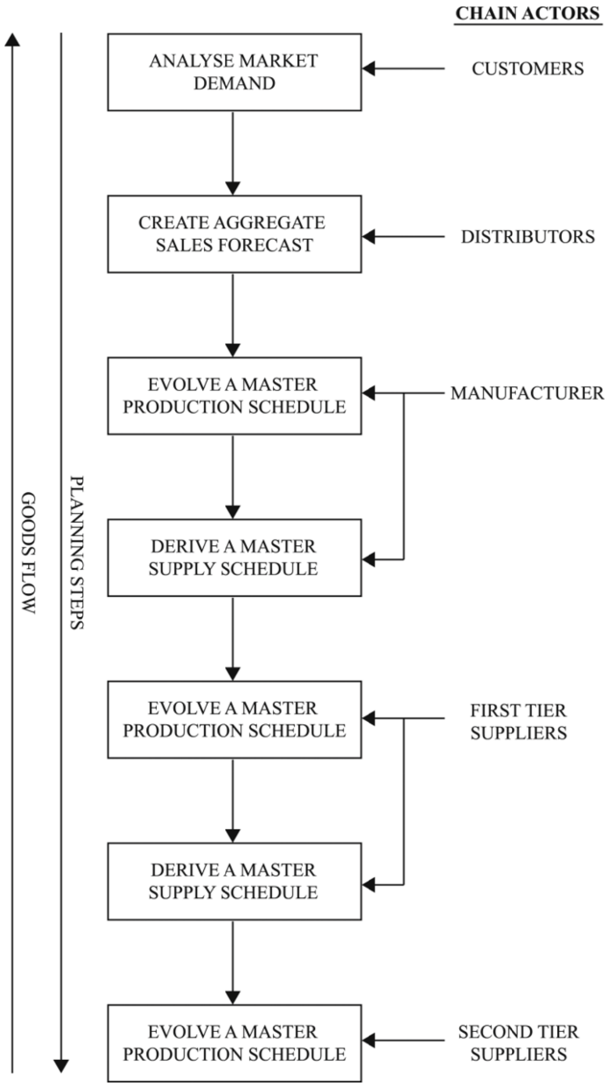

Figure 7.1. *Backward scheduling of the activities of the stakeholders of a supply network scheme*

Collaboration between all the chain members can be improved when using a software system based on what is called the blackboard model. This model relies on a division into independent software modules which do not communicate any data directly but which interact indirectly by sharing data. These modules called *knowledge sources* (KS) work on a space which includes all the elements required to solve a problem.

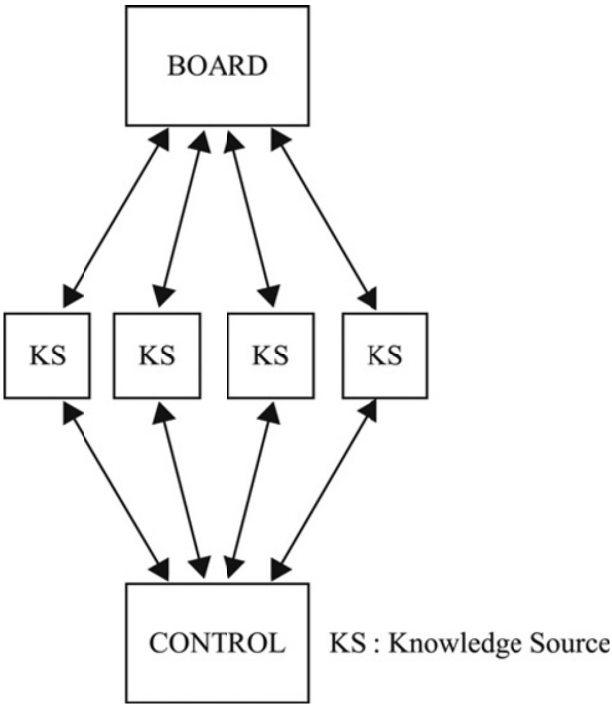

Figure 7.2. *Collaborative blackboard model*

7.2. Control parameters for e-enabled supply chain

Information systems for supply chain management (SCM) have to be able to support business decisions of all agents along the goods pipeline from suppliers to clients. Both management systems, i.e. the supply-driven system (push) and the demand-driven system (pull), are eligible for supporting the implementation of relevant SCM information systems. The availability of information technology (IT) and specially telecommunications services has given a strong momentum to e-enabled demand-driven management systems. That means that clients should be provided without latency with data about product availability, and delivery lead times. Cooperation between the agents involved must take place “in real time’’. New parameters have to be controlled and the architecture of information systems has to be adjusted to comply with the customer-oriented management style. Well-performing SCM information system should be capable of making “instant’’ market analysis by using all chain members’ information systems and considering their timely production and distribution capabilities. Through that function capability, integrated information systems should enable the chain to be fully customer-oriented. If sufficient flexibility of operations is achieved, inventory levels should be significantly reduced. Optimization of goods flows is the metrics of the supply chain performance.

The main control parameters for SCM are described in this section.

7.2.1. *Master production schedule*

The MPS details how many items (end products or semi-finished products) will be produced by specified time periods. An acceptable MPS means that the capacity requirements are fulfilled. It is used as an input to materials requirement scheduling.

A time fence has to be established to make an MPS instrumental in responding to market demand. It is a number of time periods beginning with the current period during which no change can be made to an MPS. In other words, no rescheduling of MPS can take place within the time fence. This constraint has to be ascribed to supply and manufacturing lead times. As any dynamic system, the manufacturing process shows a definite response time when subject to an input pulse.

The value of MPS for time period i is calculated as follows:

$$MPS(i) = Max\{ SS + F(i) - PAB(i-1), 0 \}$$

where:

SS = Safety Stock

F(i) = forecast of customer orders for time period i

PAB (i–1) = projected available balance for time period i–1

7.2.2. *Projected available balance (PAB)*

The PAB parameter represents the expected number of completed items on hand at the end of each time period. The logic associated with the PAB calculation is as follows:

PAB(i) = PAB (i–1) + MPS (i) – CO(i)

where:

CO(i) = customer orders booked for time period i

When the value of PAB(i) becomes negative, rescheduling of MPS is required. Any change in the values of CO pertaining to time periods prior to time period i has a direct impact on the value of PAB(i) by a propagating domino effect.

7.2.3. *Available to promise (ATP)*

The ATP parameter represents the uncommitted portion of a manufacturing organization's planned production based on the supply from the master schedule. It is used for two purposes:

– to make the maximum use of inventory;

– to protect all customer commitments.

The purpose of ATP is to check whether a customer's request (quantity for a due date) can be matched and to promise the next best date on the basis of projected on-hand inventory and released production orders.

The value of ATP after a new CO is entered becomes:

ATP(i) = Max {PAB(i) – CO(i) – new CO, 0}

If ATP(i) equals zero *and* $0 < i <$ time fence, *then* the new CO cannot be accepted as such for this time period;

If ATP(i) equals zero *and* i > time fence, *then* rescheduling of MPS may be envisaged.

A parameter called capable to promise (CTP) is suggested in the literature. It should define the ability of the plant capacity to put the customer's order into the master schedule at the requested date. It could be the answer provided by a "what-if" analysis tool. Its advantage with respect to the ATP parameter is not clearly argued. Another parameter profitable to promise (PTP) is supposed how to optimize the financial side of order entries. This means that an order fulfillment could be postponed until a later date to increase the profitability of manufacturing operations. But the fact that the order is not fulfilled at the right time is a breach of commitment.

The advanced planning and scheduling (APS) concept has been introduced to make a structured use of the parameters described in this section. It ensures that data required to derive the parameters are made available in due time to all agents involved along the goods flow. It has three major features:

– concurrent planning and scheduling of all partners' processes;

– incremental planning and scheduling capabilities;

– positioning as decision support system (DSS).

The acronym APS has two interpretations. It can be APS or advanced planning systems. Both translations can be considered as the actual meaning of both expressions covers the same management areas. APS is purposed to secure a global optimization of all flows through the supply chain by increasing return on investment (ROI) and ROAs. The APS concept was conceived to match the interorganizational issues of SCM.

7.3. The bullwhip effect

The issue at stake along a supply chain is to keep all the activities involved under control. That means triggering activities through timely coordination.

The bullwhip effect is named after the way the amplitude of a whip increases along its length. It is used as a figure to represent how the activity levels of interdependent units along a supply chain can oscillate.

A simple model is considered here to show how the chosen control parameters and the associated algorithm are critical factors to avoid explosive oscillations.

7.3.1. *The model*

Let us assume the following. A distribution company fulfils customer orders on demand from inventory:

1) Market demand Qd,t is an unlagged linear function of market price Pt.

2) The adjustment of price is effected not through market clearance but through a process of price-setting by the sales department of the distribution company. At the beginning of each period, the sales department sets a selling price for that period after taking into consideration the inventory situation. If, as a result of the preceding-period price, inventory accumulated, the current-period price is set at a lower level than previously. But if decumulated instead, then the current price is set higher than previously.

3) The price adjustment made from period to period is inversely proportional to the observed change in inventory.

With these assumptions, the model can be described by the following equations:

$$Qd,t = \alpha - \beta \, Pt$$

$$Qs,t = K \text{ (fixed supply quantity)}$$

$$Pt.+1 = Pt. - \sigma \, \{ Qs,t - Qd,t \}$$

where σ denotes the stock-induced price adjustment.

By substituting the first two equations into the third, the model can be condensed into a single difference equation:

$$Pt.+1 - Pt + \sigma\beta \;\; Pt = \sigma \, (\alpha - K)$$

or $$Pt+1 - \{1 - \sigma\beta\} \, Pt = \sigma \, (\alpha - K)$$

Its solution is given by:

$$P_t = \left\{P_0 - \frac{K - \alpha}{\beta}\right\} (1 - \sigma \beta)^t + \frac{K - \alpha}{\beta}$$

$\frac{K - \alpha}{\beta}$ is the intertemporal equilibrium price $\overline{P}$. P_0 represents the initial price.

Pt becomes:

$$P_t = \{ P_0 - \overline{P} \} (1 - \sigma \beta)^t + \overline{P}$$

The inventory level It by the end of the time period t is:

$$I_t = Q_{s_1 t} - Q_{d_1 t} = K - \alpha + \beta\, Pt = \beta\, (\overline{P} + Pt)$$

By substituting Pt into It, we get:

$$I_t = \beta\, (P_0 - \overline{P})\, (1 - \sigma \beta)^t + 2\, \beta\, \overline{P}$$

The dynamic stability of It hinges on the expression $1 - \sigma\beta$. The following table depicts the situation:

$0 < 1 - \sigma \beta < 1$	$0 < \sigma < 1/\beta$	No oscillation and convergence
$1 - \sigma \beta = 0$	$\sigma = 1/\beta$	Remaining in equilibrium
$-1 < 1 - \sigma \beta < 0$	$1/\beta < \sigma < 2/\beta$	Damped oscillations
$1 - \sigma \beta = -1$	$\sigma = 2/\beta$	Uniform oscillations
$1 - \sigma \beta < -1$	$\sigma > 2/\beta$	Explosive oscillations

8

Integration of ERP Processes with E-Commerce and E-Business Patterns

8.1. Information system architecture and business processes

Enterprise resource planning (ERP)-labeled software packages have brought forward the understanding of business processes for developing effective and efficient information systems. The best way to elicit the relationship of business processes and information systems is to devise information systems with an explicit architecture. An architecture defines the function capabilities of the parts of a system and the specifications of the relationships between these parts.

Linking ERP business processes and information system through a layer architecture of Information System (IS) modules makes possible to:

– remove barriers across organizational structures;

– make procedural structures more explicit and flexible;

– help decision-makers simulate the impact of their decisions.

8.1.1. *What is a layer architecture?*

The basic principle of any layer architecture is the delivery of services to a layer by underlying layers.

A layer architecture is based on layers of functional operations and contrasts strongly with a hierarchical architecture developed on management levels (strategy, tactics and operations).

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8.1.2. *What is a layer architecture describing a business?*

In a layered architecture, the underlying layers relate to the implementation, that is, to the different types of resources, while the upper layers relate to the business. Figure 8.1 shows a schematic example of a layered architecture. A business system may well have more or fewer layers than the ones shown in Figure 8.1, and it can also have layers in several dimensions so that one layer can itself be layered.

The basic principle of any layered architecture is the delivery of services to a layer by underlying layers. When standardization is looked for, formats of services provided are defined, not the very mechanisms engineered to supply services under consideration.

The major benefit derived from layer modeling is the versatility it has for focusing on "relevant" views of a complex system and to trace back, when required, relations with detailed or aggregated descriptions:

– The *resource layer* contains the different concrete resources needed for realizing the organization. Human resources with different kinds of skills (education, management, experience and so on) and different types of equipment (e.g. information systems and transmission and switching equipment) are found here.

– The *infrastructure layer* consists of functions generic to the type of business being modeled. Functions to support network and services management processes, accounting processes, personnel administration, office administration and so on are found here.

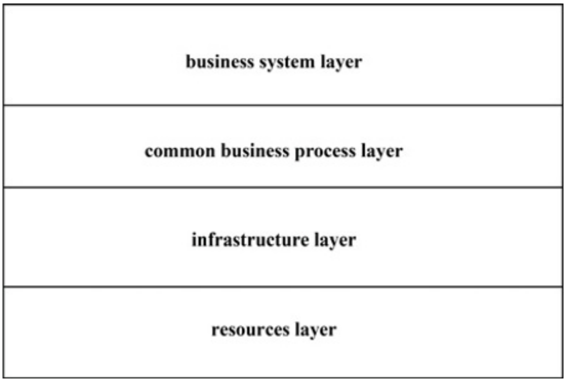

Figure 8.1. *An example of layered business system architecture*

– The *common business process layer* contains internal processes generic to the type of business modeled. These internal processes can be used by many different business processes within the company being modeled. Some of these processes can be described as cooperative services allowing for a structured workflow between the various activities of a single business process or different business processes.

– Finally, the *business system layer* consists of the different business processes. These processes must be chosen to provide the top management with synthesized views of the enterprise. These views should be described in terms of performance indicators able to trigger leverage on relevant operations.

An example of this approach in telecommunications is the well-known open system interconnection (OSI) model.

8.1.3. *Developing a layer architecture*

A layered architecture is normally developed over a long period of time: iteratively and incrementally. To help understanding a simplified view is presented here: a recursive approach which would, in practice, hardly work. A layered system must be modeled both top-down and bottom-up. It may actually be more correct to say that a top-down model is first worked out so that it is easier to anchor the bottom-up model in the next step.

The different steps are presented below:

– *Step 1: start with the whole business system*:

- make a process model of the whole business system. In this model, the actors will be the normal actors of the business system, and the subsystems will be the business processes of the company, as seen by the top management. An actor has a role that someone or something in the environment can play in relation to the business processes. Actors interact with the business processes and are the key to choose and define them. A process is a sequence of activities intended to yield a result of measurable value to an individual actor,

- make an activity model corresponding to each process model. If you want to have several activity models of the business, proceed with the next step at this stage;

– *Step 2: proceed to the next layer (common business process layer)*:

- make an activity model for the common business processes,

- identify who communicates with whom inside this layer and with the overlying layer;

– *Step 3: continue with identifying objects for underlying layers:*

- a major issue is to secure organizational memory of the architecture. As explained above, an architecture is not developed overnight and must evolve in coherence with the organizational changes of the enterprise. It can be considered as a living organism and as such its background must be recorded in order for its present situation to be fully understood and its evolution, if required, decided upon sound data. Some software packages to assist in keeping records are available on the market. One of the most versatile packages is the ARIS-Toolset. It allows users to describe the business processes as chained activities in one view and the organizational structure in another view. A third view secures the connection between the two views, i.e. giving a clear picture of who is responsible in the organization for what activity or process.

8.1.4. *Relations between different layers*

In systems with a layered architecture, it is important to define the interfaces between the various layers. Object-oriented technology provides an elegant method for doing this. This approach will be reproduced by substituting object for activity.

Every layer is a composite set consisting of only its constituent activities. The interface to a layer is made up of the interfaces to its public activities. By "public", it is meant here that it is accessible from outside. How a layer can be used by layers higher up in the structure is an important architectural decision. There are several such types of layer relations to choose. Here, we present two of them:

– the use of activities in the lower layer is covered in the activities of the higher layer. The design of the higher layers uses the public interfaces of the basic activity layer as primitives; this is because the interface is encapsulated in the overlying layer's activities, and can only be seen in these activities' implementation parts. The interface should not be used in the documentation, which describes the interaction between activities in the higher layers. A larger business system consists of thousands of activities that communicate with one another in an extremely intensive way; by concealing the communication with underlying activities inside the activities in their own layer, all documentation will be simplified.

Since they are designed to be reused extensively, basic command activities should be managed in a very different way compared to business activities: they should be carefully tested before being released; they should not be allowed to change until all business activities dependent on them have also been changed, and so on.

– activities in the lower layer need not only be covered in activities of the higher layer, but can be used in the design documentation of the higher layer; however, they cannot be changed by the designers of the higher layer. The common business process layer grows and matures during the development of several different business subsystems. It should contain the common activities of an entire business, and it should, therefore, become relatively stable after a number of releases. The layer should be managed in a way different from the business system layer, but in a way similar to the infrastructure layer. An important difference, compared to the objects in the infrastructure layer, is that it is necessary to show the activities in the common business subsystems. When designing a business subsystem, we may show the common business processes that we are using, but we are not allowed to make any changes in them whatsoever. We are only allowed to make changes in our own activities, that is, activities to realize our business subsystem. If a common business activity has to be changed, all business subsystems using that activity will need to be changed at the same time.

8.1.5. *Relations between different subsystems inside a layer*

Every layer can be divided into subsystems. The subsystems in the highest layer, if any, cover large business areas and are supposed to reflect the core business processes as viewed by the top management. They can be dependent on each other. In this case, they are interrelated through an activity or a process of the underlying layer.

Business system areas and layering are complementary. We can apply both techniques to describe a complex organization. First, use the business system area technique to find the different business system areas and their associated processes, and then develop underlying support processes within the framework of a layered architecture. The layers below the highest will be used for all of the business system areas.

Figure 8.2 describes the concrete example of a layered information system architecture pertaining to a manufacturing company.

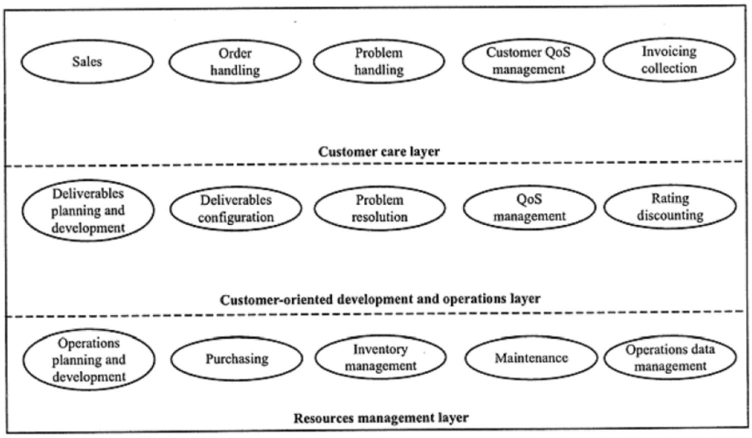

Figure 8.2. *Layered information system architecture for a manufacturing company*

The specific features of a layered architecture are best understood by comparing it with a hierarchical information system architecture for a manufacturing company as shown in Figure 8.3.

8.2. Business workflows and information system architecture

A business workflow is a chain of data processing steps carried out by application programs associated with business domains described in the information system architecture. One or several business domains can be involved in a business workflow. From the data processing point of view, a business domain is a collection of application programs and data files. According to the type of eventful messages received by a business domain, specific programs are activated and produce output data that can be possibly transferred to another business domain as an eventful message.

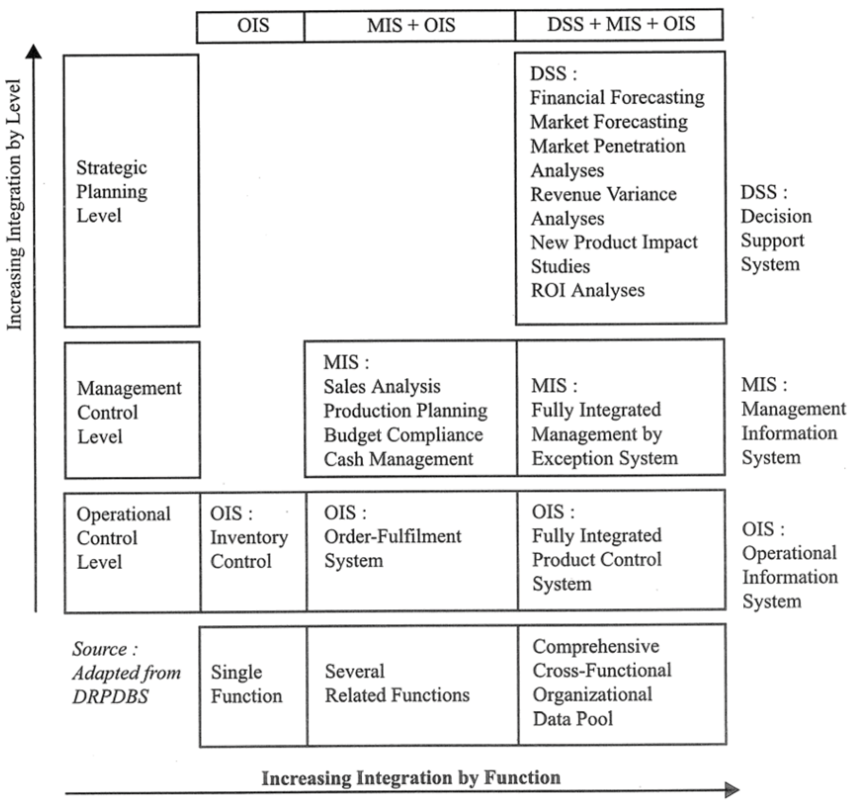

Figure 8.3. *Hierarchical architecture of application systems for a manufacturing company*

A data model for business workflow is shown in Figure 8.4.

8.3. Integration of ERP processes with e-commerce and e-business

Integrating e-commerce and e-business into existing ERP processes is best implemented by developing a customer interface layer in the information system architecture. When referring to Figure 8.2, a customer interface management layer takes a position above the customer care layer. Its function capabilities are described in Figure 8.5. This layer has to be understood as receiving inputs from electronic sources, directing them with an adequate format to business domain functions, collecting the answers and sending them back to the customer.

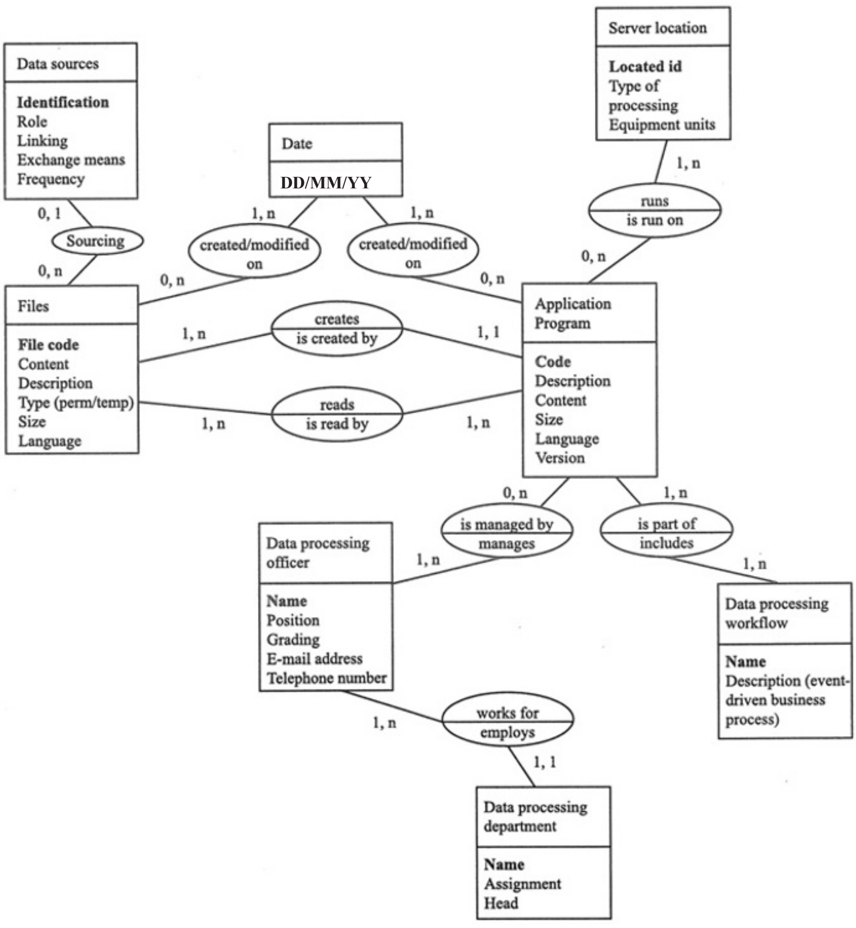

Figure 8.4. *Data model of business workflows*

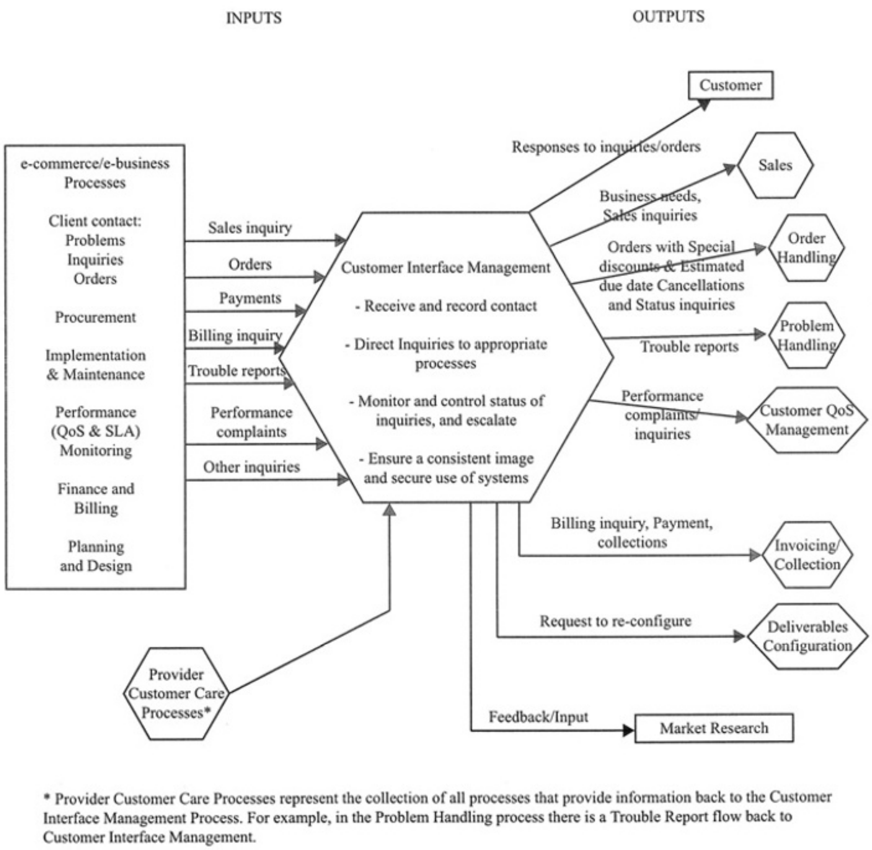

Figure 8.5. *Function capabilities of the management layer interfaced to customer e-commerce/e-business processes*

The software vendor SAP has developed a web-enabled sales process. Its stepwise description is presented in Figure 8.6.

The sales process is made up of nine main steps with associated specific functions available only to non-registered customers. This feature is intended to constrain customers to register so that their profiles can be captured in terms of behavior (browse or/and search) and products/services scrutinized. These data items about profiles are analyzed by companies to assess the attractiveness of their products/services and to deploy one-to-one marketing approaches. This technique consists of sending appropriate messages to targeted customers in line with their profiles.

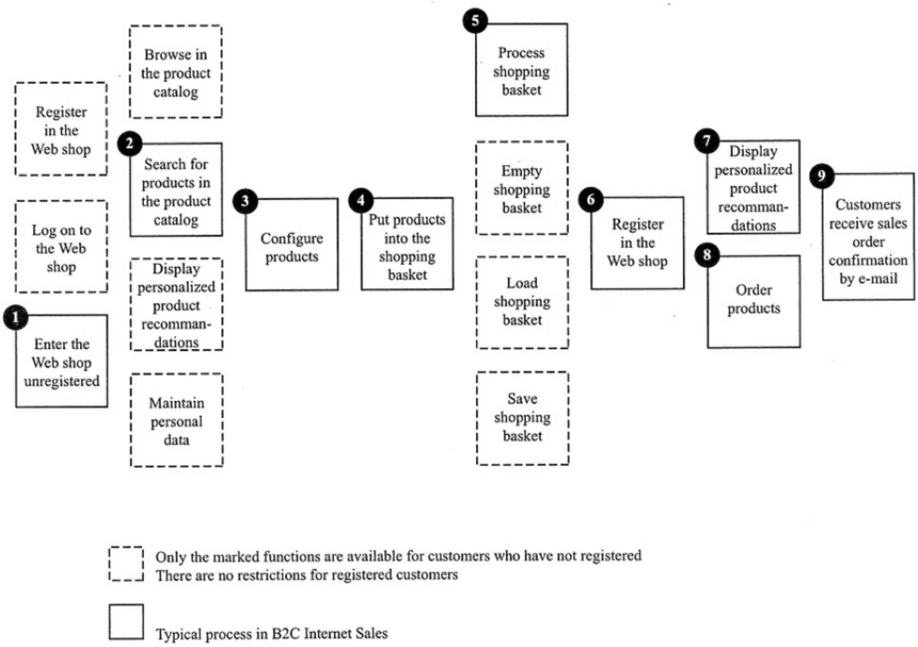

Figure 8.6. *Web-enabled sales process by SAP*

This sales process can be converted into an event-driven process. The outcome of such an exercise is partly given in Figure 8.7.

Process the "basket" is the data processing step of the sales Website interfacing the existing software packages of businesses.

In order to design the full web process at best, the logical architecture of the business information system must be known.

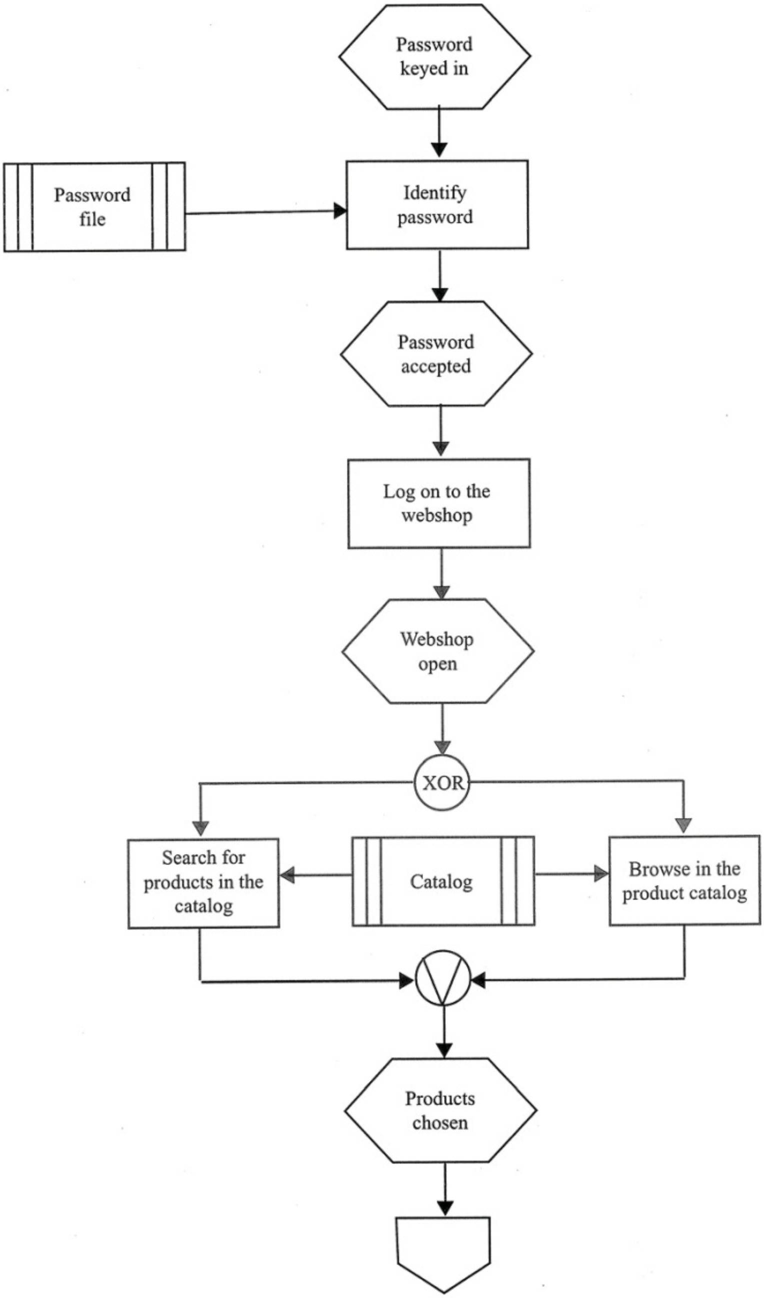

Figure 8.7. *First stages of a web-enabled sales process*

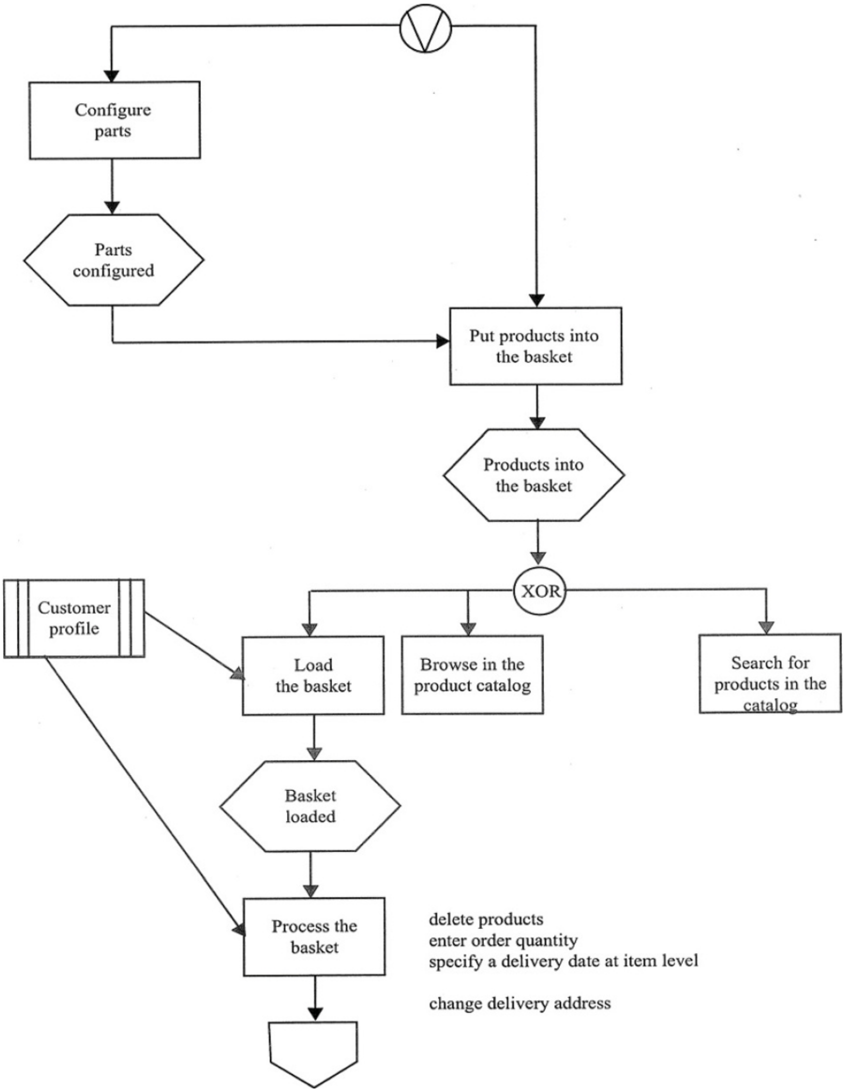

Figure 8.7. *(continued) First stages of a web-enabled sales process*

9

Roles of Information Technologies for Making Business Models Flexible

9.1. Information technologies: engine of change

Information technologies and specially data networking play a major role in changing business processes and keeping enterprises competitive in a global market. Manufacturers use data networking predominantly for the following applications:

– computer-aided design (CAD) and computer-aided management (CAM);

– electronic data interchange (EDI) engineered by communities of interest (suppliers, manufacturers and clients) to foster efficient coordination;

– accounts consolidation packages aimed at improving cost control;

– portals to link workers in different organizations across different time zones.

All these tools make enterprises more agile by reducing their response time to events and by facilitating the scalability of their operations.

The formation of virtual organizations (VOs) is a step beyond the partnership relationship in which two or more entities join together to achieve an objective. They are bound to provide new innovative functions in a knowledge-based economy.

E-Enabled Operations Management, First Edition. Jean-Pierre Briffaut.
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9.1.1. *CAD/CAM*

CAD/CAM is particularly significant in the manufacturing sector. Good design is the key to efficient manufacturing. CAD/CAM software is not just an electronic drawing board, enabling products to be conceptualized and designed on computers. It affects the whole design/manufacturing process.

CAD designs are so accurate that prototypes and mock-ups no longer have to be built. On the one hand, that saves time and money. On the other hand, CAD designs can involve different collaborative partners. For example, Dassault is bringing a new jet plane (X7) to the marketplace which has been cooperatively designed and tested without any trial runs.

CAD/CAM systems have the capability of transmitting drawings to component manufacturers and subcontractors to show them what has to be manufactured. This supports what is called concurrent engineering, i.e. simultaneous development of products and manufacturing operations.

The effect of CAD/CAM goes further than the design stage of products and associated manufacturing equipment. CAD/CAM information can be used to schedule manufacturing operations and just-in-time delivery supply of material resources. It can be turned into a collaborative implement for managing all the stakeholders along a supply chain.

9.1.2. *Quality of service and speed of delivery*

Cost is no longer acknowledged as the only factor for buying a product. Quality of services associated with a product and speed of delivery have become key factors in any purchase decision.

In many situations, the competitive advantage depends on enterprises' being a fast turnaround on customer orders. Data networking by providing distant support and order processing online is an appropriate technology to meet these challenging needs.

Customers are looking for flexibility and value for money: information technologies can contribute predominantly when adequately used.

9.1.3. *Virtual organizations*

VOs are created when consortia of legal entities (individuals or organizations) like to work together to produce a product, provide a service or tender for a contract, but do not like either to have one contracted party to which the others are subcontracted or to create a new legal entity.

VOs can be engineered on demand in the short or long term. They are established on the basis of a general VO agreement (GVOA) which outlines the framework for cooperation within which specific service level agreements (SLAs) are produced to detail each service provided. It identifies the subject and the target(s) in terms of a set of policies. At the operational level, a VO has to be defined by a number of business processes. Business processes comprise sets of operational tasks or activities (aggregated tasks) having requirements for either actor roles or service roles, or both. A service role is described by its service interface and the SLAs characterizing the service.

Coordination describing how interaction takes place in a VO between the participants is split between choreography and orchestration. Message exchanging between collaborating peers is referred to as choreography. It follows a defined set of rules. They are global "reactive" rules that declaratively prescribe normal/abnormal progress, common agreement of the outcomes and are used by each participant to determine which message exchange will/can happen next at any point of collaboration. Orchestration, on the other hand, specifies the behavior of a participant in choreography by defining a set of "active" rules executed to infer what to do next.

9.2. Approach to the specific functions of virtual collaborative context

The approach unfolds in three steps. The first step is to define what is meant by *context* in connection with *collaboration*.

In a situation where human actors interact, a context is composed of three dimensions:

– the actors involved characterized by their capabilities and roles;

– common objectives and/or a common vision evolved from overlapping individual goals;

– the environment surrounding the actors.

Filtering is an important feature to be taken into account when actors communicate through message exchanging. It refers here to the semantics of messages and can be considered as a dimension of semantic interoperability. A common basis of knowledge must be ensured between all the actors involved in order to avoid misinterpretation and as a consequence inefficient decision-making resulting from ambiguous mutual understanding.

Figure 9.1 portrays the definition of collaborative context as mentioned above.

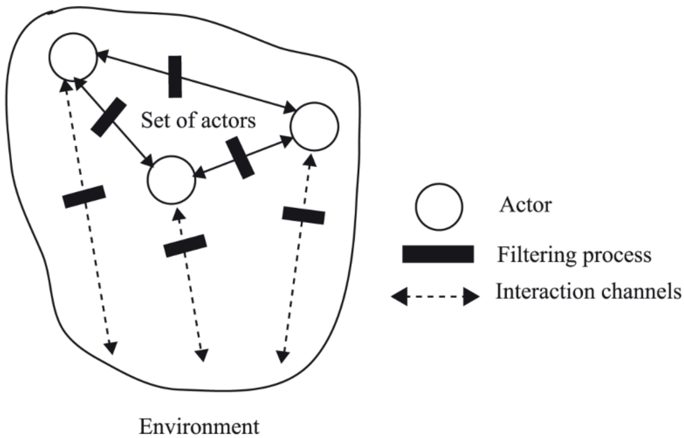

Figure 9.1. *Description of a context shared by a set of actors interacting between themselves and their environment*

In the second step, collaboration is defined and interaction patterns are investigated to complete the definition of collaborative context.

Collaboration means working together with common dynamic goals to achieve collective results that benefit all parties involved. It implies a high degree of commitment, mutual trust, a sense of belonging and common interest. A critical feature of collaboration is vision-sharing by all the stakeholders involved in producing targeted results in complex contexts.

Two interaction patterns between the set of actors can be identified, i.e. direct interaction and indirect interaction. The idea of direct interaction is straightforward to apprehend. By indirect interaction, it is meant that an actor can influence other actors' behavior through the environment. This feature underlines the importance of the environmental entity for the context-awareness concept in collaborative environments. From this point of view, the environment must be considered as an actor in itself all the more so that it becomes the only communication channel between the set of actors when a medium-based virtual collaborative environment is implemented. The behavior of each actor of the set cannot be understood and analyzed without taking into consideration how the interacting environment is perceived by each actor. Figure 9.1 is changed to Figure 9.2.

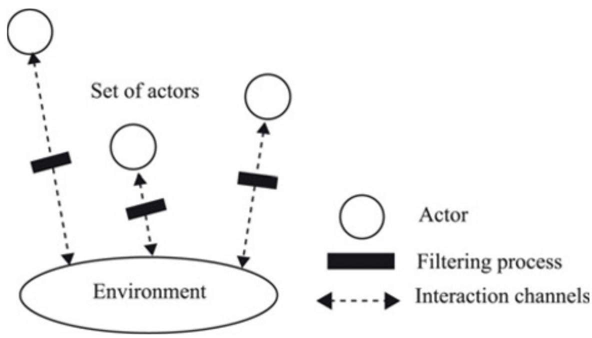

Figure 9.2. *Set of actors interacting between themselves via their environment*

In the third step, the meaning of the term virtual has to be elicited to produce a full understanding of the virtual collaborative context.

The main characteristic of the virtual space, referring to collaboration, is that actors meet:

– out of sight: dealing with systems that are proxies of people we do not see, and discussing with “faceless” partners;

– out of touch: the user has no physical control, and a narrow bandwidth for communication (no voice, no sight).

Paraphrasing a quote from Nietzsche could be appropriate to explain the user’s feeling of remoteness: *the virtual space is the place where man remembers his first great fears.*

Virtual collaboration represents man–machine interaction where technical systems perform hidden procedures to achieve the user’s goal.

A psychological aspect of the virtual space is the perceived invisibility of the system a human is interacting with. This invisibility can be ascribed to the properties of the system itself in relation with its mental representation by users. Invisibility has four dimensions, i.e. the human, the system, the task and the environment. The degree of invisibility is hard to assess and depends on the individual involved. Questions can help in understanding how an individual reacts to invisibility. The answer to the simple question "what are you doing?" reveals the basic relationship between the tool, the user and the task. If to this question already the tool is mentioned, then the tool is central to the user's mind. If only the task is mentioned, the tool has some degree of invisibility to the user. By detailing the question further: "how are you doing the task?" and "what steps are you performing to accomplish the task?", eventually the tool will be mentioned. These questions allow for understanding between what is central in the mind of users. According to the spectrum of possible user attitudes, software designers face a dilemma. The choice is between, on the one hand, enhanced integration of function capabilities and making the digital system more invisible, and, on the other hand, less integration of function capabilities and making the user more involved in the deployment of function capabilities.

Summing up the previous explanations, a virtual collaborative context is defined as:

> *A set of actors interacting through an intermediation "agent'', generally called the environment in collaborative situations, the properties of which must take account of the capabilities and roles of the actors involved and ensure a shared vision of the dynamic goals to reach, implying commitment, mutual trust and a sense of responsibility.*

Some additional comments are required to mirror all the aspects of virtual collaborative contexts:

– in spite of the fact that collaboration requires common objectives or at least a common vision of the object under consideration, each actor may have different, even divergent, goals at the back of his/her mind. For example, when negotiations take place, the various stakeholders may have divergent targets but in most cases, they want to reach an agreement, even if their interests are conflicting;

– time dependence of the environment attributes and the changeable content of common goals may be a determining factor. Common objectives, common visions and the state of the environment can evolve very fast. Real-time capture of the parameters involved may appear as a critical factor.

9.3. Applications of portals

9.3.1. *How portals impact business organizations*

Portal is a generic term for describing a man–machine Web-based interface designed and operated for facilitating business actors' tasks.

Technically speaking, it aggregates several distributed software modules (some of them can be Enterprise Resource Planning (ERP) modules) along an event-driven process mirroring the chain of business and/or cognitive activities. This specific application of IT technology has paved the way for dramatically changing not only intracompany relationships but also the way companies collaborate with suppliers and sales partners. Web-based portals have brought about imprecedented real-time connectivity, enabling companies to work together within a network. Internet on mobile phones will give a strong thrust to scalable collaborative environments.

The development of a type of global organization, i.e. transnational production networks, hinges on the function capabilities of portals. Within that perspective, companies are locked into external networks of relationships with a myriad of other companies: transnational and domestic, large and small, public and private. Today, a company is best understood as an entity at the centre of a Web of relationships. It is through such interactions that a very small company in one country may be directly linked into global production network, whereas most small companies serve only a very restricted area.

Relationships between the various stakeholders of a company can be empowered by three types of Web-based portals, as shown in Figure 9.3.

9.3.2. *Portals and negotiations in business life*

The very fabric of business life is communication between all the stakeholders involved, inside as well as outside the enterprise. A fair part of communication traffic can be labeled "negotiations".

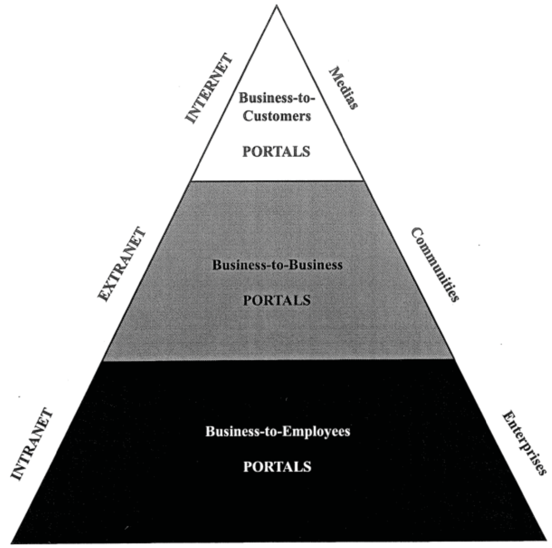

Figure 9.3. *Various types of portals*

A negotiation is an iterative two-way communication and decision-making process between two or more parties represented by agents who cannot achieve their objectives through unilateral courses of action and who search for an agreement to reach their set objectives. Portals can be considered as hubs of online negotiation-laden transactions. A transaction is intended to transfer the ownership of tangible or intangible objects or rights to services. A host of online transactions including negotiations can be brought forward as examples: negotiations between customers and suppliers, scheduling of activities, budget forecasting, auctions, etc.

When disagreement of a sort between contracting parties arises in the real world, several strategies are open to try to resolve the issue by determining what the fair or just outcome should be. It might be that a set of transaction rules might have been defined covering eventualities of conflicts and actions to settle disputes. This situation can be formalized by a negotiation protocol. A second strategy is to seek the advice of an impartial referee. A third strategy would be to conjure someone up in the imagination, a hypothetical referee. When the hypothetical agreement method is used to solve conflicts, it has to be supposed that some sort of hypothetical contract is to be made under explicit or, more often, tacit conditions. In general, tacit conditions prevail because of asymmetric information between the parties involved.

A transaction reference model is made up of three main phases, i.e. intention, negotiation and agreement. What is meant by intention is the definition of targets to be reached and the means required. Negotiation is the central phase when tendering, bargaining, bidding, mutual matching and dispute resolution come into play. Agreement is the phase where the issues raised at the intention phase have found a solution accepted by all the stakeholders involved and put in a written format as a contract accessible for consultation.

Social science contributes most of the studies regarding the nature of negotiations, but when designers of electronic negotiations try to find well-defined mechanisms, they are confused by the conflicting results and prescriptions of social science works. A precise terminology is a necessary condition for designing efficient systems supporting electronic negotiations. This terminology allows negotiation scenarios and protocols to be defined fulfilling the following properties:

– transparency;

– explicability;

– tractability;

– completeness.

Negotiation protocols can be described in terms of functional primitives mirroring the behaviors of negotiators. The main primitives are detailed in Table 9.1.

Buyer side	Supplier side	Both sides
– Proposal: buyer's requirements structured as a contract – Request for change in a contract: list of modifications – Confirmation: successful negotiation – Cancelation: aborted negotiation	– Acceptance: answer to a proposal or request for change – Refusal: answer to a proposal or a request for change – Counter offer to a request for change: list of workable modification	– Withdrawal: cancelation of a confirmed contract

Table 9.1. *Main functional primitives of negotiation protocols*

When designing a negotiation protocol, three important criteria have to be taken into account, i.e. closed or open patterns, degree of automation and synchronous/asynchronous sequencing.

When the focus of negotiations is put on asynchronous transactions pertaining to the exchange of goods and services, the medium is called an electronic marketplace. It is a platform where transactions are coordinated. Current specialized e-marketplaces such as COVISINT (see Chapter 6) offer a wider range of capabilities from auctioning, codesigning to logistics management (shipping), supply-chain management (demand/supply planning) and value-added services (payment transactions). Central to e-marketplaces is the catalog content that is managed by suppliers and presents their products. As a general rule, large buyers and suppliers interact with the marketplace by exchanging messages automatically between their data processing systems without human intervention. Small- and medium-size enterprise (SME) buyers and sellers use a Web browser device to communicate with e-marketplaces. Figure 9.4 gives an outline representative of specialized e-marketplace.

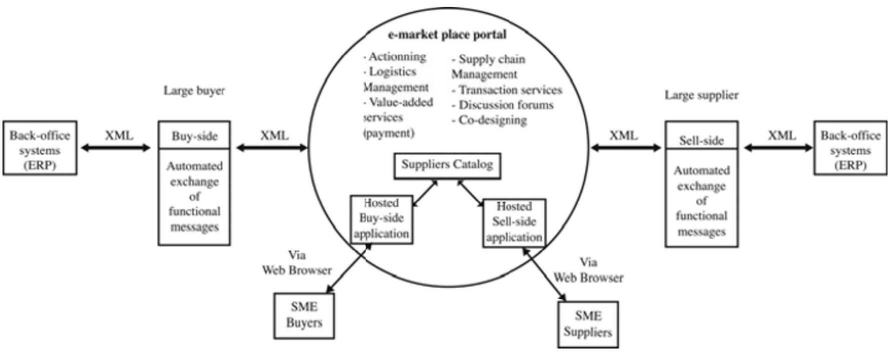

Figure 9.4. *The anatomy of an e-marketplace*

9.3.3. *Scenario of a collaborative e-enabled working environment in the fashion-sensitive textile sector*

9.3.3.1. *Motivation and context*

For a long time, price has not been anymore a decisive competitive factor for business sustainability. Servicing customer needs according to individual requirements appeared as a differentiation approach to markets taken by innovative companies. For instance, a car company is not any longer a manufacturer but a designer and a provider of transportation services by means of products called vehicles. As Information and Communication Technology (ICT) was pervading the business realm, an additional success factor came into play, i.e. time. This brings about a shift in business performance targets derived from an evolving management concept called "time-based services''.

The critical business issues addressed by this scenario are:

– time-based collaboration in a complex supply chain;

– synchronized flexibility of business operations;

– on-demand fulfillment of customer needs in a volatile market.

This scenario intends to show, on the basis of a specific example, how various economic sectors involved in serving customer markets can conflate to reduce the throughput time and the obsolescence risks incurred by holding inventory. Its purpose is also to raise all the issues at stake and to make decision-makers aware of all the implications and the risks incurred when initiating such a project.

In some economic sectors, market demands are highly seasonal and fashion-sensitive. The textile cluster of industries is a good example of this sort and is chosen here for the intricacy of stakeholders' business practices.

The rough-cut present situation in the textile and apparel industry is sketched in Figure 9.5. It shows the actors involved and the collaboration areas to be considered.

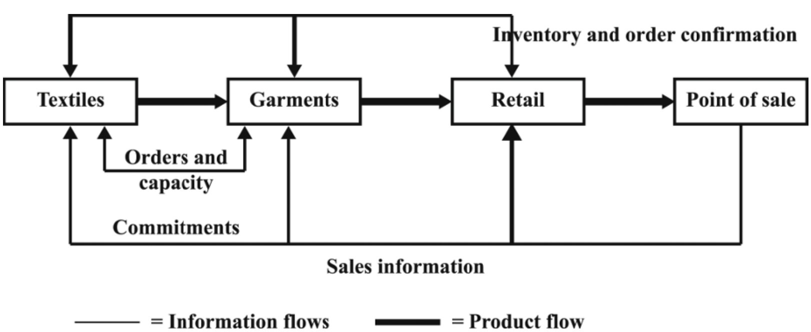

Figure 9.5. *Multisector supply chain in the textile and apparel industry*

The challenge of this scenario is to explore how all the information flows can be supported by what is called multimedia interactive communication and how this bundle of technologies impact the way collaborative business operations are conducted. The two aspects are closely interwoven.

The driving factors behind the scenario are twofold:

– exploring how a cluster of industries can integrate their operations in a seamless way by using standards based on open technologies and ensuring alignment of organizations, businesses and technologies;

– focusing on designing a flexible, scalable, robust architecture addressing immediate issues and opportunities for future evolution.

9.3.3.2. *Scenario storyline*

Cuteline is a chain of apparel retail shops selling garments for men and ladies. The trend toward greater demand for customized garments is considered by the board of directors of this company as the best way to secure a competitive advantage and to counterbalance the high-price sensitivity to which customers respond and the relational “cheating’’ taking place in this type of business.

In order to reduce costs and response times, the board of directors decided to be the leader of a project intended to set up a networked supply chain from textile mills to points of sales through the apparel industry . That means operating an Internet-based trading system revolved around a collaborative environment.

A customer comes to a point of sales to buy a “tailor-made’’ garment. The base-line process can be described in the following way:

– a fabric has to be chosen in terms of materials (wool, cotton and synthetics) and pattern; this search is made via a broker, ensuring that definite levels of quality of the products are encountered. The shop deals with a broker to secure transaction conditions (quality, delivery reliability and cost);

– an order is placed and the availability is checked. If it is not in stock or if an original pattern is chosen, it has to be manufactured. The delivery lead time is given and a quotation produced. When accepted by the client, they turn to be commitments;

– a cut style has to be decided and measurements have taken so that the garment can be cut at the right size. This phase is carried out by a tailoring company. Each tailoring company has its own domain of excellence reflected in its market image (classic, sportswear, fashion, etc.). At this stage, a broker agent acts as an intermediary between the client and the potential suppliers. A snapshot of their capabilities is provided by a catalog of products. An interactive multimedia communication channel is operated between the shop and the tailoring company when selected;

– a garment stylist discusses with the client for making his/her desires explicit. The stylist can make use of a catalog of silhouettes to help the client choose a garment style. A three-dimensional (3D) image of the client can be captured by a body scanner and transferred to the company server. Mapping the client's virtual body onto silhouettes allows us to telebuild step by step the garment the client wants. In addition, the virtual body "object'' offers him/her the possibility to see how the garment fits him/her from various points of view. When an agreement is reached, an order is placed by the client and relayed to the fabric manufacturer. A delivery due date is agreed upon.

A more detailed description featuring the main technicalities will be presented in the next section. Some key issues of the new working environment brought about by this scenario are discussed in the latter part of this section.

Change in the structure of labor division along the supply chain

This type of scenario draws attention to the role played by a new division of labor both vertically and horizontally within the cluster of textile and garments industries. Changes in both structures and decision-making processes are preconditions to the formation of a usable code of new business practices. In saying this, a crucial caveat must be considered. Given that existing structures and criteria are reflections of deeply embedded and implicit knowledge and are quite as "rational'' as any putative replacement, it seems unlikely that any change will occur through ICT revelation alone. A much more likely course of action, in fact, is one in which the development of new ways of thinking emerges slowly and painfully out of a process of organizational learning. This means that the scenario of interfirm collaboration must include, when worked out in details, the possibility of a time-phased implementation. In other words, the features and functions of a collaborative environment must take account of the fact that all stakeholders have to be able to understand the new ways of working at their own pace and are provided with the right skills.

Needing to use appropriate "beacon lights" for controlling the supply chain performance

The very presence of broker agents in the supply chain has to be explained and their role to be described. In a complex system such as the textile/garments sector, it is required for control purposes to set landmarks you can rely on to secure the overall operational performance of the system. When it becomes deviant, the controller must be able to trace back the source(s) of deviation and to take the right course of action. Each broker agent has defined assignments. When benchmarking his performance with the specifications of his mission(s) is carried out, the sources of underperformance can readily be detected. Each broker agent is in charge of monitoring the deliverables of all the resources placed upstream in the goods flow. In other words, a broker agent is a proxy of a sort responsible for his principals' deliverables.

Change in the profile of the labor force in the electronic points of sales (EPOS)

In this situation, a substantial proportion of shop assistants in points of sales is relatively unskilled. They often work part-time to complement their income. They will have to experience drastic changes in their skill profile when the described scenario is implemented because their conditions of work will be based on electronic systems. Somehow they will have to become knowledge workers of a sort. They will be exposed to Internet technology and a collaborative working environment. They should become ICT stewards for their clients in addition to giving them advice. They should receive training in the following fields:

– basic knowledge in computer and Internet technologies to give self-confidence and self-reliability;

– interacting with marketplaces (broker agents): function capabilities, browsing procedures, etc.;

– understanding how the stakeholders of the supply chain conduct and connect their operations to meet the exigencies of short-cycle production.

– converting unskilled shop assistants into ICT-skilled personnel constitutes a key factor for a successful field deployment of the scenario.

9.3.3.3. *Technical description of the scenario*

A customer wants to buy a new garment and goes to a virtual show shop. (S)he wants to choose the fabric and the cut to make his/her dreams come true.

The first step is to find the right fabric. Via a *cluster portal*, which the retailer is a member of, a choice can be made and a supplier found. The fact of having access to a "private" portal guarantees the quality of the products and the reliability of deliveries. The search can be carried out with a semantic process for securing a broad scanning of potential suppliers. But, in fact, when navigating a semantic structure, few expressions describing the search are found.

That is why specific services are offered to subscribers identified by *digital signatures*. After having keyed in his/her digital signature, the retailer gets a screen display of a list of companies and private networks able to meet the requirements. A private network is chosen. It gives access to *intermediation services*. These services are provided by a company acting as a kind of proxy for selected textile companies. They have been vetted to stand quality and reliability tests. Access is given to a knowledge base containing fabric properties (pattern, quality, price and delivery lead time). A choice is made by the customer, which completes the first step of the buying process. The fabric pattern can be sent to the customer's mail box if requested. An advanced delivery order (ADO) is sent to the textile manufacturer. By "advanced", it is meant that the delivery address (the tailor's address) is not yet known and the definite quantity is dependent on the garment cut. But this ADO can be instrumental in helping the fabric manufacturer schedule its operations.

The second step is to decide on the cut of the garment to be made. Video conferencing is a relevant interactive technique that can be used to establish a face-to-face distance communication between the client and the stylist, to capture the 3D measurements of the customer and to demonstrate the effect of choosing a specific cut on virtual mannequins generated from the client's 3D measurements. A virtual try-on is performed before the garment has come a reality. The cost price of a garment depends not only on the cost of the fabric but also, and mainly for fashion cut, on the tailor's fame. Once again, the portal technique can be usefully in demand to select a tailoring company.

The third step is to manufacture the garment from the size specifications captured by the stylist. Data pertaining to the garment design are transferred to the control system of the automated manufacturing unit. CAD data have to be converted into CAM data so that the automated manufacturing system can be run without a break in the data processing flow. The main manufacturing operations are cutting and sewing. Program-controlled equipment units for these tasks have been in use for a long time. The main issue is interconnecting CAD and CAM systems.

The fourth step is shipping and delivering the garment to the client. The garment can be sent to the client's address or to the point of sale. In any case, the client is kept informed about the delivery details by means of his/her mobile phone or e-mail box. When the delivery takes place at the point of sale, a real try-on is performed and discussions can be established by video conferencing with the stylist.

The main technologies to be made instrumental in order to turn this scenario into reality are described hereafter.

Intermediation services

By intermediation services, we mean technologies providing a centralized framework for sharing information for and about resources such as users, applications, systems and the network on the partner level. They are intended to provide facilities to enable object cooperation regardless of where they reside or what operating system they execute on.

The services should have the following capability functions:

– user information management: identity, authentication procedures, static and dynamic preferences and pieces of information to be accessed by applications;

– policies: management and security policies for resources;

– resources: metadata about shared applications and distributed databases;

– cross-sector supply network planning and control;

– methods and procedures for supply network planning (Web services, workflow processing);

– ontology-based network planning controller.

The purpose of intermediation services is to provide a single network log on, user-based security levels, personalized quality of service (PQoS), centralized management of resource configuration and efficient application development. This list can be considered as a partial description of collaborative middleware requirements.

Reduced set of CAD instructions

These instructions should mimic the way stylists think and work. By doing so, design parameters are captured and changed in a friendly user way. If this set is standardized, it could make all commercially available CAD software packages run with the same user interface. In addition, interfacing programs should be developed along this cast of thought.

CAD/CAM interfacing

The prevalent approach to seamless information flow is to prepare the program of machine control units directly from the CAD parameters. Two technologies are used for the manufacture of mechanical parts. Either the programming commands are included in the CAD-/CAM-integrated system or the CAD geometry is passed into a dedicated program to produce the appropriate commands. Considering the fact that various brands of CAD packages have to be interfaced with a variety of CAM equipment for cutting fabrics along a profile defined by a series of curves, CAD data exchange standards have to be worked out and form an important component of a specialized collaborative middleware environment.

9.3.4. *Example of a collaborative design environment*

9.3.4.1. *Context setting*

The textile industry is a sensitive economic sector in the European Union (EU). This sector was labor-intensive and the technical as well as economic changes undergone in the past decades led to a drastic slump of the workforce inducing a high unemployment level in some areas where economic activities relied mainly on textiles.

ICT offers new opportunities of collaboration between the stakeholders involved in a supply chain pattern. Everyone knows the virtues of collaboration between manufacturers and suppliers in new product development. The mantra of “early supplier involvement” has become common in a wide variety of industries. But that simple prescription will not remedy today’s product development challenges. Leading companies need more specific guidance in defining the optimal timing and integration of suppliers.

Three characteristics of supply parts that are significant from a new product development stand point can be identified:

– the degree to which consumer perceptions of the end product are influenced by the part;

– the complexity of the part’s interface with the remaining product;

– the part’s cost relative to the total cost of manufacturing the end product.

Different combinations of these characteristics lead to identify four categories of component products: critical systems, invisible subassemblies, differentiators and hidden components.

9.3.4.2. *Case study*

A car manufacturer has decided to rely on the properties of innovative technical textiles to develop a sustainable competitive advantage with respect to its competitors. These textiles will give its cars a distinctive differentiation and will be used to cover seats and decorate the inside of cars for providing a cozy atmosphere. To achieve this objective, this car manufacturer has chosen to codesign the patterns of fabrics with the fabric manufacturer and concurrently to interact with the company in charge of cutting to measure patches of fabrics and sewing them to deliver seat covers and inside decorations. Fabrics must be made up of materials which can be easily processed: that is the reason why the manufacturer of covers and decorations is involved in the design phase.

The assignment is: analyze and describe the relationship between the car manufacturer, the fabric manufacturer and the manufacturer of seat covers and decorations during the design phase.

To assist in developing the full case, Figure 9.6 portrays the messages exchanged between the various stakeholders.

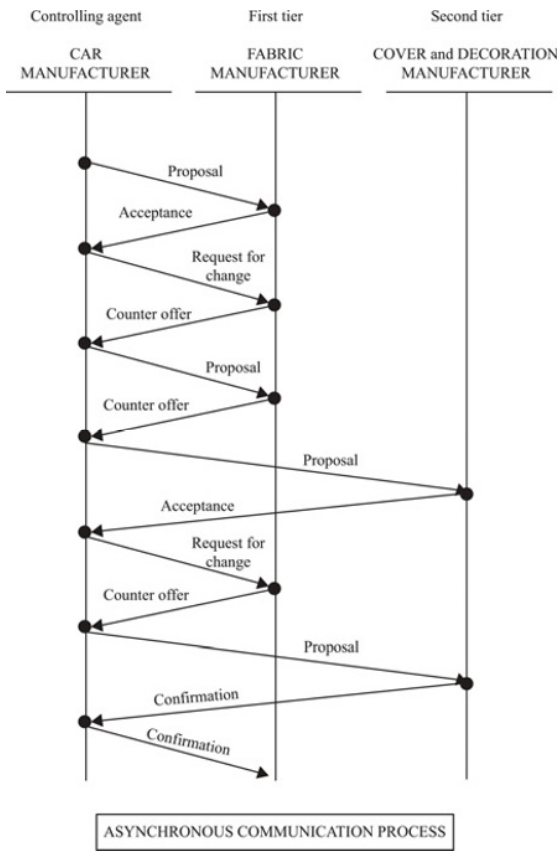

Figure 9.6. *Messages exchanged between the codesigners of car seat covers*

9.3.5. *Benefits of electronic negotiations*

Faster transaction turnaround

Although negotiation processes are asynchronous, transaction partners are aware that their messages, when sent, are quickly received by recipients. That makes reaction times shorter and the whole business runs more smoothly.

Less paperwork and savings in staff time

Sending paper reports, stock and price lists and orders is time-consuming, and as a consequence expensive. In addition, fewer errors are likely to be made as checking procedures are more easily implemented in computer software programs.

Traceability of transactions

Contents of messages can be stored so that the progress of negotiations can be memorized and key points traced back and analyzed if required.

Message standards

When using widely accepted standards, the major advantages come from facilitating the processing of contents, either automatically or manually. When exchanging design and product data, their format has to be standardized to ensure that they can be easily processed by different software programs.

Message standards have been developed at the international level for EDI. EDI stands for "electronic data interchange" (see Chapter 10). The concept of these techniques is simple: the use of direct links between computers on different sites to transmit data that would otherwise be sent in printed form. EDI is most often thought of as replacing standardized documents.

EXERCISE.–

The Business Control Model (BCM) layers for a supplier and its client are shown in Figure 9.7.

The assignment is: design the negotiation protocols at the strategic level (strategic layer of the drawing) and at the control level (control layer of the drawing).

To assist in developing the full solution, Figure 9.8 portrays the messages exchanged between a supplier and a buyer.

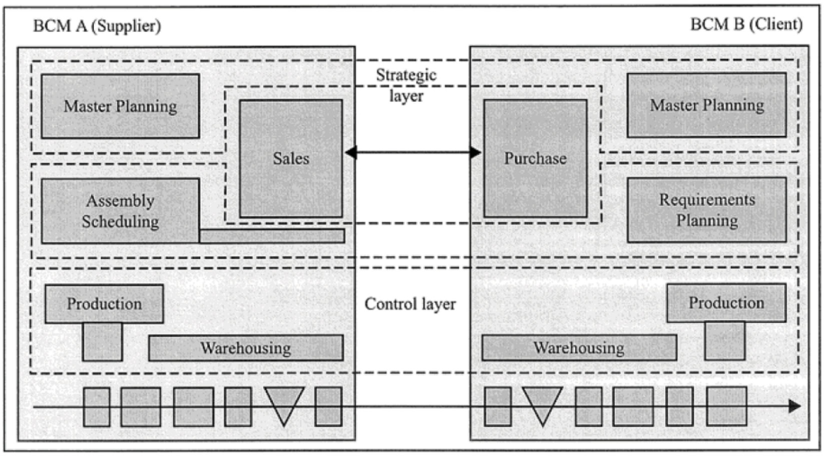

Figure 9.7. *BCM layers for a supplier and its client*

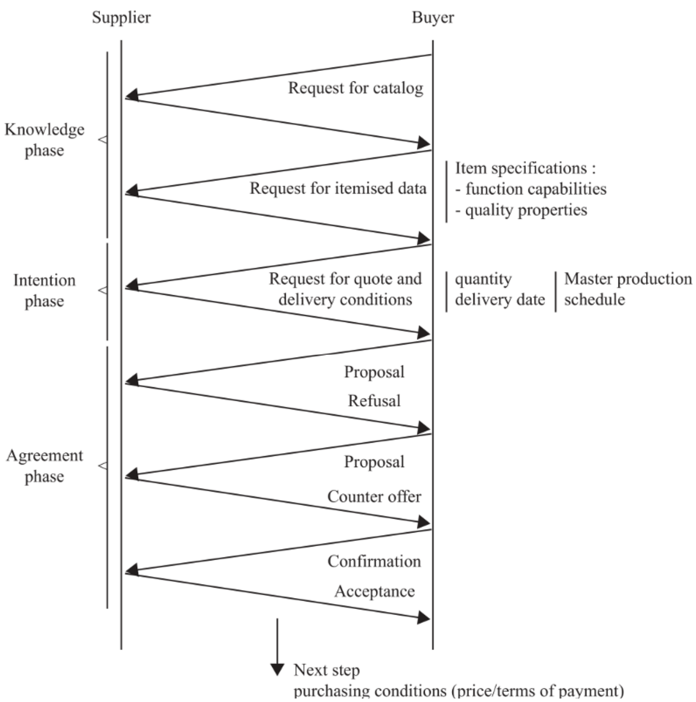

Figure 9.8. *Negotiation messages exchanged between a supplier and a buyer*

PART 4

Critical Business Functions for E-Enabled Operations Management

10

Logistics

10.1. Logistics in perspective

10.1.1. *Overview*

Logistics is closely tied up with war-making activities. The term "logistics" covers all the areas of non-combat activity.

The meaning from Greek etymology is "capability of computation". At first sight, it seems unrelated to military applications. But, a closer look at the functional description of the term "logistics" shows that it carries a lot of arithmetical operations.

The first effort to define the word with some clarity was made by Antoine-Henri Jomini (1779/1864) in his book "Summary of the Art of War" (1838). He described logistics as "the practical art of moving armies". This implies the whole range of functions involved in moving and sustaining armies. He stressed the importance of the staff activity coordinating the various functions. His views reflected the Napoleon's views, by which logistics was the science of generals and general staff.

The Prussian theorist von Clausewitz did not share Jomini's approach to logistics which he considered as ancillary services.

In the late 1880s, the American naval historian A.T. Mahan introduced logistics into the theory of sea warfare. In 1917, a U.S. marine officer

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Lt Col. C. Thorpe published his book "Pure Logistics". He broadened the conception of logistics to encompass the traditional functions of supply and transportation as well as industrial mobilization and the war economy (finance, ship building, munitions manufacture, etc.).

The latest effort to produce a theory of logistics was carried out by H.E. Eccles (a retired U.S. rear admiral) whose book "Logistics in the National Defence" was published in 1959. ECCLE's conceptual framework of logistics has two main features:

– logistics is the military element in the nation's economy, and the economic element in its military operations;

– logistics is embedded in a network of interdependent courses of actions (strategy, tactics, intelligence and communication).

10.1.2. *Components of logistics*

Four basic elements or components are distinguished in logistics:

– supply;

– transportation;

– facilities;

– services.

All these activities are supposed to be managed to properly balance supply and demand. Materials needed are either consumed or used and serve the purposes of living or moving or fighting or communicating.

10.1.2.1. *Supply*

The supply process includes all the stages up to purchasing (design – development –manufacture) and "in-the-service" phases (procurement, storage, distribution, maintenance, repair, salvage and disposal).

10.1.2.2. *Transportation*

Transportation is a major link in the chained services of logistics. Up to the mid-19th Century, seas and rivers were safer routes than roads. After this time, water transportation began to be substituted for by railways on land.

In the 21st Century, combined transportation by air and road has become the mechanized means used by technologically advanced armies to meet their requirements in the movement of troops on land.

10.1.2.3. *Facilities*

Modern armed forces own and operate a wide variety of infrastructure installations from barracks, homes and hospitals to airports, arsenals, factories and warehouses.

10.1.2.4. *Services*

Services may be defined as activities designed to enable personnel or material to perform more effectively and more efficiently. Distinction is blurred between logistics and non-logistics services. A number of activities in armed forces of advanced modern nations are assigned to "combat support" (supply, transportation, hospitalization, military justice, discipline, custody of prisoners, etc.).

10.1.3. *Logistics and the digital economy*

10.1.3.1. *Introductory remarks*

Enhanced communication facilities in terms of information as well as transportation have fostered the physical dissemination of economic activities. Up to the middle of the 19th Century, economic activities in developed countries were mainly concentrated around the sources of energy (coal and hydraulics) and ore fields (iron and aluminum). The development of highway schemes and drastically improved automotive means of transportation (automobiles, railways and planes) has allowed a different pattern of activities for being spatially deployed and, as a result, a better balanced geographical dissemination of economic activities. This trend was re-enforced during the last decades of the previous century when an unprecedented thrust in information and communication technology (ICT) and especially telecommunications was experienced. This situation has nurtured a networked economic world. The needs of physical linkage of widely distributed economic agents emerged and the attention of business management became focused on logistics as a function bringing under control transportation, handling and warehousing of goods. Furthermore, logistics has evolved as an economic sector in itself and proves by now to be a key factor of world economies.

10.1.3.2. *Virtual communities: the home stretch of the global digital economy?*

The virtual communities that want to operate effectively and efficiently involve the aggregation within an Internet portal of relevant content and services for defined groups of users, meeting their real needs and interests, and thereby drawing them together into an identifiable community favorably disposed to the particular portal provider and its brand values. Content and services possessing these "sticky" attributes are important whether the community under consideration is *vertical,* i.e. related to a specific market segment, or *horizontal,* i.e. related to a specific interest cutting across various market sectors. For example, eSteel.com has developed a trading community for steel producers.

It can be figured out that the Internet-based communities hosted by servers will emerge on a worldwide scale. These communities could gain a position to by-pass existing distribution channels. Small retail outlets were badly hit by supermarkets that expended tremendous efforts on price cutting by striking advantageous deals with suppliers through procurement pools. These supermarket companies might have to be worried now. The electronic marketplace and especially virtual communities might drastically change the balance of power in favor of customers – not only by fostering new trading structures but also by facilitating the dissemination of information for comparing product/service functions and prices on a world-wide basis. This is why large European distribution firms, such as Tesco (UK), Metro AG (D), Ahold (NL), Carrefour (F), Pryca-Centros Comer (SP), Sainburys (UK) and Marks & Spencers (UK), are organizing Websites to establish brand values and customer loyalty by web-enabling their customer relationships.

There will be a growing buzz around the actual usefulness of the incumbent intermediary players between suppliers and customers. Customers through virtual communities are likely to become web-empowered economic actors directly dealing with goods suppliers located around the world. If this happens, not only the way businesses are conducted but also the whole economic system will be changed.

The ways and means of how intermediation between suppliers and customers is structured and implemented already undergoes a drastic upheaval: e-commerce and e-business are forceful spearheads driving relentless changes in logistics networks.

10.2. Logistics and hierarchical layers of management within the framework of supply chain management

10.2.1. *General context*

Logistics must no longer be considered as a mere group of operational activities because they govern the movements of goods inside and between companies up to customers. The increase in physical transfers fostered by developing means of transportation and (tele)communication has allowed for globalization of supply and demand markets and emerging new forms of business organization (networked businesses).

The Japanese offering of diversified and customized industrial products induced an evolution in industrial patterns by reallocating divisions of activities. This has resulted in mass manufacturing of components turned into customized end products by specialized firms. Today, mass manufacturing refers to components instead of end products as was manifested in the period between the two world wars: chain manufacturing of one-type cars symbolized this situation.

Bringing logistics activities under full control has become a critical success factor in a global market for enhancing the firm's performances in terms of product cost and quality and customer service. Webshops have brought the importance of logistics to a climax.

Logistics must be clearly identified as a management layer located between tactics and operations as shown in Figure 10.1.

Figure 10.1. *Layered architecture of business management*

> The logistics function is in charge of managing physical transfers {transportation, warehousing and handling} between operations along the firm's flow of goods/services from suppliers to customers.
>
> Its performance capability has a direct impact on the firm's strategy and tactics.
>
> Conversely, strategy and tactics determine how logistics is organized.

A more operational definition can be given: logistics is the timely provisioning of materials (spare parts, equipment units, components and goods) and/or manpower and/or facilities.

The concept of supply chain management has been described in Chapter 2 as an integrated approach to planning and controlling the whole goods flow through a network of suppliers, factory sites, warehouses, distribution centers and retailers to end users. The emphasis is shifted from managing materials supply to satisfying customer demand: pull from push and demand from supply. Logistics plays a key role in the supply and distribution processes.

When transactions with suppliers and clients are electronically (paperless) carried out, the supply process is called by software vendors e-procurement and the sales process is called by web-based customer relationship management (CRM). Within this framework, stringent constraints are put on logistics activities because deliveries are committed to be performed within specified time periods.

The three main business areas concerned by logistics (i.e. deliveries from suppliers (supply logistics); physical distribution customers (distribution logistics); and support to in-house operations such as maintenance and administration (support logistics)) can be enabled by software tools as shown in Figure 10.2.

The issue of logistics in business planning and control has become unavoidable in a collaborative working environment. Logistics is the function securing seamless synchronized operations of all the stakeholders along the supply chain from suppliers to clients. When a logistics operation fails along the chain, its output is disrupted and commitments cannot be fulfilled.

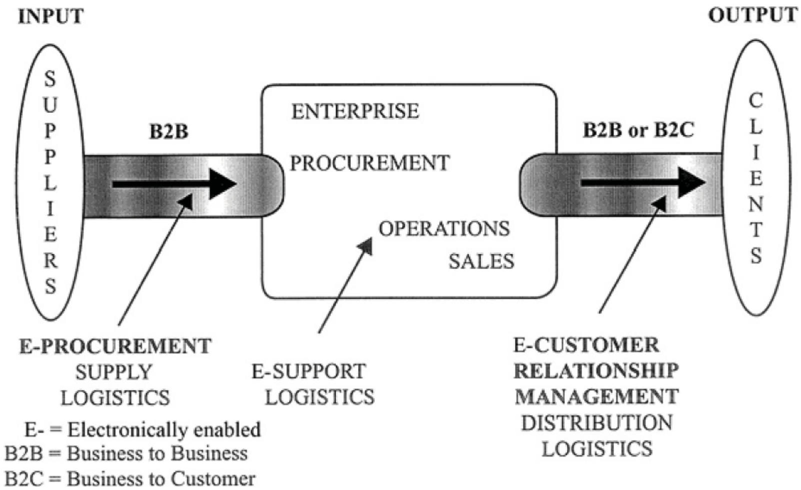

Figure 10.2. *Logistic activities taking place upstream, inside and downstream an enterprise*

10.2.2. *Promotion of logistics strategy by Toshiba of Japan*

Toshiba's strategic approach of market globalization relies upon promotion of logistics strategy.

Logistics is viewed by Toshiba as a key factor in implementing a global business. It sees its operations as forming more of a network linking equals, with Tokyo as an important center, but not the only one. It expects an erosion of political borders.

Toshiba decided to use logistics as a managerial tool to cope with borderless operations. Logistics has a double meaning for Toshiba. First, logistics is understood as an innovation in management in order to foster communication and, as a result, collaboration between all people involved in meeting input on needs from sales people. Second, it also explains the steps taken to establish a management system aiming at controlling resources at its disposal:

– *by optimizing global production*

Products which are international in nature are manufactured for the world market at whatever place best ensures international competitiveness.

Products meeting specific local needs and demands are to be developed, manufactured and sold within the relevant local markets.

– *by diversifying procurement*

When possible, greater local procurement by overseas production bases is encouraged. International procurement offices (IPOs) have been set up in nine locations around the world to detect the best products available in the world market.

– *by clinching strategic alliances*

The basic conduct toward alliances is reliant on the three “Cs” that underpin successful relations: competition, cooperation and complementarity.

Alliances are attractive for a number of reasons. The cross-fertilization, the dynamic pace and vast extent of modern technologies, which have to be incorporated into new products, push to co-operation between companies, thereby making them able to challenge competitors in the market place.

– *by controlling resources*

Toshiba wants to be prompt in incorporating market needs into its products. Compliance with this requirement assumes that Toshiba has brought all its resources under full control, and is in a position to make the best use of their capabilities for establishing its predominance ahead of the pack, and overcoming severe competition.

Figure 10.3 shows Toshiba’s logistics strategy in a stylized way.

10.3. Information system for e-logistics

10.3.1. *Introduction*

It is vital for any organization to have a relevant business control system available. The prime tasks of such a system are to ensure that the correlated flows of goods, money and information are carefully and coherently monitored. In addition, it should provide comprehensive support facilities to help all management levels in decision-making processes in the areas of marketing, logistics, finance, manufacturing (if any) and management accounting.

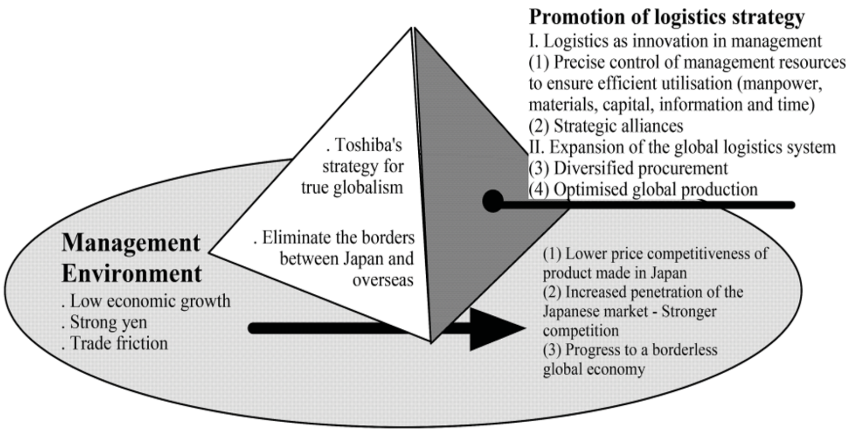

Figure 10.3. *Stylized representation of Toshiba's logistics strategy (source: adapted from Financial Times – June 27, 1994)*

In operation, the business information system is supposed to take over the routine business procedures so that, at a supervisory level, attention can be focused on variances and special situations. An integrated information structure is highly advisable; this is featured by a database allowing for master data to be shared by a wide range of data users.

In order to meet the required variety of information need, in the most logical and simplest way, the business information system has to be split up into component parts. It can be conveniently broken down into five parts as found in software packages:

– goods movement control system:

- order management and goods movement registration,

- physical distribution,

- purchasing,

- purchase invoice handling,

- invoicing;

– financial planning and control system:
  - project accounting;
  - automatic journalizing;
  - general ledger.
– financial movement control system:
  - accounts receivable;
  - accounts payable.
– product/customer planning and control:
  - inventory control;
  - product/customer planning and control.
– office communication and control system.

Only the goods movement control components and inventory control component will be detailed later on. The important technical tool electronic data interchange (EDI) will be described as an example of electronic communication between computer systems without human intervention.

10.3.2. *Goods movement control system and its components from the customer side*

10.3.2.1. *Goods movement registration*

The *Goods Movement Registration* component is intended to provide a fast and efficient means of registering customer orders and scheduling their fulfillment for an organization supplying from existing, or planned available stock. It has to be designed to operate in a multi-company/multi-division environment and should comprise the *Order Management*, *Inventory* and *Physical Distribution* components. As an integrated system, these three components cover the servicing of customer orders from the initial receipt of the order, up to the shipping of the goods and the creation of the invoice.

10.3.2.2. *Order management*

Through the *Order Management* component, the sales department must be able to obtain information on stock availability – what is available now, and what will be available in the future. And it should be possible to evaluate orders, taking into account customer pricing conditions or input prices and conditions, and to prepare orders for physical distribution and invoicing. In addition, the *Order Management* component should be capable of identifying exceptional situations such as credit or gross margin exceptions. Furthermore, it should be able to control back orders and forward orders, and to monitor their release. In short, it must provide all the necessary information for handling and controlling orders and for responding to customer questions.

10.3.2.3. *Inventory control of end products*

The prime objective of the *Inventory Control* component is to control stock so that an optimum balance between customer service and inventory investments can be achieved. The component provides a number of functions to assist in achieving this aim.

One of these functions is the determination of seasonality of demand. This can be assessed by calculating the annual distribution through a comparison of monthly demand against an average month. A further function is that of forecasting future demand. This is arrived at by using the current demand over a given period against the last forecast for the same time. The new forecast acts as the basis for a replenishment calculation. This involves the calculation of stock norms via the extrapolation of the new forecast over required periods of time. The basis of results is achieved either with a fixed or a variable interval forecast. The aim of the calculation of the norms is to automatically carry out reviews, by comparing economic stock with calculated stock norms, in order to activate the provisioning functions (manufacturing in the case of a manufacturing company or purchasing in the case of a distribution company). Branch replenishment is also possible, and the component advises on restocking of branches via a main warehouse if the branch is dependent upon the latter's situation. This can also be carried out by establishing a branch replenishment routine. An additional important function which the component offers is simulation. It involves the evaluation of policy alternatives in the real-time environment, based upon real stored data and its own input data.

A further advantage of the *Inventory Control* component is that it can take the initiative to replenish, or alternatively evaluate replenishment decisions taken elsewhere. To achieve an effective operation, the *Inventory Control* component interacts with other components, such as manufacturing or purchasing. This enables supplier orders and commitments to be automatically registered if desired.

Inventory Control gives the user a powerful tool for replenishing most articles automatically. This frees him/her to concentrate on those critical items requiring human intervention, so that more effective use is made of available manpower.

The variables used for controlling inventory are those presented in Chapter 7, i.e. projected available balance (PAB), available to promise (ATP) and capable to promise (CAP).

10.3.2.4. *Physical distribution*

With an efficient physical distribution system, any organization's costs can be considerably reduced. This can mean a more profitable operation through the ability to be more competitive. The *Physical Distribution* component should offer the user the ability to plan and control the arrangement of physical transportation and at the same time, reduce the number of small deliveries. This is achieved by the system's process of gathering goods movements onto one delivery note during printout. The logical and cost-effective planning of delivery services is further assisted by the delivery notes being printed in various ways: by geographical area, by group of geographical areas, by customer and by order. The system is further refined by the printout of the picking list being sorted by location: either by an individual or by a run of delivery notes. In addition, facilities are provided which enable confirmation of dispatch, picking and delivery.

Vehicle routing efficiency can be improved, as the system can provide a map showing the delivery sequence within a given area. A further advantage of this map is that it also gives store and warehouse personnel bills of lading for each vehicle. In the case of picking differences or changes in the means of transport, the user can recall and modify delivery notes as necessary, reprint them or even cancel them. Where unusual situations arise, signals are created to alert those responsible for action. These include online invoicing and the grouping of invoices per shipments. In addition, export documents can be handled and printed out such as customs documentation, etc.

With such extensive features and facilities offered by the *Physical Distribution* component, it is possible to achieve a multi-company, multi-division operation that is independent of the commercial organization. In addition, as it is a table-driven system, the storage and physical distribution operation can be changed as required, simply and quickly. The component also provides the necessary tools for progress control and planning operations. And its built-in functions ensure that the elements in a storage/handling/distribution operation are optimized.

Figure 10.4 outlines the main functional steps of customer order fulfillment hinging on the pivotal inventory component.

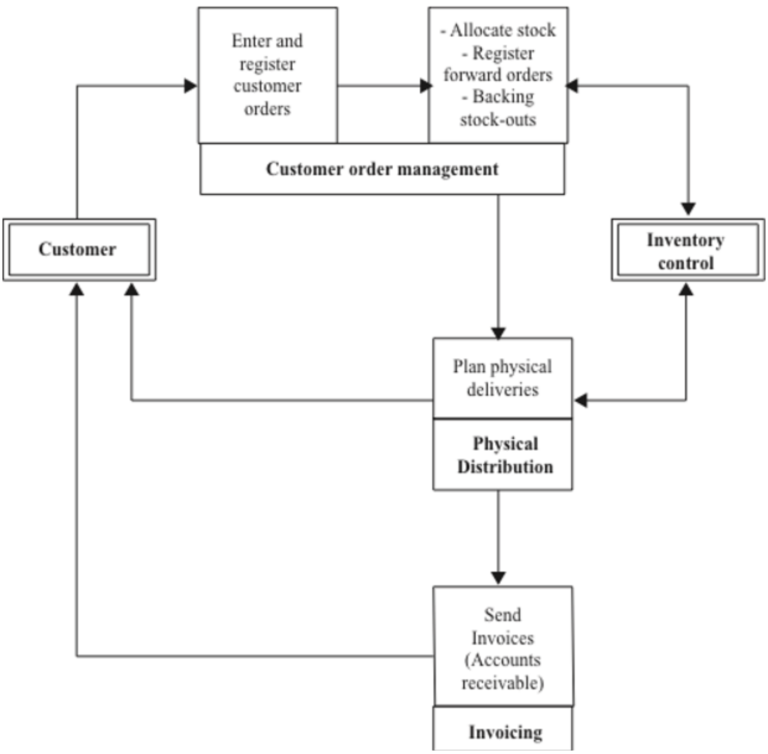

Figure 10.4. *Main steps of customer order fulfillment*

10.3.3. *Goods movement control system and its components from the provisioning side*

10.3.3.1. *Provisioning*

The *Provisioning* component takes care of all necessary registration, maintenance and processing of orders placed by commercial divisions with their providers[1]. The orders themselves are created nowadays in real time via a server.

Greater versatility of operation is assisted by the component's capability of linking with external operations, and its integrated functioning with the other components of the business information system. Via a data link, the component permits the user to communicate directly with a provider for sending delivery orders, receiving providers' confirmation, sending updates on orders and receiving pre-shipment information, etc. It also maintains dialogue with the *Inventory Control* component. This permits the automatic creation of orders for routine replenishments, or it advises when manual registration of orders is necessary, via the creation of special messages.

Greater efficiency is obtained through the link of the *Provisioning* component to that of *Order Management* and via the *Inventory Control* component. This is because the system has the additional benefit of providing up-to-date indications of order quantities and anticipated receipts which can be related to future commitments (forward orders). In this way, it is even possible to carry out availability checks against probable orders and receipts over short or long periods in advance, and register provider delivery schedules into the system. In addition, replenishment orders for direct deliveries and trans-shipments can be created automatically. The integration with the *Supply Invoice Handling* component enables straightforward processing of goods receipts and supplier invoices. The use of the supply system makes it possible to check the authorization of goods receipt notes and invoices against the purchase file. Any discrepancies are automatically noted.

Throughout every stage in the provisioning order processing chain, the system constantly monitors what is going on. Any exceptions or deviations to what is normally expected are immediately signaled. Consequently, the planner can forget about the more routine work, and concentrate upon unusual and specialized situations. This allows more efficient use of manpower and more effective control of the ordering and processing of incoming goods.

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1 The term "provider" covers both in-house suppliers and outside suppliers to a provisioning department. When the term "supply" is used, it refers to outside suppliers in our context.

10.3.3.2. *Supply invoice handling*

The control of invoices is improved and simplified by checking the authorization of invoices against the supply[2] entry file and the goods receipt file. Prices and quantities are compared, and any deviations are signaled to the persons responsible. Cost invoices can also be handled. And the overall result is increased accuracy and reduced clerical work.

The system comprises two basic transactions: registration of the incoming invoice and the goods receipt. These two items are deliberately kept separate, as different situations can arise if the invoice arrives either before or after the goods, or if they accompany each other.

When the two documents arrive at different times, the component carries out registration of the second using the information contained in the one which is already in the system. This is a particular advantage for administrative personnel, as it cuts out a lot of unnecessary duplication of paperwork. The component also provides the added advantage of enabling invoice registration using automatic readable input.

If the invoice and goods receipts are registered separately, the system offers a lot of support in matching related lines. Should the quantities not tally, the lines can be split to arrive at ones with identical quantities. As soon as invoices are registered, they are linked to accounts payable, with the status “awaiting authorization by Supply Invoice Handling”. This enables the precise level of an outstanding debt (whether authorized or not-yet-authorized), to be seen in accounts payable. In addition, all relevant information on invoices and goods receipts is transferred to general ledger, both at the registration and the final authorization moment, to ensure that book-keeping is always up-to-date.

When the goods have been received, and provided that there are no unauthorized deviations in quantities and/or prices, the invoices are authorized for payment. They are then linked to accounts payable ready for payment.

Through the *Supply Invoice Handling* component, the control of deliveries, and their invoices, can be greatly improved.

2 Recall that the term “supply” refers to outside providers that have to be paid.

Figure 10.5 portrays the relationships between the *Customer Order Management*, *Inventory Control* and *Provisioning* components of the logistics information system. It shows the central role played by the *Inventory Control* component.

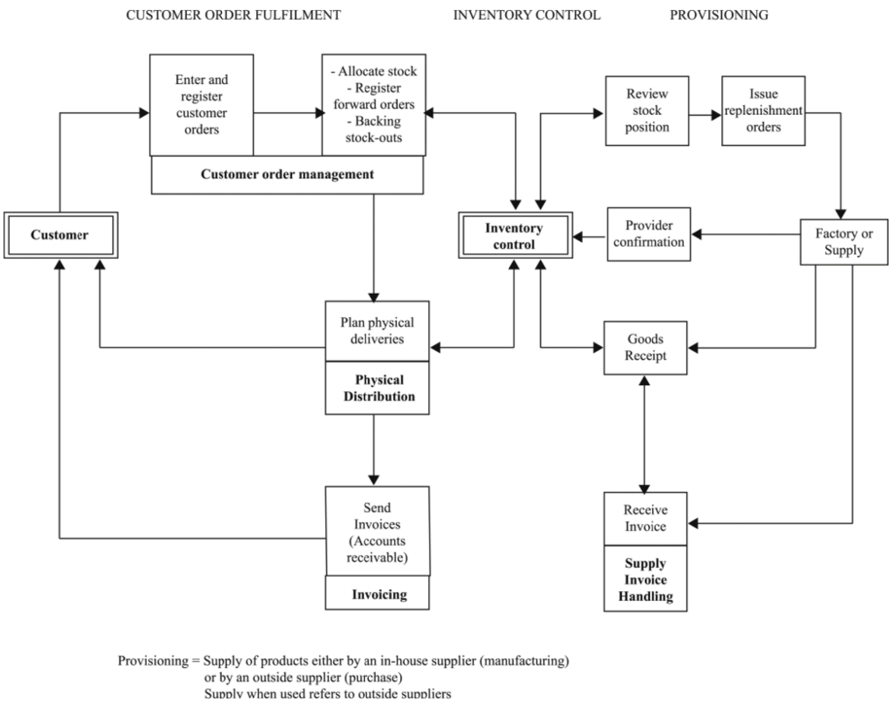

Figure 10.5. *Linkages between components of the business information system*

10.3.4. *Electronic data interchange*

10.3.4.1. *EDI definition*

EDI is a method of doing business and carrying out transactions electronically. Documents are exchanged between computer systems via a transmission medium in predefined electronic formats agreed upon by the trading partners. EDI covers most of the things that might normally be done by paper communication. This includes placing orders with suppliers, transmitting instructions to clients, distributing official documents and carrying out financial transactions. EDI has the potential to affect all business operations.

10.3.4.2. *EDI process*

The purpose of an EDI system is to pass data from one computer system to another. It does this in a number of stages. Typically, an EDI system will:

– take the output from some process on one trading partner's computer (such as an inventory check or a design step), and determine what data need to be sent to the other partner via the EDI system;

– format the data into messages according to the requirements and protocols of the EDI system;

– connect to a central computer system (the "EDI bureau"), owned by the company or a third-party, and carry out any security checks;

– send the messages to the EDI bureau. These are then stored in a "mailbox" for the destination computer, possibly after some further format conversion.

Once stored at the EDI bureau, the rest of the process works as follows:

– the other computer calls the EDI bureau and, after carrying out similar security checks, fetches the messages;

– the messages are decoded and the data stored in a form that can be used by the next process in the chain.

Throughout this procedure, accounting processes and audit trails are maintained. Additionally, there will often be control processes in both trading partners' computers to start off the EDI functions and to pass messages to and from other parts of the computer system.

Figure 10.6 describes the unfolding of an order placement process.

10.3.4.3. *Aims of EDI in the basic goods movements information*

The aims of an EDI are to:

1) accelerate information exchange;

2) integrate with accounting;

3) give reliable and error-free information transfer;

4) integrate easily with automated data-processing systems;

5) reduce clerical workload;

6) provide a tool for control of goods in the pipeline;

7) improve internal procedures;

8) provide uniformity in trade procedures.

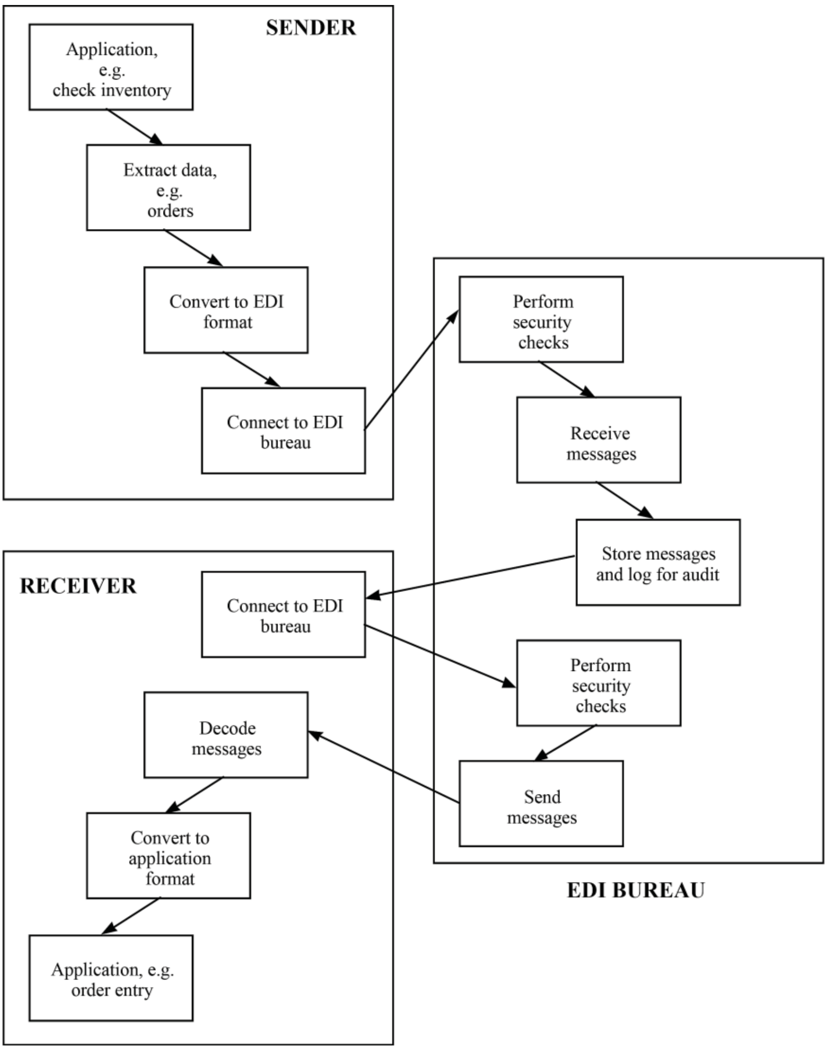

Figure 10.6. *The unfolding of an order placement process*

10.3.4.4. *Accelerate information exchange*

Most of the information about goods movement is written on hard copy documents which physically accompany the goods. Consequently, most of the clerical handling can only begin after the goods arrive. The shipment confirmation messages give goods movement information in advance. Clerical handling can be prepared before the goods physically arrive, for example customs clearance, goods receipt or customer information.

10.3.4.5. *Integration with accounting*

With regard to intercompany shipments, the most important functions of the shipment confirmation messages are as mentioned in the previous section.

Nevertheless, bearing in mind the principles of internal control, it is also necessary to integrate other functions related to shipments, with the implementation of the shipment confirmation messages. Especially the accounting function (stock registration and updating current account) also has to be effected based on the shipment confirmation messages as well on the receiver's side (invoice-to function) as in the sending organization (invoice-from function).

10.3.4.6. *Reliable and error-free information transfer*

Nowadays, most of the information about international goods movements is still given via a hard copy invoice. The invoice information is used for data entry at the receiver's side. Manual input errors can be made, for example false interpretation of the invoice (due to unreadable copies of invoices). When data transmission is used, automatic, reliable and error-free data entry is possible.

10.3.4.7. *Easy integration with automated data-processing systems*

In the past, every supplier developed his/her own system for invoicing. These developments were dependent on the existing order and/or planning systems. Also, receivers have developed their own systems for invoice handling and used the hard copy invoice for manual input into their system. Nowadays, the invoice contains approximately 90% of all required information about international goods movements. In communication via standard messages, it is essential that the different kinds of data-processing systems used for handling the information flows associated with goods movements can be linked.

10.3.4.8. *Reduced clerical workload*

Today, data entry in most systems is done manually. Using shipment confirmation messages, data transfer is done system-to-system and manual data entry is no longer required.

10.3.4.9. *Tool for control of goods in the pipeline*

In large companies, it is obvious that there is an enormous amount invested in goods in the pipeline. In most cases, the receiver (who is responsible for the stock in the pipeline) does not know where the goods are until they arrive at his/her premises. The shipment confirmation messages, sent the moment the goods are shipped, give the receiver information about the dispatch date of the shipment. This information can be used, for example, for pipeline control.

10.3.4.10. *Improvement of internal procedures*

The implementation of EDI has to be organized carefully because it affects a great number of activities. Several checklists have been made to ensure that all activities are covered. Experience has shown that in-going through these checklists a lot of "historical" activities can be avoided because they are no longer required or have been replaced or integrated. Using EDI demands clear and well-defined procedures which reduce the chances for redundant activities.

10.3.4.11. *Uniformity in trade procedures*

Worldwide, on an international level, trade procedures are the subject of studies about standardization. In many countries, simplification of trade procedures (SITPROs) organizations exist which are composed of representatives of governments, branch organizations and companies.

10.3.4.12. *EDI standards*

EDI networks could not operate without the existence of standards to govern the way in which data are transmitted from one trading partner to another.

EDI standards define the techniques for structuring data into the electronic message equivalents of paper-based documents. They define the acceptable content of messages and the codes used to describe EDI entries. Once these rules have been defined and ratified as standards, users can develop EDI messages appropriate to their needs. EDI standards cover five interrelated areas:

– messages;

– segments;

– data elements;

– syntax;

– message design guidelines.

An EDI message, also known as a transaction set, is the equivalent of a paper document, such as an invoice or purchase order, which requests an action on the part of the recipient. EDI messages are compiled from standardized interchangeable elements called segments. Segments relate to specific objects or entities within the message. They are the rough equivalent to the fields of a database record. Examples are name, address, delivery location, product number and type of product. Segments consist of strings of data elements which are the vocabulary of EDI and the smallest item of information in an EDI message. Typical data elements are postal and zip codes, loading bay numbers and quantities of items to be ordered.

EDI syntax defines the grammatically correct ways of combining the data elements and segments in messages. For EDI transactions to run efficiently, codes are used to identify products and locations. They are more accurate than descriptions and overcome international language barriers.

Message design guidelines give directions on how to build messages to answer the particular business needs within a given industry.

There are several standards currently being used in EDI transactions. Unfortunately, no single set of universal EDI standards as yet exists to handle all of the different types of transactions required by businesses and organizations around the world. There have been a number of important advances toward the development of international standards, however, and the UN-sponsored EDI standard Electronic Data Interchange for

Administration, Commerce and Transportation (EDIFACT) continues to gain ground.

LIST OF EDIFACT MESSAGES

COMMERCE

INVOIC	Invoice
ORDERS	Purchase order
DELFOR	Delivery schedule
DELJIT	Just in time delivery
DESADV	Dispatch advice
ORDCHG	Purchase order change message
ORDRSP	Purchase order response
PARTIN	Party information
PRICAT	Price sales-catalog
QALITY	Quality data
QUOTES	Quote
REQOTE	Request for quote
STATAC	Statement of account
INVRPT	Inventory report
SLSRPT	Sales data report
PRODEX	Product exchange
RECADV	Receiving advice
SLSFCT	Sales forecast

CUSTOMS

CUSCAR	Customs cargo report
CUSDEC	Customs declaration

CUSREP	Customs conveyance report
CUSRES	Customs response
CUSEXP	Customs express consignment declaration
PAXLST	Passenger list

EMPLOYMENT

JAPRES	Job application result
JINFDE	Job information demand
JOBAPP	Job application proposal
JOBCON	Job offer confirmation
JOBMOD	Job offer modification message
WKGRDC	Work grant decision
WKGRRE	Work grant request

SERVICE

DIRDEF	EDIFACT directory definition
FUNACK	Secure functional acknowledgment

FINANCE

CREADV	Credit advice
CREEXT	Extended credit advice
DEBADV	Debit advice
PAYEXT	Extended payment order
PAYORD	Payment order
REMADV	Remittance advice
DOCAPP	Documentary credit application
BANSTA	Banking service

DIRDEB	Direct debit
DOCADV	Advice of a documentary credit
DOCINF	Documentary credit issuance information
PAYDUC	Payroll deductions advice
PAYMUL	Multiple payment order

TRANSPORTATION

IFTMAN	Arrival advice
IFTMBC	Booking confirmation
IFTMBF	Firm booking
IFTMBP	Provisional booking
IFTMCS	Instruction contract status
IFTMFR	Framework
IFTMIN	Instruction
BAPLIE	Bayplan, occupied and empty location
BAPLTE	Bayplan, total numbers transport
IFCSUM	International forwarding and consolidation summary
CALINF	Call information
COARRI	Container arrival
CODEPA	Container departure
CCOVLA	Container overland
COPDEM	Container predeparture instructions with guidelines
COPRAR	Container prearrival message
COPRDP	Containers predeparture
COSHLA	Container shortlanded
IFTSTA	International multimodal status report

VESDEP	Vessel departure
IFDTGM	Dangerous goods notification
IFTFCC	International freight costs and other charges
ITRGRP	In transit report group
ITRRPT	In transit report detail
MOVINS	Stowage instruction
COACOR	Container acceptance order
COARCO	Container arrival confirmation
COARIN	Container arrival information
COARNO	Container arrival notice
CODECO	Container departure confirmation
CODENO	Container customs documents expiration notice
COEDOR	Empty container disposition order
COHAOR	Container handling order
COITON	Inland container transport order notice
COITOR	Inland container transport order
COITOS	Inland container transport response
COITSR	Inland container transport space
COPARN	Container pre-arrival notice
COPINF	Container pick-up information
COPINO	Container pick-up notice
COREOR	Container release order
COSTCO	Container stuffing confirmation
COSTOR	Container stuffing order
DESTIM	Equipment damage, repair estimate message
GATEAC	Gate and intermodal ramp activities
REACTR	Equipment reservation, release, acceptance and termination

10.4. Logistics flow process management: logistics performance indicators

In order to let the firm's management verify whether the implementation of a planned action is in fact realizing the targets set, the control cycle must include performance measurements that cover the physical operations of the logistic chain. The information they provide should be quantitative and must make managers able to trigger diagnosis when it is relevant. The measurements should be simple to be carried out, their interpretation easily worked out and understood, and clearly reported. Interdependence of the various activities along the logistic chain should be taken into account to derive purposeful indicators. What is required for an integral control of the goods flow is a comprehensive but limited set of logistics key performance indicator (PIs) providing feed-back on the progress of logistic activities.

10.4.1. *Definition*

A PI is a variable indicating the effectiveness and/or efficiency of a part or whole of the process under consideration against given standards/plans. It is determined on the basis of measurements recorded during a well-defined time period.

It must be pointed out that the PIs do not themselves identify a problem or its source. Their sole purpose is to compare actual results with a pre-set target and to show the extent of any deviation. They are used to help pinpoint where an investigation should be carried out.

10.4.2. *Logistics key indicators*

The indicators relevant to the goods flow of a distribution company are shown in Figures 10.7 and 10.8. Two configurational patterns are considered.

Figure 10.7 refers to an organization with central warehousing and Figure 10.8 refers to direct supply to local warehouses.

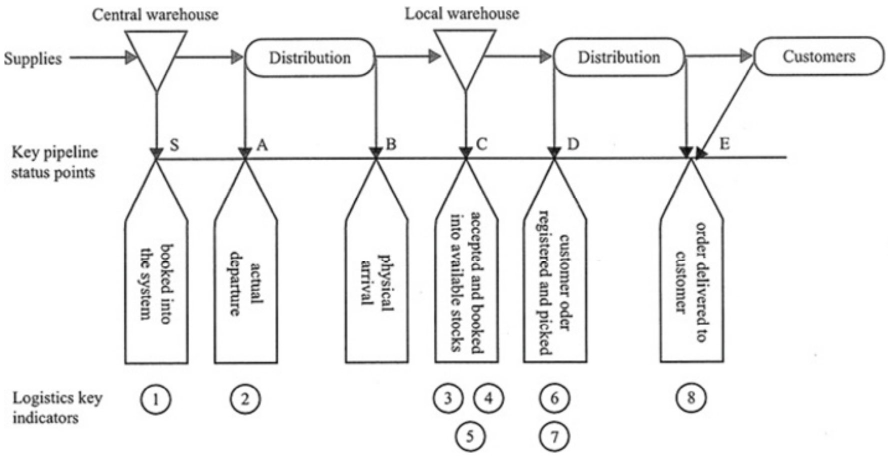

Figure 10.7. *Performance indicators for a distribution channel with central warehousing*

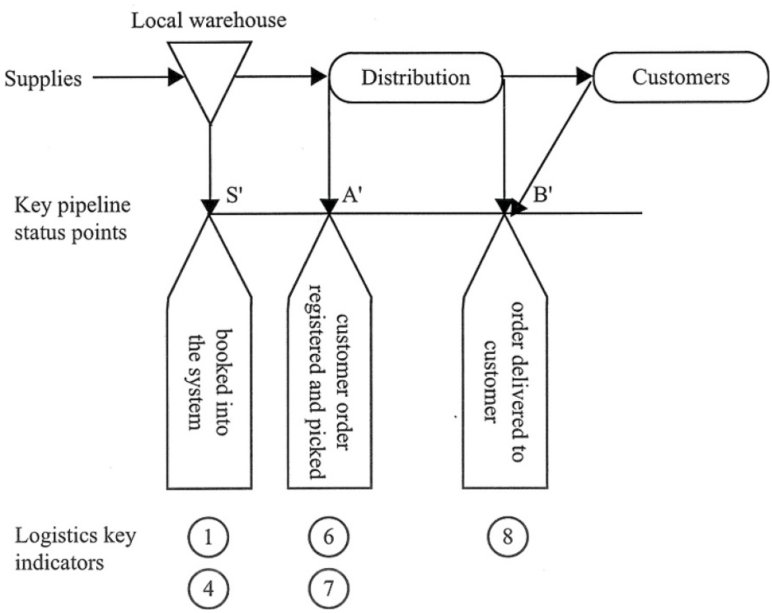

Figure 10.8. *Performance indicators for a direct distribution channel*

Depending on the types of goods and the nature of customers (internal or external), one or another system can be implemented on the basis of costs/customer service-level benefits. The two systems can co-exist: some goods transit through a central warehouse before being dispatched to local warehouses, some goods are directly delivered to local warehouses.

10.4.3. *Definitions of logistics key indicators*

Logistics key PIs are derived from measurements within a certain period of time.

1) *Supplier delivery reliability*

1-a line item supplies

$$PI = \frac{\textit{Number of order lines delivered complete on due time}}{\textit{Total number of order lines committed in purchasing orders}}$$

1-b supply lead times

2)–3) *Pipeline time*

Percentage of shipments received or forwarded by time buckets within or outside due dates.

4) *Stocks level*

Inventory on hand measured in quantity demanded per time bucket.

If a software package is used, more detailed data can be derived.

5) *Supply reliability*

$$PI = \frac{\textit{Number of lines - items delivered complete on due time}}{\textit{Total number of lines - items committed in delivery orders}}$$

6) *Customer service level*

$$PI = \frac{\textit{Number of services customer orders}}{\textit{Number of registered customer orders}}$$

7) *Customer supply planning reliability*

$$PI = \frac{\textit{Actual supplied quantities when commitment time is reached}}{\textit{Rolling supply plan target used to compute commitment}}$$

8) *Order cycle time*

$$PI = \frac{\textit{Number of deliveries within standard time}}{\textit{Total number of deliveries}}$$

10.5. Location analysis of warehouses and transportation

Firms are faced with the task of locating warehousing facilities to meet customers' requirements at the lowest cost.

The selection of warehousing sites is influenced by many factors and results from a sequence of decisions. The principal factors which are of importance in the decision-making process can be summarized as four sets of factors:

– supply (movement/transport of items from suppliers to customers);

– service (need to provide easy access to customers);

– non-quantitative assessments (subjective attitudes, traditions, culture, etc.);

– costs.

Quantitative methods can assist in helping solve this type of problem. The classic transportation model can be used. This model is not restricted to warehouse- and outlet-type problems but addresses a wide range of questions. Examples include:

– analyzing the benefits and costs of adding a new facility to an existing distribution system;

– designing an emergency service system with minimum coverage in each zone;

– establishing an optimal shipping schedule allowing for product transshipment.

10.5.1. *Transportation method*

10.5.1.1. *Characteristics of transportation problems*

Transportation problems have these characteristic features:

– a finite and homogeneous set of discrete units must be shipped from several sources to several destinations in a particular time period;

– each source has a precise number of units that must be shipped in the time period;

– each destination has a precise number of units that must be received in the time period;

– each discrete unit to be shipped has a specific transportation cost from each source to each destination;

– the objective is to minimize the total transportation costs for the time period;

– the decision variables represent the number of units to be shipped from each source to each destination during the time period.

Such problems were first formulated in the 1940s and the solution procedures that will be presented in this section were developed in the 1950s. Although the characteristics listed above accurately depict the problems as they were originally formulated and solved, later formulations and solutions allow a much broader range of problems. As we will see later in this section, problems with constraints, maximization objectives, demands greater than supply and other characteristics are now routinely described as *transportation problems*. Solution procedures that constitute the *transportation method* are also used routinely to solve such expanded problems.

10.5.2. *Procedure of the transportation method*

1) Formulate the problem in a transportation table.

2) Use the northwest corner rule or VAM to obtain a feasible starting solution.

3) Test the optimality of the solution by using the stepping-stone or MODI method. If the solution is optimal, stop. If not, continue to the next stop.

4) Develop a new transportation table that is an improved solution. Go back to Step 3.

Notice in steps 2 and 3 of the procedure of the transportation method that the two alternative ways can be used to either test a solution for optimality or obtain a starting solution. The same problem will be worked out with the northwest corner rule and the stepping-stone methods, the MOdified DIstribution (MODI) and Vogel's Approximation Method (VAM) methods so that the relationships among the methods can be appreciated.

10.5.3. *Stepping-stone method*

10.5.3.1. *Logic of the stepping-stone method*

In this procedure, we want to determine if the present transportation table is optimal and, if it is not, which variable should enter the solution. Each unfilled cell (a variable not in the solution) is investigated to determine whether period costs would be reduced if units were moved from a filled cell (a variable in the solution) to an unfilled cell. The stepping-stone circuit is simply a logical way of determining the per-unit change in period costs if units are moved into an unfilled cell.

10.5.3.2. *Steps of the stepping-stone method*

1) Select an empty cell from the transportation table.

2) Draw a closed circuit between the empty cell and other stones (occupied cells) by using only straight vertical or horizontal lines. The circuit may skip over stones or other empty cells, but the corners of the circuit may occur only at stones (occupied cells) and the empty cells that are being evaluated.

3) Beginning at the empty cell being evaluated, move clockwise and alternatively assign positive (+) and negative (–) signs to the costs of the cells at the corners of the circuit from Step 2.

4) Total the per-unit of the cells at the corners of the circuit. The circuit total corresponds to the amount of change in total shipping costs that can be realized by moving one unit to the empty cell under examination. Positive values mean costs will rise; negative values mean costs will fall.

5) Return to Step 1 and continue until all empty cells have been evaluated. The new cell to enter the solution is the cell whose circuit has the most negative circuit total cost.

6) If all the circuit totals are positive or zero, the solution is optimal. If negative circuit totals exist, develop an improved solution.

10.5.3.3. *Determining the new solution*

Once we determine that period costs would be reduced if some units were moved into an unfilled cell, how many units should be moved? We should move as many as possible. The change in the solution is determined by examining the stepping-stone circuit with the most negative total circuit cost. In this circuit, among the filled cells with negative costs, locate the filled cell with the smallest number of units to be shipped. Subtract the number of units from all filled cells with negative costs and add this number to all filled cells with positive costs on that stepping-stone circuit.

10.5.4. *VAM method*

10.5.4.1. *Steps of the VAM method*

1) For each row and column of the transportation table, compute the difference between the lowest unit cost and the next lowest unit and record this difference. Place the row differences in a column to the right of the table under a heading of D_i and the column differences in a row across the bottom of the table with a heading of D_i, where i represents the number of times you have done this step.

2) Select either the row or column with the largest difference. If ties occur, arbitrarily select between tying elements.

3) Allocate as many units as possible to the cell with the lowest cost in the row or column selected in Step 2.

4) If the units in a row or column have been exhausted in Step 3, that row or column may be eliminated from further consideration in subsequent calculations by drawing a line through it.

5) When differences cannot be calculated in Step 1 because only one row or one column remains, this is not an unusual occurrence as we near the end of the process. Calculate the differences that are possible and continue.

6) Return to Step 1 and continue until the units in all the rows and columns have been allocated.

10.5.5. *Problem setting*

The TranseuropeaN Manufacturing Company (TNMC) presently has two factory sites at Budapest and Lisbon and three warehouses at Paris, Berlin and London. In recent months, TNMC has been unable to produce and ship enough of its computer peripheral units to satisfy the market demand at the warehouses. A new factory in Munich has been proposed to increase factory capacity. Bill Mayer, TNMC's CEO, wants to determine what TNMC's monthly shipping costs will be with the new factory located at Munich.

The monthly capacities of the old and new factories, the monthly warehouse requirements and the transportation costs per unit from each factory to each warehouse are shown in Table 10.1.

Factory	Monthly capacity (units)		Warehouse	Monthly warehouse requirement (units)
Budapest	400		Paris	300
Lisbon	1,000		Berlin	900
Munich	600		London	800
Total	*2,000*		*Total*	*2,000*
	Transportation costs			
		Warehouse		
Factory	Paris	Berlin	London	
Budapest	€ 21	€ 21	€ 42	
Lisbon	20	21	30	
Munich	23	20	15	

Table 10.1. *Monthly capacity and warehouse requirements and transportation costs*

1) Use the transportation method to determine the total monthly transportation costs if the new factory is located at Munich.

2) How many units per month should be shipped from each factory to each warehouse after the new factory is built?

10.5.6. *Solution with the northwest corner rule and the stepping-stone method*

1) and 2) *Formulate the problem in a transportation table and use the northwest corner rule to obtain a starting solution.*

Note that the monthly factory capacities are placed on the right-hand side of the table opposite the appropriate factory row. Similarly, warehouse requirements are placed along the bottom of the table under the appropriate warehouse column. The per-unit shipping cost is shown in a box within each factory-warehouse cell. Note also that the total capacity for all factories equals the total warehouse requirements cell.

The starting solution shows how many units are shipped from each factory to each warehouse. When a cell is empty, zero units are to be shipped. The initial solution is obtained by beginning in the northwest cell (Budapest-Paris) and allocating as many units as possible to this cell and proceeding likewise from left to right and downward. Only, 300 units are possible in the Budapest-Paris cell because this amount satisfies the Paris warehouse requirement. Moving to the right, we can allocate only 100 units to the Budapest-Berlin cell because this completes the Budapest factory capacity of 400 units. Next, we move downward and allocate 800 units to the Lisbon-Berlin cell, move right and allocate 200 units to the Lisbon-London cell, and so on until all 2,000 units have been allocated. The starting solution is made visual in Transportation table Steps 1 and 2.

3) *Test the optimality of the solution by using the stepping-stone method.*

This step requires systematically evaluating each of the empty cells in Transportation Table Steps 1 and 2 to determine if monthly transportation costs can be reduced by moving any units into the empty cells. The stepping-stone evaluation method involves the procedures which have been already described. As shown by Transportation Tables Step 3, Transportation Table Steps 1 and 2 is not optimal because we have a negative circuit cost for the

Lisbon-Paris cell and monthly transportation costs can be reduced by moving some units into this empty cell. All the results are aggregated in Transportation Table #1 and the monthly costs of Transportation Table #1 are calculated.

4) *Develop a new transportation table that is an improved solution.*

An improved solution is obtained by moving as many units as possible into the empty cell of the last transportation table with the most negative circuit cost. But, how many units can be moved into the Lisbon-Paris cell, which had a negative circuit cost in Step 3? Let us again examine the stepping-stone circuit for this cell.

The maximum number of units that can be moved into the Lisbon-Paris empty cell is 300-the smallest number of units in a negative cell on the Lisbon-Paris stepping-stone circuit. To complete the improved solution, subtract the smallest number of units in negative cells, 300, from all negative cells and add this same number of units to the positive cells of the circuit. All other cells not on this circuit remain unchanged. This new solution is shown in Transportation Table # 2.

Transportation and costs tables are found in Figure 10.9.

This solution is an improved one – € 43,200 in Transportation Table # 1 versus € 39,900 in Transportation Table # 2 – but is it optimal? Optimality can be determined once again by following the stepping-stone procedures. The stepping-stone circuit costs of the empty cells are shown in circles in Transportation Table # 2. Because all stepping-stone circuit costs are either positive or zero, the solution in Transportation Table # 2 is optimal.

Now, let us answer the questions of TNMC's location problem:

1) If the factory is located at Munich, TNMC's total monthly transportation costs will be € 39,900.

2) TNMC should make the monthly shipments shown in Table 10.2.

Step 3a : First evaluate the Paris - London empty cell : Circuit cost = + 42 - 30 + 21 - 21 = + 12. Place this cost in a circle.

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100	[42] (+12) (+)	400
Lisbon	[20]	[21] 800	[30] 200	1 000
Munich	[23]	[20]	[15] 200	600
Warehouse Totals	300	900	800	2 000 / 2 000

Step 3b : Next, evaluate the Lisbon - Paris empty cell : Circuit cost = + 20 - 31 + 21 - 21 = - 11. Place this cost in a circle.

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100 (+)	[42]	400
Lisbon	[20] (-11) (+)	[21] 800 (-)	[30] 200	1 000
Munich	[23]	[20]	[15] 600	600
Warehouse Totals	300	900	800	2 000 / 2 000

Step 3c : Next, evaluate the Munich - Paris empty cell : Circuit cost = +23-31+21-21+30-15=+7. Place this cost in a circle.

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100 (-)	[42]	400
Lisbon	[20]	[21] 800 (-)	[30] 200	1 000
Munich	[23] (+7) (+)	[20]	[15] 600	600
Warehouse Totals	300	900	800	2 000 / 2 000

Step 3d : Next, evaluate the Munich - Berlin empty cell : Circuit cost = + 20 - 21 + 30 - 15 = + 14. Place this cost in a circle.

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100	[42]	400
Lisbon	[20]	[21] 800 (-)	[30] 200 (-)	1 000
Munich	[23]	[20] (+14) (+)	[15] 600 (+)	600
Warehouse Totals	300	900	800	2 000 / 2 000

Step 1 and 2 : Starting Solution Using the Northwest Corner Rule.

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100	[42]	400
Lisbon	[20]	[21] 800	[30] 200	1 000
Munich	[23]	[20]	[15] 600	600
Warehouse Totals	300	900	800	2 000 / 2 000

Step 4 : Transportation Table # 1

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] 300	[21] 100	[42] (+12)	400
Lisbon	[20] (-11)	[21] 800	[30] 200	1 000
Munich	[23] (+7)	[20] (+14)	[15] 600	600
Warehouse Totals	300	900	800	2 000 / 2 000

The monthly costs of Transportation Table # 1 are :

Factory	Warehouse	Units to Be Shipped per Month	Monthly Transportation Costs
Budapest	Paris	300	€ 9 300
Budapest	Berlin	100	2 100
Lisbon	Berlin	800	16 800
Lisbon	London	200	6 000
Munich	London	600	9 000
	Totals	2 000	€ 43 200

Step 5 : Transportation Table # 2

From \ To	Paris	Berlin	London	Factory Totals
Budapest	[31] (+11)	[21] 400	[42] (+12)	400
Lisbon	[20] 300	[21] 500	[30] 200	1 000
Munich	[23] (+18)	[20] (+14)	[15] 600	600
Warehouse Totals	300	900	800	2 000 / 2 000

The monthly costs of Transportation Table # 2 are :

Factory	Warehouse	Units to Be Shipped per Month	Monthly Transportation Costs
Budapest	Berlin	400	€ 8 400
Lisbon	Paris	300	6 000
Lisbon	Berlin	500	10 500
Lisbon	London	200	6 000
Munich	London	600	9 000
	Totals	2 000	€ 39 900

Table 10.2. *Transportation and costs table*

Factory	Warehouse	Number of units
Budapest	Berlin	400
Lisbon	Paris	300
Lisbon	Berlin	500
Lisbon	London	200
Munich	London	600
Total		*2,000*

Table 10.2. *Optimalized monthly shipments from manufacturing sites to warehouses*

10.6. Reverse logistics: cash from trash and environmental issues

Reluctantly, most of the manufacturers and mail-sell companies have long accepted returns of damaged or unsold items as a necessary cost of doing business. A growing number of companies are now finding that they can make money from returns. At Estée Lauder, a US cosmetics company, returns now represent its third most profitable product line. The secret lies in what is called “reverse logistics’’: the business of sending unsold goods back to the factory and then resorting, repackaging and reselling them at a profit. Estée Lauder has developed a piece of software to tie all this together.

These days, companies pay close attention to the logistics of shipping goods out to retailers, but hardly any to taking them back. Most of the returned goods are thrown in the back of trucks in crushed boxes, often crammed with mixed-up products, some past their sell-by date, some damaged, others without original packaging or instructions, but some in a good enough condition to be resold.

Few manufacturers have thought about how to deal with their returns let alone making money out of them. In addition, by failing to log returns, companies deprive themselves of information about which their customers dislike.

With companies offering increasingly generous return guarantees for winning market shares and customers’ loyalty, the volume of returned goods is prone to grow. Land’s End, an American catalog retailer, allows customers to return any item, in any condition, no question asked, for a complete refund. Even cosmetics, traditionally hard to exchange for reasons of hygiene, are returnable these days. Rite-Aid, an American pharmacy chain, is running advertisements encouraging customers to buy a lipstick, try it and bring it back if they do not like the color.

The software system developed by Estée Lauder for managing returns paid for its $ 1.5 m cost in 9 months, because it has enabled this company to resell two-and-half times more items than with the previous system at a lower cost incurred. Estée Lauder plans to license its software to other retail companies: it proved flexible enough to deal with most other consumer products from books to white goods.

It has become mandatory in many developed countries to collect products cast aside and containing toxic materials liable to contaminate the biosphere (air, water and soils). Numerous examples can be found: mercury-containing batteries or lamps, refrigerators, personal computers, cars, etc.

In some cases, by law, the producers or distributors of environmentally unfriendly products have to get involved in organizing and/or operating logistics networks to recuperate discarded products, make them environmentally safe and recuperate for reuse valuable materials, if any. A new economic sector is emerging and is called green logistics. Under the pressure of ecologist movements, the concept of the "circular economy" is being evolved. The arguments underpinning this concept are straightforward: owing to the projected physical scarcity of raw materials or forecast high costs for exploiting new resources, it is critical to foster a sustainable economy by recycling worn out shoes, textiles, etc., and recuperating valuable materials from industrial products (cars, household equipment, etc.).

11

Sourcing and Physical Distribution

11.1. Sourcing policy

Three ideal options for the procurement of goods and services can be distinguished. They may not accurately reflect all the interactions between a buyer and its suppliers but provide a basic framework for designing and implementing an effective and efficient organizational system.

11.1.1. *Pure market option*

A pure market option is typified by a potentially large number of suppliers.

One of the main advantages is that the buyer can choose the best supplier from among all those available in the market and therefore maximize what is called by economists “static allocation efficiency”.

Moreover, under this option, innovation is by and large the responsibility of the supplier and the buyer can take advantage of new technologies brought in the market place.

However, the pure market option may also result in a higher degree of competition-induced uncertainty since suppliers (even those who have won orders) will be uncertain from one round of tendering to the next round whether they will win new orders.

Under the pure market option, there will be little incentive for potential suppliers to invest in “transaction specific assets” such as equipment, human

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skills which are relating to a particular buyer and are worth relatively less for alternative uses. This problem can negatively affect the user–supplier relationship and lead the firm to attempt to modify these circumstantial conditions by switching to other options. The high standards of quality required often form an argument to address this question.

11.1.2. *Controlled competition option*

Controlled competition involves a relatively long-term and stable cooperative relationship with a selected group consisting of a small number of suppliers.

In a general way, the controlled competition option secures more effective coordination between the buyer and suppliers compared with the pure market mechanism (price and competition). In particular, it facilitates non-market-mediated flows of information and partnership. From the suppliers' viewpoint, these circumstances represent a strong incentive to invest in transaction-specific assets. Among the other advantages, this approach helps engineer user-oriented innovation and high standards of quality. All these advantages result in cost cuttings.

Against these advantages must be set the limited ability in the short run to switch suppliers. Although some competition may remain inside the small group of suppliers, higher coordination costs are likely to be incurred if the buyer attempts to share information and obtain agreement between several independent firms.

An extreme case is a partnership with one supplier. This situation can be described as co-makership. It can be justified in some specific contexts. Arguments can be put forward to categorize this case in the vertical integration option when the supplier has only one client. Its possible use must be borne in mind as a feasible supply option.

11.1.3. Vertical integration option

Vertical integration means internal development and provision of products/services which a firm does not wish to purchase in the market place.

Various types of advantages favoring this option can be detected. The vertical integration option may help organize more effective coordination between complementary activities since these activities are under the same "command structure", and consequently may result in synergies and cross-fertilization. There will be an incentive rationale to invest in transaction-specific assets since the costs of diverting these assets to lower-return alternatives will have to be borne by the firm itself. Additionally, risks of knowledge-leakage to competitors are minimized as is competition-induced uncertainty.

The major disadvantage refers to the innovation which remains under the responsibility of the buyer and thus requires research facilities with adequate funding and domains of competence. This may lead the firm to be locked in some forms of innovation without being able to take advantage as easily of alternative innovations generated by third parties. Furthermore by definition, this option implies the absence of competition in terms of price and innovation and no opportunity to switch from an internal to an external supplier. It is to mitigate these consequences that vertically-integrated firms usually leave some options for purchasing outside the firm.

Figure 11.1 brings together the salient features of the three options for sourcing.

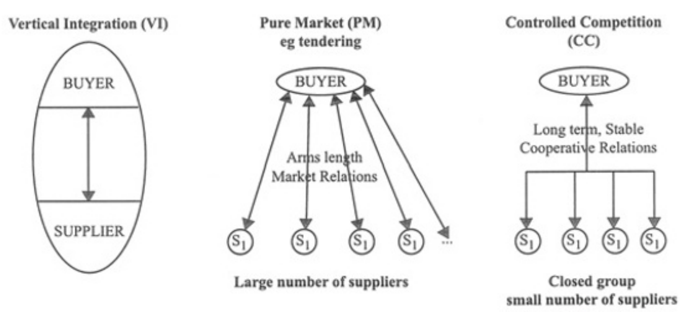

Figure 11.1. *Sourcing patterns*

11.1.4. *Advantages versus disadvantages of the various options in relation to business strategy and types of products*

In view of the potential implications of the three procurement options, it is not possible to reach a conclusion regarding the efficiency of these options without inserting the firm's strategic choices in the assessment. The relevance of the selected option depends upon the firm's competencies including the extent to which it is possible, organizationally and managerially, for each option to exploit the advantages analyzed while dealing effectively with the disadvantages. Advantages and disadvantages for each option are summarized in Table 11.1.

Pure Market Option	Controlled Competition Option	Vertical Integration Option
	Advantages	
1) Maximize static efficiency	1) Better coordination, better information flow	1) More efficient coordination through central direction
2) Innovation under the responsibility of supplier/competition-induced innovation	2) Limited competition more likely	2) Know-how-leakage minimized
	3) Greater incentive to invest in transaction-specific asset	3) Greater incentive to invest in transaction-specific asset
	Disadvantages	
1) Competition-induced uncertainty	1) Limited ability in the short term to switch suppliers	1) Innovation responsibility of user
2) Limited incentive to invest in transaction-specific asset	2) Possible high coordination costs (autonomous firms)	2) Absence of competition-induced innovation
	3) Some competition-induced uncertainty	3) No switching from internal to external supplier
	4) Possible knowledge leakage	

Table 11.1. *Advantages and disadvantages of the different sourcing options*

The choice of a procurement policy has to fit in with the business strategy against the advantages and disadvantages of the various options. A model can assist firms in their decision-making process. For this purpose, we have designed a three-step model taking into account circumstances internal and external to the firm. The approach of this model is based on the final step, scoring purchased materials/products or groups thereof by attributing them to one of the boxes of a matrix depicting classifications established in the first two steps. These classifications mirror internal and external situations referred to by combined indices.

The procedure to produce the decision matrix is as follows:

Step one: determining the frame of internal constraints

The matrix frame relies on two two-value indices; it has the risk index on the horizontal axis and the economic index on the vertical axis.

The risk index refers to a two-value variable (“low”, “high”) reflecting the risks the firm is exposed to when processing a material/product. These risk-bearing activities are appraised in terms of human skills to be brought into play, quality standards to be met, equipment units to be used, etc.

The economic index refers to the relative cost weighting of a material/product under consideration in the final cost price of the end product where this material/product is used. It is quantified as “heavy” or “light”.

When applied to a material/product, the combination of the two indices results in a procurement classification as displayed in Figure 11.2.

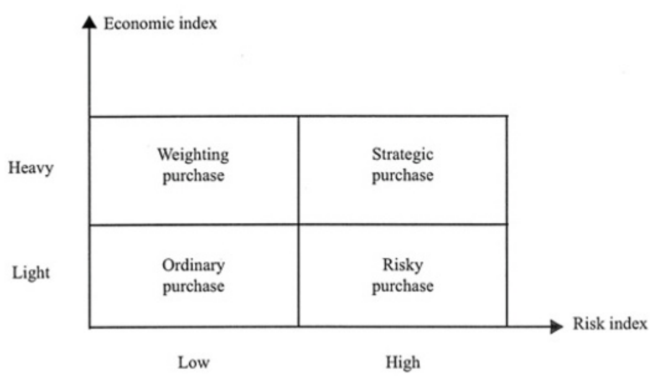

Figure 11.2. *Internal constraints on sourcing*

Step two: determining the frame of external constraints

External constraints account for pressure on the firm from its business environment. The matrix frame boxes correspond to purchasing positions of materials/products with respect to their technical complexity on the vertical axis and to their commercial complexity on the horizontal axis.

By technical complexity is meant assessment of technical risks incurred by the choice of one or another supplier. The index of commercial complexity serves as the explanation of risks incurred by the competitive structure of the supply market and the sustainability of suppliers' operations.

Plotting a material/product in the matrix boxes produces the classifications as shown in Figure 11.3.

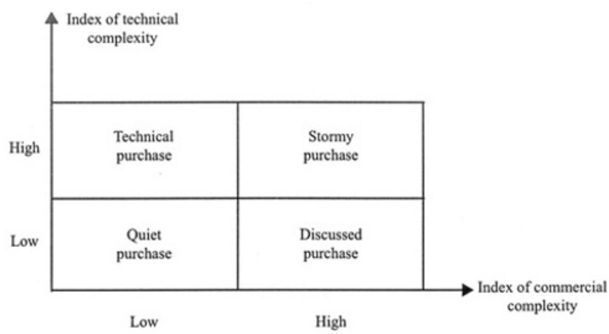

Figure 11.3. *External constraints on sourcing*

Step three

The classifications derived from the two previous matrices are combined to produce the decision-making matrix. Its horizontal axis posits classifications related to internal constraints, and its vertical axis those related to external constraints. Well-defined sourcing features requiring a suitable policy are supposed to be associated to each box. The positional implications in terms of purchasing are easy to deduce for some boxes. For other boxes the choices to be made are not straightforward and depend upon judgments of the firm's management. These judgments may appear to be subjective from outside the firm: the important point is to secure globally consistent choices. The situation is shown in Figure 11.4.

When a material/product is plotted in a box labeled “to be avoided”, attempts should be made to move to a better classification.

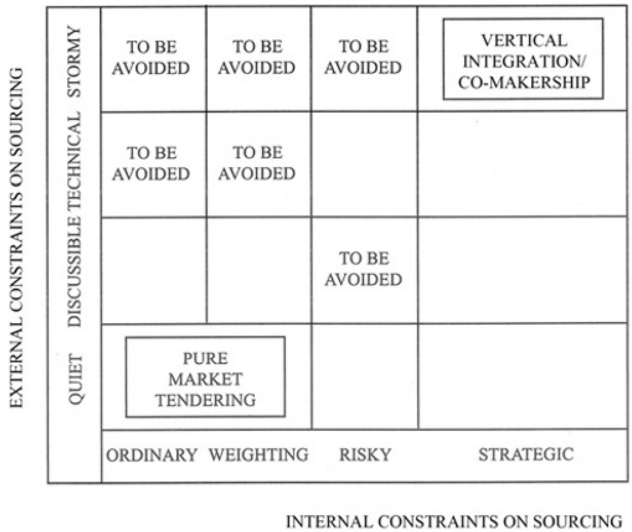

Figure 11.4. *Decision-making matrix for sourcing*

11.2. Physical distribution policy

11.2.1. *Objectives and constraints*

The concept of any physical distribution system has two basic objectives:

– providing an optimum customer service; in other words, delivering goods to the customer reliably and quickly;

– performing the logistics function at the minimum cost.

This concept has two priority constraints which are intended to contribute to the achievement of these objectives:

– minimizing the number of stock points and carrying out a short customer order cycle time; this results in decentralized warehousing, in principle near the markets;

– taking into account certain criteria, among others direct deliveries from suppliers to local warehouses.

We will consider how these priority constraints combined with the basic objectives are converted in terms of physical distribution.

11.2.2. *Various patterns of physical distribution*

The function of physical distribution is to place the goods provided by suppliers at the disposal of end users. The Figure 11.5 depicts, in diagrammatic form, who does what.

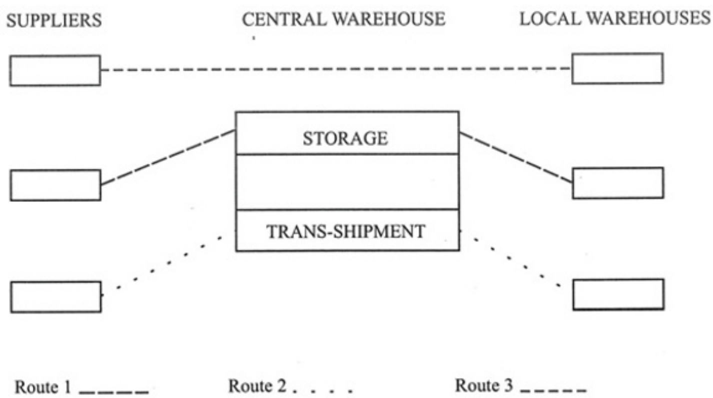

Figure 11.5. *Physical distribution patterns*

Three routings are possible between suppliers and local warehouses:

Route 1

The goods of each supplier are stored in the central warehouse and then go to local warehouses on call-off.

Route 2

The goods of each supplier are delivered to the central warehouse and not stored, and then dispatched after trans-shipment to local warehouses on scheduling.

Route 3

The goods of each supplier are shipped directly to local warehouses.

11.2.3. *Choice of a physical distribution option*

Deciding upon one option or another depends on integral costs. A susceptibility analysis provide an excellent point of reference for direct delivery, trans-shipment or central warehousing. The arithmetical model is displayed in Table 11.2.

Options Costs of resources	Direct delivery to local warehouses	Trans-shipment	Central warehousing
Space			
Physical handling			
Clerical handling			
Inventory holding costs			
Transportation			

Table 11.2. *Template for assessing resources costs incurred for different distribution options*

12

Quantitative Quality Management

12.1. ISO 9000 standards: impact upon business operations

The groundswell in interest in the quality of products and services has created a need for commonly accepted global standards of quality. The International Organization for Standardization (ISO) got involved and issued guidelines for implementing quality (ISO 9000 standards). The standards cover not only the manufacturing and presale inspection of products but also business organizational aspects. They specify what is required but not how to do it. Covering all business areas, they are designed to define and secure the nature and contents of two-party transactions. A purchaser should specify the standards as a part of the purchase contract. The supplier has then to provide assurance of compliance. The usage of ISO standards converts transactions into contracts enforceable by mutual agreement.

The ISO standards are categorized into five classes:

– ISO 9000: overview and introduction to the other standards in the series, including definition of terms and concepts related to quality;

– ISO 9001: comprehensive general standard for quality assurance in design, development, manufacturing, installation of products;

– ISO 9002: more detailed standards focusing on manufacturing and installation of products;

– ISO 9003: more detailed standards covering final inspection and test of completed products;

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– ISO 9004: guidelines for managing a quality control system (well suitable for use in auditing quality systems).

The implementation of these standards in businesses has led to develop the following:

– supplier–customer partnerships: long-term contracts are established with selected suppliers delivering parts of agreed specifications;

– customer service, distribution, installation for quality: customers' perceptions of quality are very important to maintain and/or increase the market share.

These two features directly impact logistics (transport, warehousing and handling).

12.2. Acceptance testing

The sampling technique is intended to yield information about batch products from inspecting sampled ones in order to cut testing costs. It is internationally known and widely applied for checking the specifications of deliveries by suppliers. An acceptance plan is the overall scheme for either accepting or rejecting a batch on the basis of data gained from samples. It identifies the size of the sample, the sampling procedure and the acceptance criterion. Only single-sample acceptance plans by attributes will be considered later on. A single-sampling procedure is shown in Figure 12.1.

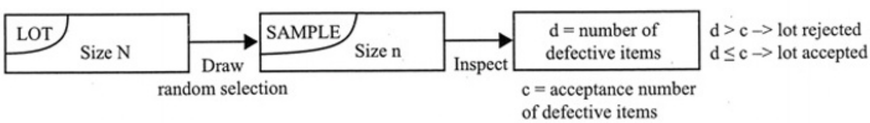

Figure 12.1. *Single-sampling procedure*

12.3. Operating characteristic curve

If the sample of items conforms to the required quality level (i.e. maximum number of defectives), then the whole batch from which it comes is accepted. Otherwise, the whole batch is rejected. The procedure is shown in Figure 12.2.

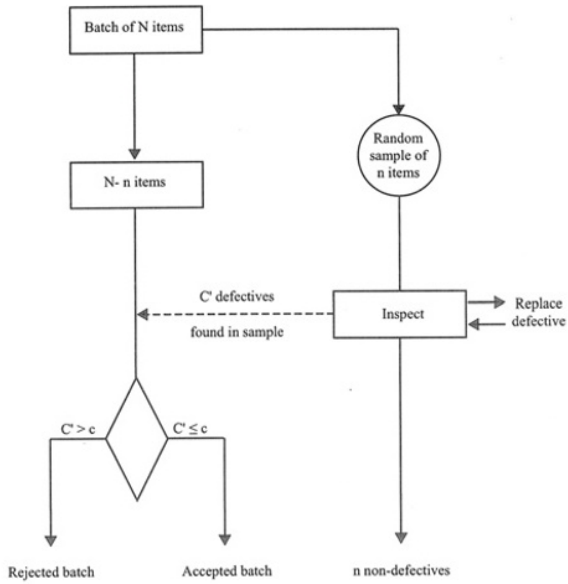

Figure 12.2. *Acceptance procedure*

The operating characteristic (OC) curve shows the probability of accepting batches as a function of the percentage of defectives in the batch. It can be calculated and plotted if the following are specified:

– the sampling procedure (with or without replacement);

– the sample size;

– the acceptance number, i.e. the allowance number of defectives in the sample, c.

The probability that a given number of defectives will be found (when a sample of a given size is drawn *with replacement* from a batch with a known proportion of defectives) is:

$$P(r) = \frac{n!}{r!(n-r)!} (p)^{r} (1-p)^{n-r}$$

where n = sample size;

r = number of defectives found;

p = percentage of defectives in batch;

P(r) = probability of finding r defectives in the sample.

The probability of accepting a batch with the percentage p of defectives on the basis of tested samples with less than c defectives is expressed by:

$$P(a) = \sum_{r=0}^{c} P(r) = \sum_{r=0}^{c} \frac{n!}{r!(n-r)!} (p)^r (1-p)^{n-r}$$

EXAMPLE 12.1.–

sampling procedure with replacement

sample size n = 10

acceptance number of defects c = 1 or less

$$P(0) = \frac{10!}{0!10!} (p)^0 (1-p)^{10} = (1-p)^{10}$$

$$P(1) = \frac{10!}{1!9!} p (1-p)^9 = 10\,p\,(1-p)^9$$

$$P(a) = P(0) + P(1) = (1 + 9p)(1 - p)^9$$

The values of P(a) computed for different values of p are presented in Table 12.1.

p%	P(a)
5	0.9
10	0.77
15	0.55
20	0.37
25	0.22
30	0.13
35	0.08

Table 12.1. *P(a) values*

The OC curve can be constructed from the table above and is shown in Figure 12.3.

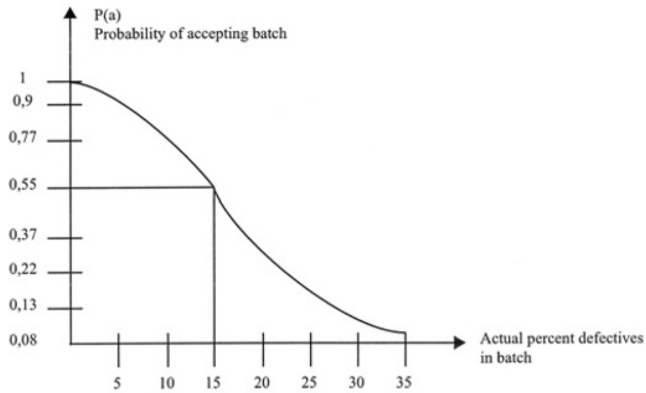

Figure 12.3. *OC curve based on the acceptance procedure of Figure 12.2*

The merit of any sampling plan against full inspection of batches depends on the relationship between sampling cost and risk. In terms of risk, the OC curve for any plan shows the probability of accepting batches with more than the acceptable number of defectives and rejecting batches with less than the number of defectives.

It is the supplier's desire to minimize the probability of rejecting batches with an acceptable number of defectives, and the client's desire to reduce the probability of accepting batches with too many defectives. These attitudes are called the producer's risk (a) and the consumer's risk (b), respectively. These two values combined with acceptable quality level (AQL) and lot tolerance percent defective (LTPD) values are used to define two points A and B of the OC curve and subsequently to design an acceptance sampling plan. AQL is the worst quality level of item batches accepted by the producer for his/her own manufacturing operations. LTPD is the worst quality level accepted by the consumer. The way the four values are combined to define the points A (AQL, α) and B (LTPD, β) is depicted in Figure 12.4.

When the OC curve is chosen to pass through the points A and B, a trial-and-error procedure can be used to derive the sample size n and the acceptance number c by substituting into the binomial probability formula until a fitting curve is obtained.

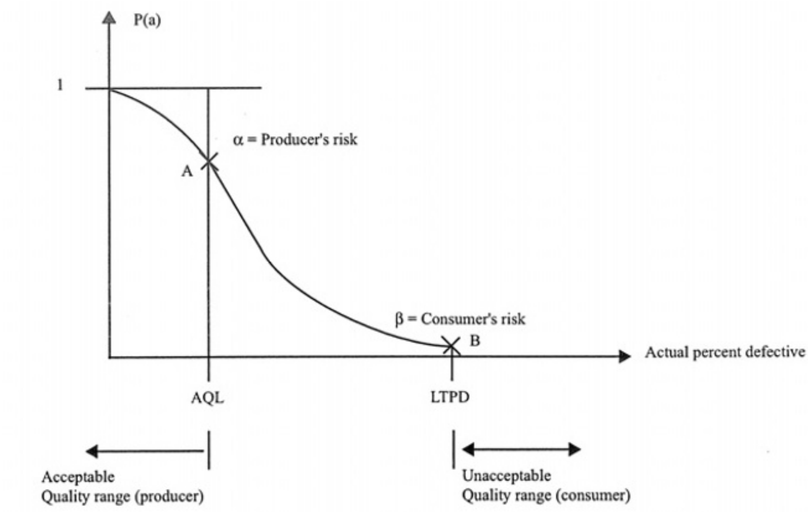

Figure 12.4. *Meaning of AQL and LTPD*

The customer's risk (β) is usually specified at approximately 10% and the producer's risk (α) at approximately 5%. The values of AQL and LTPD depend on case-by-case needs.

12.4. Average outgoing quality

The average outgoing quality (AOQ) is the overall proportion of defective items in a large number of batches when all batches are assumed to have the same percentage of defectives and when all batches are subjected to a specific type of operational sampling procedure.

In order to obtain a high quality level for batches with a minimum of inspection, the sampling procedure is operated as shown in Figure 12.5.

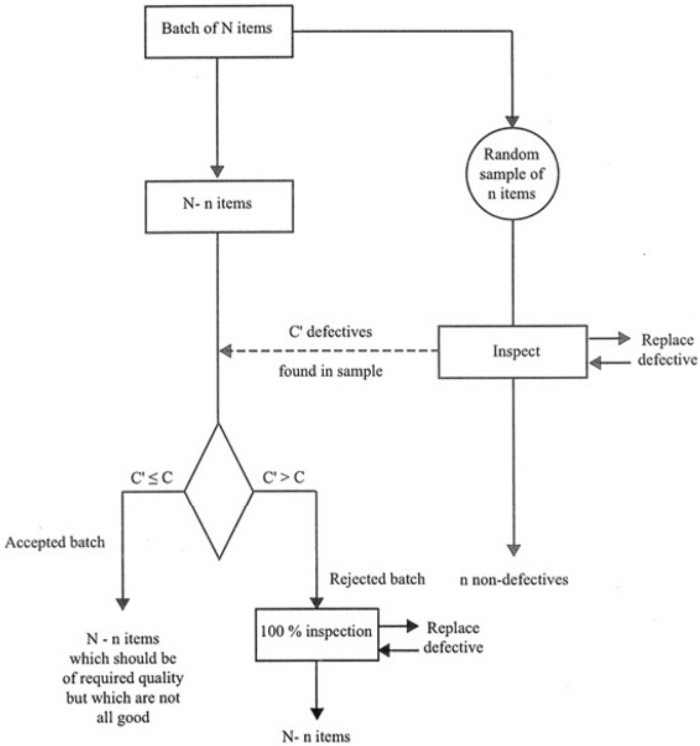

Figure 12.5. *Acceptance procedure with 100% inspection of rejected batches*

The AOQ percentage (%) can be found as follows if the preceding sampling procedure isoperated:

$$AOQ\% = \frac{Number\ of\ defectives\ remaining}{Total\ number\ of\ items}$$

$$= \frac{Number\ of\ defectives\ items\ in\ accepted\ batches\ each\ of\ size\ N - n}{Total\ number\ of\ items}$$

$$= \frac{P(a)\ p(N - n)k}{Nk}$$

where P(a) = probability of accepting batch (from OC curve);

p = actual percent of defectives in all batches;

N = batch size;

k = large number of batches.

The final expression of AOQ % is given by

$$= \frac{P(a)\ p(N - n)}{N}$$

EXAMPLE 12.2.–

Construct the AOQ % curve for the sampling plan where:

N = 200;

N = 10;

C = 1 or less.

The values of AOQ % are computed by using data from Table 12.1 and are presented in Table 12.2.

p %	P(a)	AOQ %
5	0.9	4.3
10	0.77	7.3
15	0.55	7.8
20	0.37	7.0
25	0.22	5.2
30	0.13	3.7
35	0.08	2.7

Table 12.2. *AOQ Percentage Values*

The AOQ % curve is shown in Figure 12.6.

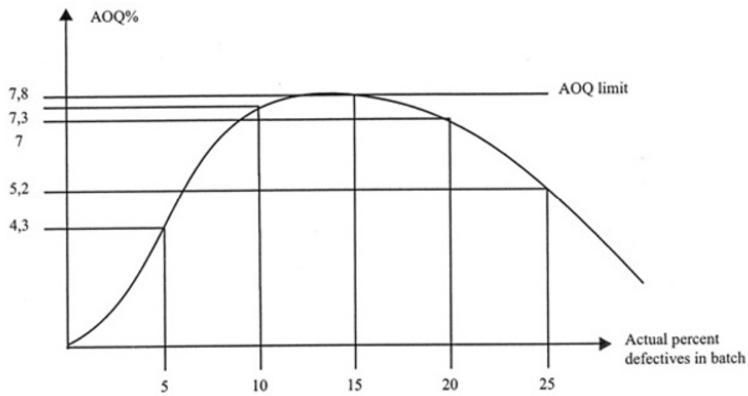

Figure 12.6. *Average outgoing quality % when the acceptance procedureof Figure 12.5 is applied*

Some comments can be made about the AOQ % curve. The AOQ % is always better than the actual percentage of defectives in batch. This is to be ascribed to the "rectify or replace" steps of the acceptance plan. A "built-in" limit for the proportion of defectives, the average outgoing quality limit (AOQL) exists. This limit represents the worst average quality, which over a large number of batches may be expected to pass either to the customer or to the next operational stage. It is explained by the fact that an increasing percentage of defectives in batch produces a higher rate of full batch inspection.

As a conclusion, sampling plans may be designed to provide:

– either an AOQL when interest centers on the average quality level after inspection;

– or a given consumer's and producer's risks (LTPD/AQL) when certain given levels of risk have to be satisfied.

12.5. Terms used in an acceptance plan for attributes

Acceptance plan: scheme for accepting or rejecting a batch of items on the basis of data gained from sampled items

Acceptable quality level (AQL) = worst quality level of item batches manufactured by the producer

Average outgoing quality (AOQ)

Average outgoing quality limit (AOQL)

Consumer's risk: risk taken by a customer for accepting a batch of items when it should be rejected

Lot tolerance percent defective (LTPD) = worst quality level of item batches accepted by the customer

Producer's risk: risk taken by a producer for rejecting a batch of items when it should be accepted

Sampling technique: inferring information about batch products from sampled ones to cut costs

Part 5

Case Studies

13

Case Studies: Hellas Corporation and the E-Enabled Car Industry

13.1. Hellas Corporation case study

The Hellas Corporation is an established manufacturer of personal computers (PCs). Its current lines of products consist of cheap machines offering basic processing capabilities and user-friendly interfaces, and expensive machines delivering a wide range of professional functions.

The potential step-by-step enhancement of low-grade machines by adding electronic boards ensures the competitive advantage of the Hellas Corporation. This feature results from its core competence in electronic board design.

Products are marketed through two distribution channels:

– Quarterly contracts are negotiated with purchase pools serving retail chains. That means in organizational terms, that activities and associated resources requirements can be planned. These contracts yield 75% of the turnover.

– Orders placed by small retail outlets are committed to be fulfilled within three working days. This type of contract calls for a specific operations layout and appropriate control.

1) *Describe the business control model by identifying and documenting the main activity-based process, the control system*

Derive the specifications of the Information System.

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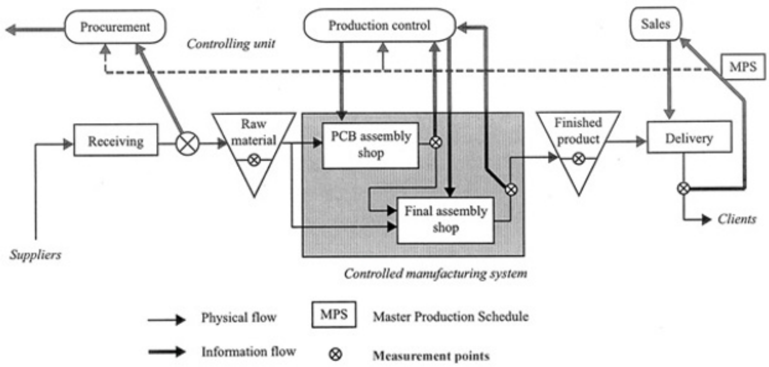
2) In order to increase the corporation's market reach the CEO decides to substitute the sales department for a Website for entering orders from small retail outlets

Describe the Website process and changes in data requirements.



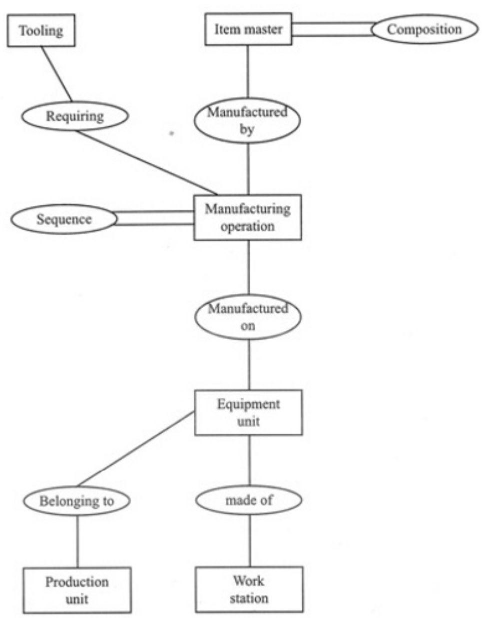


Figure 13.1. *Data Model of manufacturing operations*

ITEM NUMBER	A15 (MANDATORY)	
DESCRIPTION	A30 (MANDATORY)	
UNIT OF MEASURE	A3 (MANDATORY)	
VENDOR CODE	A6	
PLANNER NUMBER	A4	
DIVISION	A1	
UNIT OF PACKING	A3	
CONVERSION PACKING/ UNIT OF MEASURE	N7.3	
ITEM TYPE	N1 (MANDATORY)	0 = PHANTOM, 2 = MANUFACTURED, 1 = ASSEMBLED, 3 = RAW MATERIAL, 4 = PURCHASED, 9 = OTHER
DRAWING FORMAT	A2	
STANDARD U-COST	N11.4	
CURRENT U-COST	N11.4	
NEW CURR U-COST	N11.4	
LIST PRICE	N11.4	
CURRENCY CODE	A3	
PURCHASE PRICE	N11.4	

A.x = Alphanumerical data coding with x fields

N x.y = Numerical data coding with x digits out of which y are decimals

Figure 13.2. *Attributes of item masters entities*

13.1.1. *Logistics scoreboard*

A. Supply delivery reliability/customer service level

1) *Supplier delivery reliability*

1a line item supplies:

$$PI = \frac{\text{Number of order lines delivered complete on due time}}{\text{Total number of order lines committed in purchasing orders}}$$

1b supply lead times:

$$PI = \frac{\text{Number of order lines delivered on time}}{\text{Total number of order lines committed in purchasing orders}}$$

2) *Customer service level*

$$PI = \frac{\text{Number of serviced customer orders}}{\text{Number of registered customer orders}}$$

B. Manufacturing dependability

$$PI = \frac{\text{number of manufacturing orders delivered on time}}{\text{total number of manufacturing orders committed per time bucket}}$$

$$PI = \frac{\text{quantity of resource actually consumed}}{\text{forecast consumption of resource}}\Bigg|\begin{array}{l}\text{per manufacturing order or}\\ \text{for a period of time}\end{array}$$

$$PI = \frac{\text{number of rejects}}{\text{number of products to be manufactured}}\Bigg|\begin{array}{l}\text{per manufacturing}\\ \text{order}\end{array}$$

C. Inventory levels

The metrics units used to give a control-oriented value to an inventory are:

– the number of consumption days for supplied materials;

– the number of manufacturing days for finished products.

The figures expressed in these units provide information about the risks incurred when supply orders or manufacturing orders are not fulfilled on time whatever can be the reason.

13.2. The e-enabled car industry

13.2.1. *Introduction*

In the 1980s, the car manufacturing industry experienced drastic pattern (r)evolutions under the pressure of quality and customization requirements pioneered by the Japanese car industry.

The manufacturing management underwent complete changes in concepts and codes of practice and was still on the move in the year 2000 as proved by *The Economist* survey herewith appended. The term "manufacturing management" refers to the entire array of physical, logical and organizational elements constituting the actual manufacturing activity-based process from procurement to physical distribution to retailers and clients. These elements range from conceptual planning issues to concrete operations and control ones such as plant layout, production information system, cost accounting and control and so on.

A major contribution of the Japanese has been their managing of *throughput time*. They have accomplished much in this area mainly by switching from push to pull manufacturing. With *push manufacturing*, the sales forecasts drive the production plan and goods are manufactured to meet this plan. The production plan "decouples" the market place from the manufacturing shop floor. The sheer purpose of this technique is to make the best apportionment of business resources to activities. Manufacturing activities are time-phased triggered to meet the committed production plan.

Conversely with *pull manufacturing*, market demand triggers manufacturing activities committed to fulfilling an order within an agreed period of time. This is achieved by re-engineering manufacturing processes and, if necessary, re-designing the products for making them more easily manufacturable. The information system pertaining to a pull manufacturing organizational pattern must be able to provide managers with the right tools for controlling business operations timely: historic data is not relevant within this prospect.

13.2.2. *Assignment*

– Analyze the appended article and work out its salient features. It reflects the backdrop and the stakes relative to the car industry at the time of its publication. Try to investigate how the situation has evolved ever since and whether the issues raised at the time of publication had been assessed with perspicacity from an “a posteriori” point of view.

– *On the conclusions of this analysis, design*, a business control model for a car manufacturer of the future and elaborate an information system meeting the requirements of the new organizational pattern envisaged by the horizontal portal “COVISINT” (visit the Website to find a description of its current function capabilities).

13.2.3. *Car manufacturing*

“Car factories of the future will be smaller and cleaner, and not all owned by car companies” – The Economist, February 21, 2002

The full article can be downloaded from the Website of *The Economist*. It is interesting to contrast the current situation with the prospective view presented in this 2002s article.

Incredible shrinking plants

The following is a summary of the main issues expressed in it. The tense of verbs refers to what was written in 2002:

The Rouge plant in Dearborn on the outskirts of Detroit is the place where Henry Ford developed his manufacturing ideas and created a huge integrated factory complex. It is about to experience a dramatic upheaval. It will be turned into a lean, flexible assembly line, the symbol of modern car manufacturing.

The car industry worldwide is no longer a vertically integrated industry. It has become an industry assembling parts supplied by specialized companies and delivering mobility services. This strategy of outsourcing allows over-capacity to be managed in a “soft” way without hot disputes with trade unions. Seers see that the ultimate pattern will be even more different when the concept of vehicle brand owners (VBOs) is deployed. They will restrict their activities to their core competencies of designing, engineering and marketing vehicles. The final assembly will be done by the parts manufacturers. This happens already with niche cars (Porsche, Mercedes, BMW and Saab).

This new industrial organization will entail redefining relationships between parts manufacturers and VBOs. Japanese car manufacturers pioneered the concept of special relations with their parts suppliers in the 1980s. This model is operative in Europe.

The American car industry is lagging behind and has to bring its relations with its suppliers in line with Japan's. The economic backdrop relative to the American car industry in the 1990s explains this situation. At that time, the three big manufacturers in Detroit turned aggressively to their suppliers in an attempt to recover from heavy losses. It appeared that this course of action failed but its outcome was disguised by the unexpected success of profitable minivans and sport and utility vehicles (SUVs). The Detroit companies built new facilities to manufacture these vehicles rather than convert existing production lines unsaturated by the changing market demand.

The resulting over-capacity triggered a widespread discounting and cheap leasing deals in an attempt to bring in cash. This policy resulted in losses. This trend was enhanced after September 11, 2001. The main reason why the production of loss-making cars is maintained is to conform with federal guidelines on the average fuel consumption of any one manufacturer's fleet. The small cars compensate for the gas-guzzling SUVs and bring the average down.

The structure of revenues is under threat for two reasons. On the one hand, the American congress moves to put profitable SUVs under tighter rules within the framework of what is called the corporate average fuel economy (CAFE). On the other hand, Japanese car manufacturers produce competitive models in American sites.

In the 1990s, the profits and shareholder returns of the American car industry were illusory. As a matter of fact, its business model was obsolete and proved irrelevant to the prevailing economic context. This industrial sector has for some time consumed resources without creating wealth. It enjoyed years of profitless prosperity, which is unsustainable. The return on capital plunged from around 20% in its heyday to 3%.

As Japanese companies' SUVs are challenging the Americans on their home ground, the big three from Detroit have to take steps for a drastic change making manufacturing more responsive to consumer demand. It is thought that it will imply a shift from huge plants seeking economies of scale to smaller, more widely distributed plants.

Two other features of car markets come into consideration to switch to flexible manufacturing systems. In America and Europe, markets are saturated and a growing need emerges to supply niche models manufactured in small volumes at controlled cost. Another factor has been the increasing use (notably by Audi, Fiat and the Mercedes part of DaimlerChrysler) of so-called space-frame technology. This technology uses extruded metal parts, which are riveted or even glued together to make up the skeleton of a car body, to which plastic or other lightweight panels can be attached. This dispenses with the expensive machines needed to stamp out load-bearing panels, and so favors the use of smaller and cheaper factories.

Car manufacturers are called to respond to the need for flexible factories to cope with variation in demand for high-volume vehicles, and the need for low-cost, flexible manufacturing for low-volume production (up to 100,000 vehicles a year). Most new factories are now built to make around 200,000 units a year.

Honda leads the pack down the road to flexible global manufacturing. Not only are all its car factories capable of making several models, they are also now equipped to switch from one model to another model very quickly. It takes Detroit between four and six weeks to alter models in a factory, re-jigging the robots and other tools. Honda can now do it overnight, simply by changing the software in the robots. To achieve this, it has installed one single global manufacturing system.

A growing number of car manufacturers are working fruitfully with suppliers to produce pre-assembled modules. That strategy gives more flexibility to manufacturing and makes possible the choice of specific components by customers, which may prove to be a bursting marketing competitive advantage.

Anand Sharma, founder of a manufacturing consultancy, is convinced that the car industry will gradually move to a pattern where most of a car will be made in modules that are simply snapped together in small assembly lines close to the consumer, where details can be adapted to local tastes. He calls this trend "distributive manufacturing", which he sees being driven largely by the growing demand for mass customization (or "build-to-order") in industries such as PCs.

The picture is very different in the aerospace industry, for example, where Boeing and Airbus leave engine development to the three makers of large jet engines (General Electric, Rolls-Royce and Pratt & Whitney), and hand over responsibility for their landing gear and avionics to a small number of world-class suppliers.

Some visionaries think that technical changes in the foreseeable future could spark a revolution in car making around the world. These changes refer to propulsion and control systems. Electricity is their common denominator. As far as propulsion is considered, fuel cells are envisaged to generate electricity supplied to electric engines on each wheel. However, steering, braking and other controls are all electric rather than mechanical. In spite of the fact that these electric control systems have been used in Airbus aircraft for nearly 20 years, such equipment would need legislation in most countries before vehicles could be authorized as fit for the road without mechanical links between the driver and the steering. Moreover, the human factor has to be taken into consideration. Mercedes estimates that it will take 10 years before the young car buyers of tomorrow, brought up on video games, will accept electronic steering. These twin technical revolutions will generate a breaking point in car manufacturing, rendering obsolete lots of old factories making clunky engines, gearboxes and even suspension systems.

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