ROUGH DRAFT

13 Management of Digital Enterprises – A Synthesis

Contents

13.1 Introduction

Successful management of e-business involves two major issues: a) how to employ information technologies (i.e., networks, databases, and distributed applications) to transform/improve the business condition and management processes, and b) how to manage and support these technologies effectively. These two topics are of crucial importance because information technologies are critical to the survival of most organizations. Despite the economic slump and .com bubble burst, between 50 to 80 percent of modern companies' business -- ranging from cash flow to supply chains -- is being conducted through online processing networks. While the debate on different aspects of IT and its actual impact on organizations continues, the number and types of automated services and computer-based applications keeps growing steadily [Laudon 2003, Lee 2003, Porter 2001, Severance 2002, Shea 2003, Siegle 2003].

Information technologies need to be managed as valuable assets because not only the information systems but also several business functions rely directly heavily on these technologies. The loss of network access for airlines is a disaster, especially with increased use of e-tickets. Similar situations exist in manufacturing, telecom, healthcare, and virtually all other industry segments. In investment companies, for example, the wireless and wired networks are used for online Web access from customers, financial and customer databases are used by the financial analysts, and the middleware technologies are used to provide access to mission critical databases and programs that are dispersed among the desktops, mainframes, and minicomputers. It is naturally important to manage these critical technologies wisely and invest in them as business "insurance".

These technologies can also help in the management process. For example, the computer-communication technologies can help in the organization structure design by developing a location independent organizational structure. In other words, the distributed computing platform *is* the organizational structure. The organizational information and decision flow can change without having to move the people. Another example is the evolution of management platforms which utilize the capabilities of networks and databases to manage the corporate applications. A more important development is the ***real-time enterprise model*** [Jones 2002, Lindorff 2002] in which the real-time status of business activities critical to the company's day-to-day operations is displayed and acted upon. GE is using this model to monitor, once every 15 minutes, GE's mission-critical operations such as sales, daily order rates, inventory levels, factory production, and other important activities across the company's 13 different businesses around the globe. The icons of up-to-the-minute business performance across the company are checked by using "cockpits" that represent critical business activities as green, yellow, and red icons on a large screen. Information technologies are the nervous systems of the real-time enterprises. We will visit these topics in Sections 13.4 and 13.6.

The chapter starts with a quick overview of strategic issues in e-business management and then proceeds through the management cycle (planning, organizing, staffing, monitoring and control) with particular attention to e-business. The management cycle topics have been discussed widely in the general management literature. It is not our objective to survey the general management literature and practice, instead our focus is on the deltas (the differences) in how these activities differ in managing information technologies in the turbulent e-business world. A difficulty in discussion of technical management issues is that technical and management issues get confusingly intermixed. While unavoidable in some situations, we will keep our eyes mainly on the management issues in this chapter. For technical background other modules of this book will be referred to.

The chapter concludes by illustrating the management processes and associated tools needed for a real life example. The case studies in Chapter 5 further illustrate the concepts discussed in this chapter.

Key Points

- The current trend in e-business is increasing the reliance of organizations on IT. Thus IT must be managed as a valuable asset.
- The traditional cycle of planning, organizing, staffing, development, monitoring and control is a good framework for managing IT assets.
- IS Planning in modern enterprises must start with business strategies and go through information systems planning and resource/cost estimation/evaluation.
- Organizational structures in the modern digital enterprise raise interesting centralization/decentralization, and interdependency management issues that impact management roles.
- Organizational design in real-time and virtual enterprises is an interesting area of development.
- Development, deployment and support is becoming increasing challenging due to the complexity of enabling IT infrastructure, outsourcing options, and fluctuating staffing/training considerations.
- Monitoring and control of IT assets involves security, performance, and fault management. The current breed of "Management Platforms" provide an interesting and effective approach to monitor and control IT assets.

13.2 Strategic Issues in Digital Enterprise Management – An Overview

Figure 13-1 attempts to put the information systems in context and shows how the current trend in e-business is increasing the reliance of organizations on IT. Business strategies decide what type of products and/or services are needed (1). The financial, marketing, and other services are outlined to support the business strategy (2). Basically ISs are developed to support products and services and the support systems as shown by arrows 3, 4 and 5. The IT infrastructure in the past was only developed to support the information systems (6). But now, the same IT infrastructure is also used to deliver the products and services as well as the information systems. This is the main shift due to e-business.

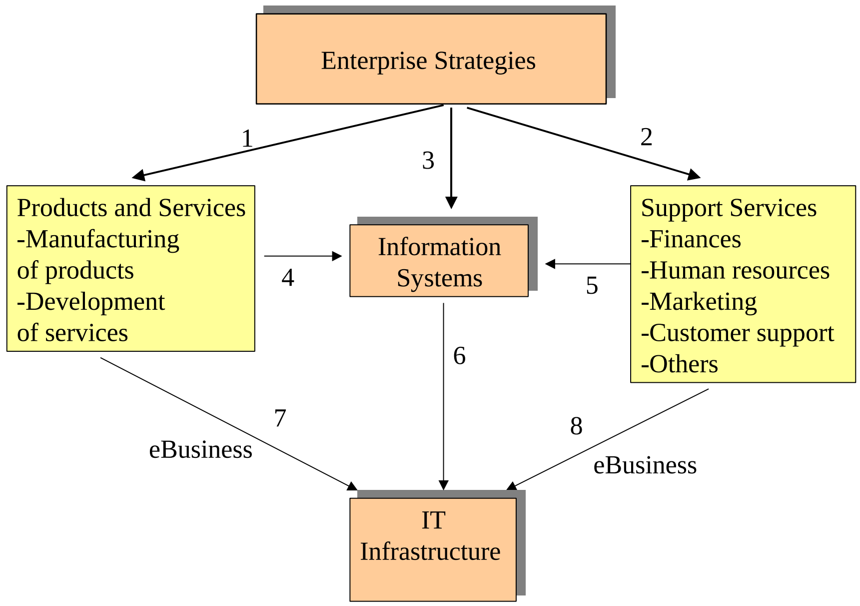

Figure 13-1: Putting IS in Context

It is important for upper management to provide a vision for the management and support of distributed computing technologies. Once a vision has been stated, continued and active support from top management is essential for materializing the vision. The vision must be clearly defined and doable in the given time frame. As noted by a CEO [Charan 1991]:

"There is a fine line between vision and hallucination".

To avoid "hallucination", the promises and pitfalls of the changing and evolving underlying technologies in networks, distributed databases, client-server systems, and distributed application systems must be kept in mind. A quick trip through the well known management cycle of planning, organizing/staffing, development/deployment and monitoring/control, shown in Figure 13-2, can be used to solidify visions. In other words, this cycle can be exercised in a small project to develop an understanding of the management processes and the tools needed for e-business. The processes of particular interest to us are as follows:

- **Planning for e-Business**. This process, discussed in Section 13.3, shows how the technologies discussed so far in this book are employed to support corporate visions. Given a business architecture of an enterprise, this process produces a technology architecture which shows the application and network architectures. The objective of the planning process is to exploit the role of this technology to shape a company's future.
- **Organizing for e-Business**. This process, explained in Section 13.4, produces an organizational structure to support the plan. The centralization/decentralization of organizational activities (e.g., central administration of data, decentralized development) is discussed in this Section. As a result of this process, tasks are delegated, responsibilities are assigned, and flow of decisions and information across organizational units is determined.
- **Development and deployment of e-Business**. This process, discussed in Section 13.5, actually delivers the services promised in the planning process. The distributed computing related issues are how to select, purchase/develop and install the diverse array of hardware/software components needed.

- **Monitoring and control of e-Business**. This process, discussed in Section 13.6, is concerned with the day-to-day administration and support activities needed to assure smooth customer services. These include the tools and environments being developed for distributed systems configuration management, fault management, performance management, security, accounting etc. Distributed computing introduces the issues of distributed application plus the network management problems.

Figure 13-3 shows the reference model that has been used throughout this book to identify the major building blocks of information systems (applications, databases, middleware, networks) that needs to be planned, organized, monitored, and controlled. As shown in this model, all building blocks need to be managed. We will use this reference model to guide the discussion.

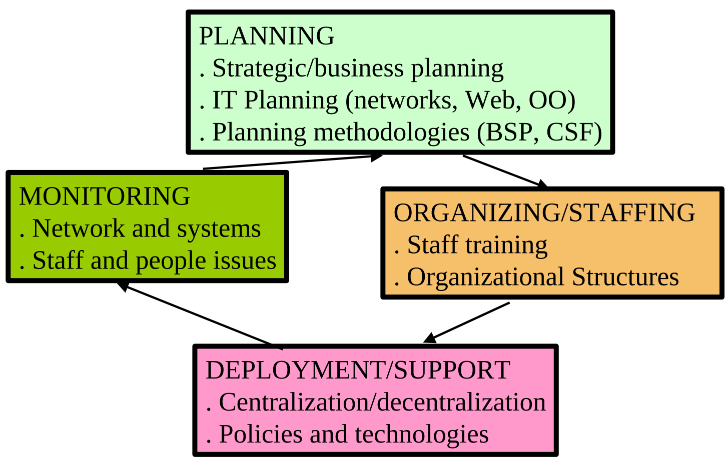

Figure 13-2: Management Activities

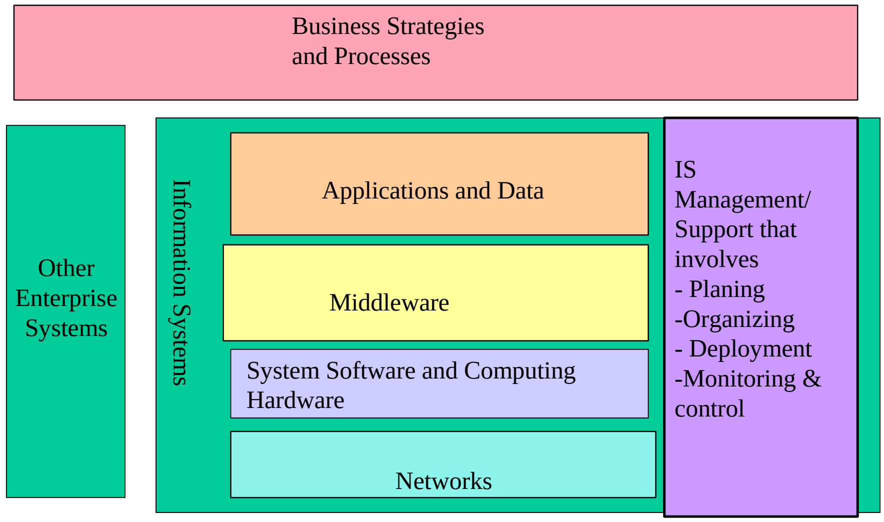

Figure 13-3: Distributed Systems Reference Model

e-Business Management - Selected References

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The Agenda
- IS Planning
- Organizational Structures
- Development and Deployment
- Monitoring and Control

13.3 IS Planning in Modern Enterprises

13.3.1 Overview of Planning in Enterprises

Planning determines what needs to be done (the objective), outlines the steps and the sequence of steps to accomplish the objective, and lists the time and effort needed to meet the objective. The result of a planning process is a document, a ***plan***, which is a repository of information about the approach, the steps, the resources needed and the time frame for an effort. Within this general framework, several levels and types of planning exist in real life and enterprises. We all remember planning a vacation, planning a family relocation from one city to another, or planning a wedding (there are professional wedding planners also -- there is a movie by that name starring Jennifer Lopez). Our focus is on planning for transition from strategies to working solutions. Figure 13-4 shows the main choices – in reality, a mixture of these choices is used. We will discuss these choices as we go along (see chapter 3 of the Applications Module for additional details).

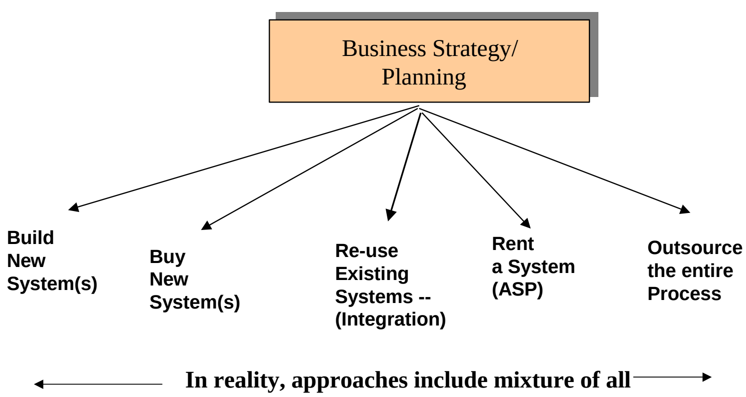

Figure 13-4: Options to Translate Strategies to Working Solutions

In enterprises, there can be several types of planning efforts (business, IS, IT infrastructure) at several levels (strategic, tactical, operational). These planning efforts cover different horizons (strategic plans are longer range than tactical or operational ones) and have different areas of focus (business plans concentrate on business issues while IS and IT infrastructure plans focus on information systems and technologies). These plans also support and feed into each other (IS plans support business plans and strategic plans feed tactical and operational plans). Table 13-1 shows the various levels and types of plans with interrelationships between them. The reality is quite different than this almost idealized view. In many real life cases, one big plan exists (if at all) that includes all levels and types. In most cases, corporate attention is paid to strategic planning and the tactical/operational plans are left to the individual business unit management. Our focus is also on strategic planning.

The IS plan that we are interested in, whatever it is called, is directly related to business strategy making. Figure 13-5 shows a traditional versus new approach to strategy making that serves as the foundation of IS planning. In the traditional model, the business executives created the business strategy, and associated plan, that described where the business wanted to go. This strategy was then translated by IS executives to develop an information system strategy, and associated plan, that showed how IS could support the business strategy. An IT strategy is a technical plan that shows how the needed IS could be developed, deployed, and supported. For example, when Paul Marciano, co-chair of GUESS jeans, decided to triple sales between 1999 and 2003, an IS plan was developed that included aggressive web-based advertising and online purchasing. An IT plan to support web-based advertising and purchasing was also developed that included revamping of the network by working with Cisco [York 2001]. This model assumed, as seen in the GUESS example, a four to five year planning horizon and thus a great deal of time, up to a year, could be spent in building a strategy and the associated plans. Due to the long time horizon, there was enough time to translate the business strategy into an IS and then into an IT plan. This model also assumes that [McNurlin 2001]:

- The future in the business as well as technology landscape can be predicted
- Time is available to progress through the three stages
- The role of IS is to support and follow the business
- Top management knows best because they have the broadest view of the business and how the company fits into it
- The company can be viewed and run as an army where the leaders issue the orders and the rest of the company follows

Table 13-1: Planning Types and Levels

	Business	Information System	IT Infrastructure
Strategic Plan(3-5 years)	Strategic business planning Goal: What new markets to get into in the long run	Strategic IS planning Goal: What ISs will be needed to support the strategic business plan	Strategic IT infrastructure planning Goal: What type of IT infrastructure will be needed to support strategic IS plan
Tactical Planning (1-2 years)	Tactical business planning Goal: What to do with the existing products and services	Tactical IS planning Goal: How to support the tactical business plan through IS. and also the strategic IS plan	Tactical IT infrastructure planning Goal: How to support the tactical IS plan through IT . and also the strategic IT plan
Operational Planning(6months-1 year)	Operational business planning Goal: How to deliver the products and services to existing customers	Operational IS planning Goal: How to support the operational business plan through ISs. and also the tactical IS plan	Tactical IT infrastructure planning Goal: How to support the operational IS plan through IT . and also the tactical IT plan

At present, none of these assumptions are true due to a mixture of reasons such as the increased use of the Internet[1], increased competition, focus on customers (their needs change very quickly), flattening of organizations, and globalization. In the new model, the planning horizon is very short and more interaction exists between current, past and future activities. The result is that the planning process is a more reactive process that is ongoing and iterative. This needs to be kept in mind while discussing the planning processes.

13.3.2 The Planning Process

Figure 13-6 shows a broader view of the three major levels of IS planning in enterprises. This view puts the IS planning in context along with other systems of the organization and also shows a fourth "development" level for completeness. At the highest level, as stated previously, is the business strategic planning which determines the enterprise services to be provided. At the next level, the strategic systems (financial, engineering, manufacturing and information systems) are planned. The infrastructure (facilities, equipment, human and IT infrastructure systems) needed for the services are planned at the third level. The actual development and support is conducted at the fourth level. Consider, for example, a startup company that wants to build and sell network products. The business strategy of this company is to use "just in time" assembly processes to minimize on-hand inventory. Towards this goal, the company will have to develop manufacturing facilities and processes, among other things. On the IS side, the company will need to develop applications (e.g., inventory control, materials requirement planning) that will support the company goals and minimize the delays between steps to assure just in time processes. The major planning processes and the interrelationships between the planning processes are displayed in Figure 13-6 Our main interest is in the information systems related processes (highlighted borders in Figure 13-6).

[1] For example, when every one has a web site for advertising and supports online purchasing through the Web, then this is not a strategic edge. GUESS strategy would be difficult to sustain in 2003.

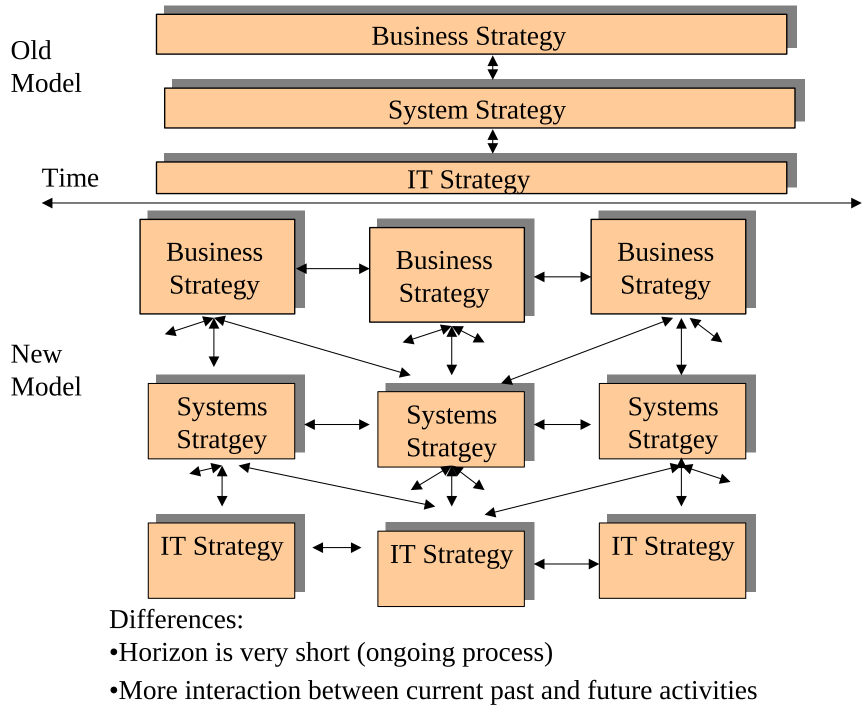

Figure 13-5: Strategy Making –Traditional Versus New

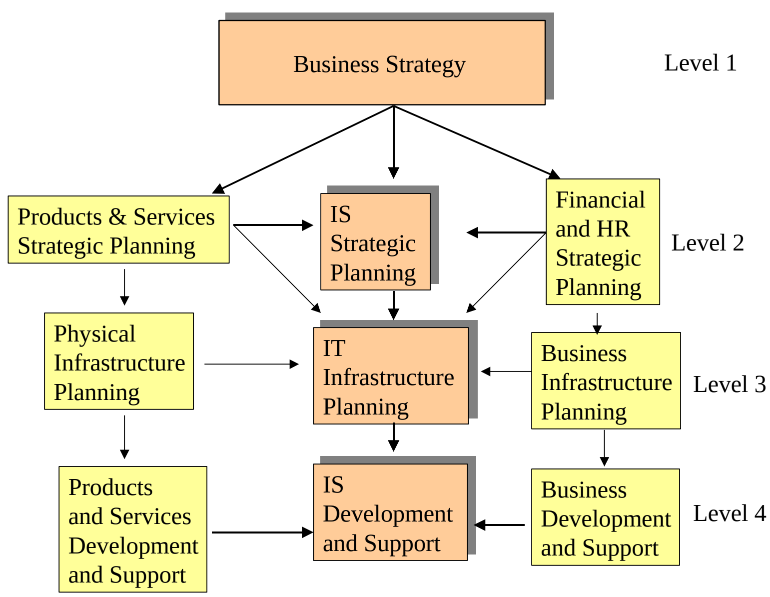

Figure 13-6: Planning Levels -- A Simplified View

To reduce complexity, let us now synthesize the three levels of planning into an enterprise-wide information system (IS) plan which must satisfy the following requirements:

- Business requirements that drive the entire IS initiative.
- Application functional requirements, which state the things done by the applications being used in different parts of an enterprise.

- Application interconnectivity requirements which establish the mechanisms of information exchange between applications at different enterprise sites such as remote logon, file transfer, distributed database management, and cooperative processing.
- Management control, security, interoperability, portability and integration requirements to make the applications independent of the underlying distributed computing platforms so that changes in the platforms do not necessitate modifications of the application systems.
- Physical network response time, availability, and cost requirements imposed by the end users and management throughout the enterprise.
- Network growth and interconnectivity requirements between the various computing devices, communication devices, and network transmission mechanisms used in the enterprise.

Our objective is to combine all aspects of IT/IS into a single procedure. For example, existing work on network planning primarily focuses on the last two requirements. Application interconnectivity and interoperability requirements are not commonly discussed in network planning despite their key role in integrated environments. On the other hand, the information system planning literature does not address the network requirements. Figure 13-7 shows the stages of the enterprise-wide IS planning process as an iterative process where the planning can start almost anywhere depending on a trigger. This process addresses the aforementioned requirements and is based on the Distributed Systems Reference Model shown in Figure 13-3. Although discussed as a series of sequential activities, the planning process is, in reality, an iterative and ad-hoc process (see, for example, [Boar2002]). Sections **Error! Reference source not found.** through **Error! Reference source not found.** describe these stages in more detail.

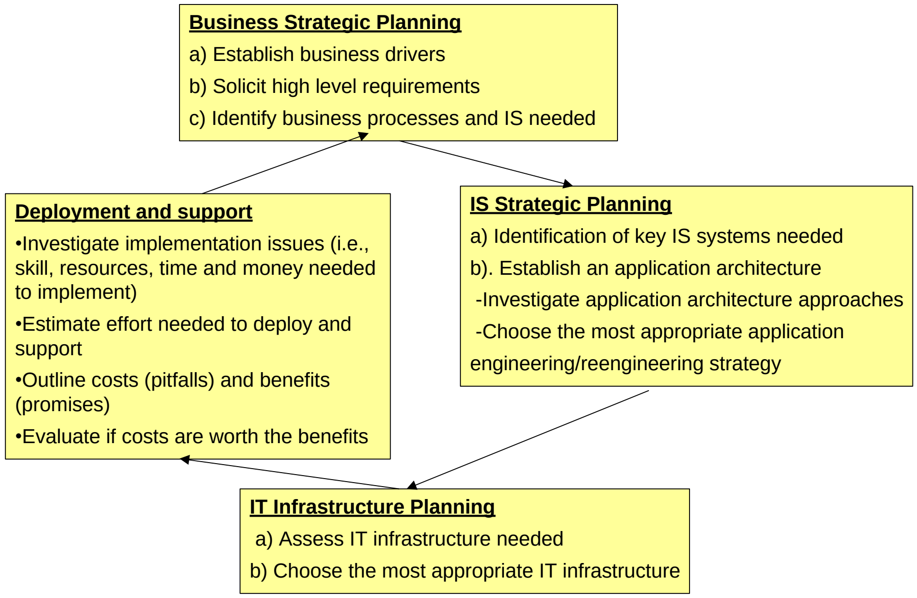

Figure 13-7: Enterprise-wide Information System Planning – A Checklist

Suggested Review Questions Before Proceeding

- What is IS planning and what are the results of IS planning?
- What are different types of planning and at what level do they operate?
- Suppose you are in-charge of introducing on-line purchasing of office supplies for a chain store that resembles Staples. Prepare a checklist, in the form of a table, for planning of this system at strategic, application, and IT infrastructure levels. The checklist should show the main activities and the main results from each activity.
- List some examples of IS planning that you are familiar with.

13.4 Organizational Structures and Centralization/Decentralization

Let us now focus on establishing the organizational structure, the information and decision flows, and the management and staff responsibilities to meet the plan developed in the previous section. For example, how should an enterprise organize itself to integrate the manufacturing, business and engineering information systems. After the 1958 seminal article "Management in the 1980s" by

Leavitt and Whisler [Leavitt 1958], which predicted the impact of computing on management, many interesting articles appeared in the management literature in the late 1980s on the computer-communication technology based organizations of the future [Applegate 1988, Drucker 1988] and later on the impact of Internet on organizations [Cronin 1995, Dawdow 2001, Hammer 2001, Kalakota 2001, McNurlin 2001]. Although a detailed analysis of organizational issues and problems is beyond the scope of this book, it is important for us to review the basic approaches in organizational design and understand the impact of e-business on the current practices. Specifically, the following questions need to be addressed:

- What are the basic issues and approaches in organizational structure design (Section 13.4.1)?
- What is the impact of e-business on the centralization/decentralization issues (Section 13.4.3)?
- What is the impact of e-business on organizational interdependencies (Section **Error! Reference source not found.**)?
- How are the roles of management being impacted by the e-business initiatives (Section 13.4.4)?

The basic premise of this book, as stated in the Overview Module, is that e-business is a special form of distributed systems. Thus the impact of distributed systems on organizational structures underlies this discussion with emphasis on the unique issues specific to e-business. In addition, many organizational e-business issues seemed to first appear in the context of computer integrated manufacturing (CIM) in the 1980s where an attempt was made to integrate manufacturing with engineering and business operations. Thus, reference to CIM in this discussion is appropriate[2]. In addition, real-time corporations such as GE and Intel are building digital nervous systems that connect everything involved in the company's business from factory production to customers payment. This is in fact a revisit to the CIM initiatives. The case studies and discussions in chapter 5 of this module illustrate the concepts discussed here.

13.4.1 Overview of Organizational Structure Design

All organizations require a vision and a strategic plan, resources (financial, human, technological) to satisfy the plan, and organizational design to direct the resources to accomplish the plan. Organizational design consists of organizational structures, policies/procedures, reports, performance measurement and evaluation, and rewards/reprimands. Our focus is on organizational structures which define the division of labor into subunits, subunit work assignments, and controlling the interdependencies and interactions between the subunits. It is important to study organizational structures for two reasons. First, new technology gives more options and raises new issues that must be addressed. Second, bad structures lead to too many conflicts and coordination problems which result in poor employee morale and eventual failures of organizations.

13.4.1.1 Organizational Structure Design -- The Traditional View

Design of organizational structures is commonly referred to as structure design in management literature and should not be confused with software structure design. This field has progressed through several stages: the Classical School of Management, the Human Relations School, the Carnegie-Mellon School and the Integration School. In addition, the approaches of "one best way" versus "it all depends" have been used by management consultants and theorists for quite a while (see, for example, [Mintzberg 1979]). Significant literature has been published on the theoretical as well as empirical aspects of this area. The main idea is to structure subunits by similarity (e.g., function, service/product, geographical location). Organizations are commonly structured by the following (see Figure 13-8):

[2] This may just be a personal opinion because I worked heavily on CIM projects in the 1980s and am finding many similarities between CIM and e-business initiatives -- it is deja vu all over again.

- **Function:** Each subunit is responsible for a function (e.g., marketing).
- **Product/project/service**: Each subunit is responsible for a product.
- **Matrix:** Combination of functional and product structures where work definition is left to workers.
- **Geographic locations**: Subunits are consolidated by country, region, etc.

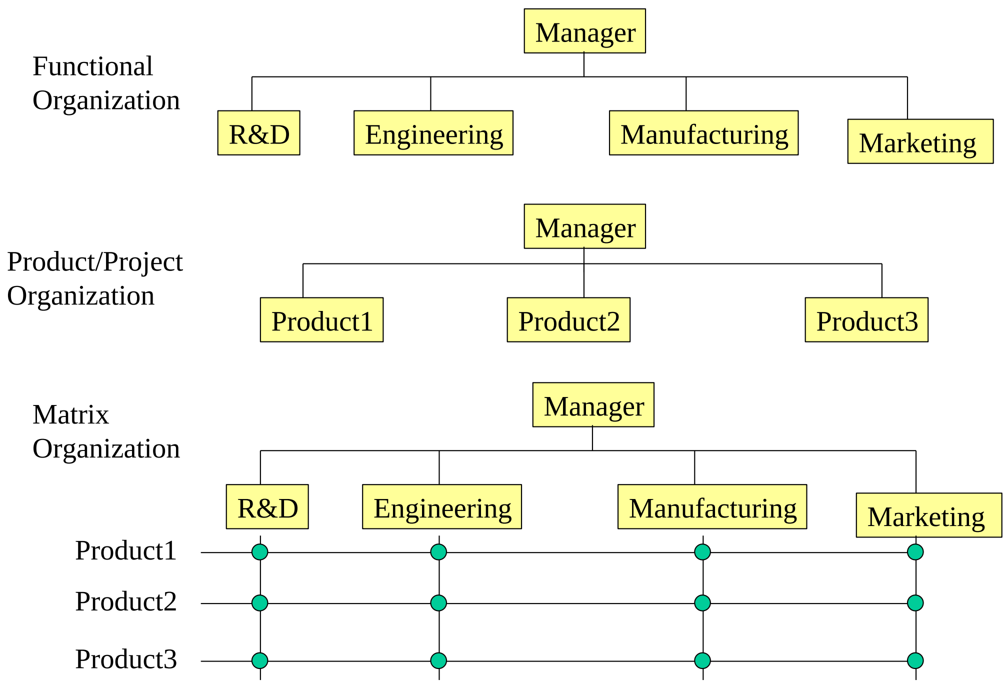

Figure 13-8: Basic Organizational Structures

There are, of course, advantages/disadvantages of each (see the sidebar "Main Advantages/Disadvantages of Basic Organizational Structures"). A given organization typically uses a combination of organizational structures where functional subunits at one level are decomposed into product subunits at the next level -- these subunits can be grouped within regions for administrative control. In addition, knowledge workers and researchers are usually organized differently to allow direct interactions and exchange of ideas. Thus knowledge workers are organized differently than plant floor operations in the same company. In addition, organizations change structures with new products and services.

Main Advantages/Disadvantages of Basic Organizational Structures

Functional Organizations

+Good utilization of area specialists (e.g., researchers, engineers)

+ Easy and natural for new ventures

- Not good for products and services (little loyalty for products)

Product/Service Oriented Organizations

+ Good for volatile products/services

+ Good for products/services of varying sizes

- Can lead to duplication, lack of standards, and integration problems (people working on product1 do not see any reason to cooperate with product 2)

-+ Develop loyalty towards products

Matrix Organizations

+ Good utilization of staff skills

+ Good for volatile industries (e.g., government contracts)

- Two bosses (project manager versus functional manager)
- Not good for new companies

13.4.1.2 Organizational Design in e-Business

To illustrate the main concepts, let us review the structure designs for e-business environments. Such organizations depend heavily on information technologies for integration of enterprise processes such as procurement, supply chains, customer relationship management, manufacturing, engineering, administration, and office processes. The goal is to produce high quality products/services with minimum cost and in minimum time. e-Business enterprises encounter two sets of organizational problems: a) the typical organizational problems between the product *versus* functional management, and the engineering/manufacturing/marketing interfaces, and b) the information technology related organizational problems of coping with the expectations/implications of technology. Here is a list of specific challenges in organizational structure design for such systems:

- Organizational units must be able to develop, at internet speed, new systems for global markets that can be easily integrated with back-end systems. Many of these systems must be developed to operate at Internet scale (i.e., thousands of users), with Internet connectivity (e.g., unpredictable open Internet), and for multiple customers with multiple interests.
- These systems must satisfy multiple, often conflicting requirements for performance, reliability, flexibility and maintainability. For example, EB systems must be based on flexible architectures for evolving customer needs as well as technologies. In addition, these systems must be easily modifiable to reflect changes in competitive market conditions and national/international standards.
- These systems are dispersed among the enterprise units which may be located in different cities or countries. Consequently, management of integration requires a great deal of interdisciplinary work among geographically distributed units with potentially different equipment, standards, and policies.

- These systems are developed by professionals (systems engineers, computer scientists, business programmers, etc.) with diverse backgrounds, training, specialized terminology, and professional outlooks.
- Development of these items requires an understanding and synthesis/application of existing and evolving tools, techniques, standards and models in enterprise services (e.g., manufacturing), computing devices, communication technologies, systems engineering, and management. These tools and techniques include growing areas, such as database systems, software engineering, artificial intelligence, operations research, distributed intelligence, organizational behavior, and ergonomics.

The main question is: How can an organization structure itself to handle enterprise-wide integration? Should this responsibility be assigned to an existing group or should a new group be initiated? Who should this group report to and how should it interface with other organization subunits? How should this group be staffed and trained, etc.? Examples of organizational structures needed for EB initially appeared for computer integrated manufacturing [Aulds 1988, Cloutier 1988, Daner 1988]. A survey of the approaches being adopted by various companies involved in CIM indicated three main approaches [Umar 1991]:

- Single functional ownership in which a group starts somewhere within a functional department, such as manufacturing, engineering, or finance/administration.
- A project team is introduced to oversee the planning, design, implementation, and management of corporate-wide activities. The project leader may belong to any of the functional areas with team members representing various functions, as well as multiple levels in the organization.
- Top management involvement which is similar to the project team approach. The main difference is that the integration project manager reports directly to top management. In large organizations, the integration project manager may report to a top management representative, such as a division vice president.

Other approaches are variants of these three. Our studies at that time suggested that an organization may choose all three approaches or combinations at different stages. The situation has not changed much lately. For example, the initial investigation of an EB integration may be conducted by a project team to study and evaluate the organizational and technological aspects of internal as well as B2B integration. In the next stage, after management approval, the project team may be elevated to a top management team for detailed planning of the needed tasks. The implementation may be achieved by decomposing the tasks into functional areas which are managed by the functional units. In this stage, the team members may assume the role of agents and advocates of the plan in their respective functional units. A corporate-wide team may still exist, however, both to monitor individual unit progress and to provide an integrative approach that includes external partners. It is possible to use e-business patterns for organizational structure design. For example, the companies that use web for marketing only through web sites may have one organizational structure that is fundamentally different from completely digital corporation structures. See [Adams 2001] for a discussion of e-business patterns and Chapter 1 of the Applications Module for more discussion on e-business patterns.

Figure 13-9 shows a procedure for evaluating various organizational structures which combines many of the existing techniques into a single framework. Our experience has shown that such a systematic approach for a detailed examination and analysis of proposed organizational structures is quite useful. It has been especially useful in providing a uniform basis for evaluation: it has led to valuable insights and discussions. It was also found that the model was instrumental in keeping the discussions more focused on appreciation of tradeoffs. Table 13-2 shows another approach.

13.4.1.3 Location Independent "Virtual" Teams - IT For Organization Design

Information technologies can help in the organization structure design by developing a location independent organizational structure. *In such a structure, the IT platform is the organizational structure.* The platform is the corporate Intranet (Internet implemented inside an organization) that allows managers and workers to communicate with each other independent of their geographical location. With this structure, the organizational information and decision flows can change (an organization restructure) without moving people's desks. Thus the organization structure is defined through software, i.e., the desktops and security/authorization/reporting procedures can be reconfigured to define a new organizational structure [Keen 1991].

Let us extend the discussion to "virtual teams" and "virtual enterprises". Basically, a ***Virtual Enterprise (VE)*** is a network or loose coalition of a variety of value adding services in a supply chain, that unite for a specific period of time for a specific business objective, and disband when the goal is achieved. An example of a VE is the Virtual Parts Supply Base (VPSB, http://www.vpsb.com/) to supply hard to find parts for the US Government. Many organizations are participating in this effort for a specific purpose. Similarly, a virtual team is formed for a specific period of time for a specific business objective, and disbanded when the goal is achieved. For example, Ford Motor Corporation has adopted a cross-continent virtual team model to design its automobiles. Ford launched the Mustang design as a simultaneous collaborative effort between designers in Dunton (England), Dearborn (Michigan), Japan, and Australia [Laudon 2002]. Similarly, the very popular Apache Web Server was developed by a team of independent developers around the globe. In these cases, the notion of distance in organizational design disappears -- the Internet becomes the vehicle for organizational design.

1. Identify the problems that need to be addressed (interdependencies, lack of coordination, etc.).
2. Identify the main candidate structures which appear to address the problems identified (should not exceed 4, current structure must be a candidate)
3. List the major requirements to be satisfied by the organization:
   - organizational requirements
   - responsiveness to change
   - integration requirements
   - human needs/requirements
4. Assign importance to the requirements (0 to 5) and choose, if possible, the most important requirements (about 10)
5. Evaluate the candidate structures against the requirements on the scale 0 to 5
6. Repeat steps 1 through 4 if needed
7. Analyze the results and make recommendations

Figure 13-9: A Procedure for Organizational Structure Design

The Internet technologies have eliminated distance as a factor for many types of work for many situations. Many employees can work from their homes, cars or boats (these people are crazy!). The workers can collaborate across continents by using Internet as the communication mechanism. In these cases, the main thing that keeps an organizational structure together is the expertise and the desire of people to work on common projects. The organizational structure itself becomes a virtual concept.

13.4.2 Organizational Design in Real-Time Enterprises

Real-time enterprises are complex sensing organizations that run everything from payroll departments to remote factories across the globe through real-time monitoring [Jones 2002, Lindorff 2002]. To support the monitoring and split-second reaction times across widely distributed business units, the companies have to rely on sophisticated IT infrastructure (see the case study "GE Becomes a Real-Time Enterprise" in Chapter 5 of this module). Companies such as the Inditex Group are using this model to make sure that every process in the company is instantly accessible to the management layers. The foundation of such organizations is a digital nervous system that connects everything involved in the company's business. This system can be used to monitor everything in real-time from sales operations to supply chains. The main underlying technology for real-time enterprises is the message oriented middleware that supports a publish and subscribe model so that different important events can be posted and responded to by publishers and subscribers, respectively. See Chapter 1 of the Middleware Module and Chapter 1 of the Integration Module for a discussion of messaging middleware and publish/subscribe models.

What are the implications of organizational design in real-time enterprises? At present, nobody knows for sure. The main ideas are that the organizational design has to be very efficient and flexible to respond to real-time decisions. The notion of virtual teams is very appealing in this context because different groups in different parts of an organization can be interconnected electronically to form new groups to respond for special situations. In addition, each group has to support "agents" that gather information about the various activities and report to the "management command center". This is an interesting area of research.

Table 13-2: Evaluation of Organizational Structures

Evaluation Criteria	Structure1	Structure2	Structure3
. Decision Effectiveness:			
- goal setting ease	3	4	5
- time required to make decision	5	2	1
- progress monitoring ease	5	4	4
- problem diagnosis ease	3	4	4
- openness to innovation	2	4	5
- standards and policy enforcement	2	3	4
- feedback facilitation	2	4	5
- path length reduction	3	2	4
2. Responsiveness to change			
- change in manufacturing process	2	2	2
- change in the market place	1	2	4
- change in organizational focus	1	2	4
3. Technology Utilization (see note 2)			

- computing technology	2	4	3
- communication technology	2	4	3
- software technology	2	4	3
- compatibility	3	4	5
4. Integration Effectiveness			
- coupling (interdepartmental communication)	2	3	4
- binding (intra departmental communication)	4	3	2
5. Human Resource Utilization			
- professional growth	2	3	3
- promotion opportunity	2	3	4
- job security	3	4	4
- employee turnover reduction	2	3	4
- burnout reduction	4	3	2
- productivity improvement	2	3	4

Notes:

1. Criteria: very good (5), good (4), soso (3), bad (2) , very bad (1), unknown(?)
2. Information technology is assumed to be part of the same functional unit

13.4.3 Centralization/Decentralization Debate

The impact of computerization on centralization (single site) and decentralization (multiple autonomous sites) management approaches has been debated since the 1970s. At issue is the effect of computerization on organizational decision authority and management control. Emergence of distributed computing technologies and the Internet has added new dimensions to this debate. The impact of distributed computing on centralization versus decentralization of enterprise activities has been discussed widely. Several reference models were developed, initially in computer integrated manufacturing for organizations to address the management problems of centralization versus decentralization of activities (see for example CIM-OSA [LaVie 1988] and CIMA [Campbell 1988]). Similar models have been developed for EC/EB in different industry segments. See, for example, the Telecommunications Management Forum (www.tmforum.org). What can be centralized and decentralized? Here is a partial list:

- Management decisions and control
- Application system planning
- Application development
- Application support
- Application deployment/operation (i.e., centralization/decentralization of data, programs and user interfaces)
- Computing equipment

Table 13-3 represents a typical situation in which four application systems (payroll, inventory control, order processing, online purchasing) are managed, planned, developed, deployed and supported in a modern environment. For example, all organizational activities related to payroll are centralized while all organizational activities related to online purchasing are decentralized. It can be seen from this table that a large number of centralization/decentralization configurations can be envisioned. How can we evaluate the "goodness" of these choices. Here are some factors:

- Computer hardware/software purchase and maintenance costs
- Network hardware/software purchase and maintenance costs
- Security, integrity, and configuration control
- Backup and recovery considerations
- Flexibility of services needed by the users
- End-user autonomy
- Performance of the system
- Availability and reliability of the system
- Organizational politics
- Staff training and morale considerations

Table 13-3: Example of Centralization/Decentralization of Applications

	Payroll	**Inventory control**	**Order Processing**	**Purchasing**
Planning	C	C	C	C
Development	C	C	D	C
Deployment	C	D	D	D
Support	C	D	D	D
Management	C	C	C	D

Note: C means centralized, D means decentralized

Although the technology has changed considerably over the years, the basic centralization/decentralization decisions have stayed the same. For example, the detailed discussion of the various centralization/decentralization choices and the evaluating factors given by King [King 1983] still holds. To illustrate the key points, we describe the models proposed by Rockart [Rockart 1977], Donovan [Donovan 1988], and King [King 1983]. **Error! Reference source not found.** shows the three models graphically. The analysis and examination of this topic by George and King [George 1991] concludes this section. It is not our objective to give a comprehensive treatment of the subject matter. Instead, we want to highlight the key ideas by looking at some classical literature in the field.

13.4.4 Impact on Management Roles

Information technologies are significant in changing the role of management. Classic work in this area is the paper by Leavitt and Whisler [Leavitt 1958]. They predicted that by the late 1980s, the combination of management science and information technology would cause middle management ranks to shrink, and top management to take more of the creative functions. Despite a great deal of criticism in the 1960s and 70s, we have seen that these two predictions became true by the late 80s. Let us review the changing roles of middle and top management.

The traditional thinking in management has been that the top management makes decisions and the operational staff carries out the decisions [Drucker88]. Thus, in typical organizations the decisions flow down and the information needed for decisions flows up (see Figure 13-10). The following comments reflect the thinking of many management theorists [Drucker 1988]:

> " It turns out that whole layers of management neither make decisions nor lead. Instead, their main, if not only function, is to serve as "relays"..."

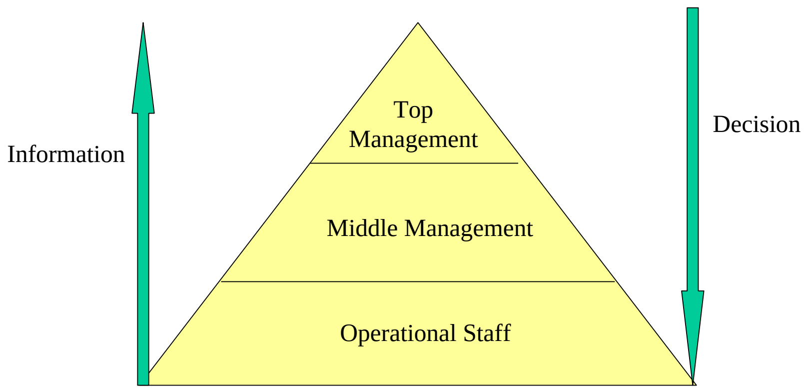

Figure 13-10; Traditional Organizational Model

With the availability of corporate wide networks with transparent end-user access to data at any site, top management can directly communicate their decisions to the operational staff and the information from the operational staff can be directly viewed by top management. This raises the question: What will be the role of middle management in such a case? Here are some thoughts and observations:

- The number of levels in organizations will decrease leading to more flat organizations. This was first observed in the late 1980s. For example, [Daner 1988, Drucker 1988] proposed that the typical "pyramid" organizations with 12 to 13 layers of management will evolve into flatter organizational structures (see Figure 13-11). One estimate indicated that organizations had eliminated more than a million middle management and staff positions between 1979 and 1987 [Applegate 1988]. This reduction in levels of management is also driven by the need to have a more responsive and efficient organization. For example, when Eastman Chemical Company split off from Kodak in 1994, it had $3.3 billion in revenue and 24,000 full-time employees. By 2000, it generated $5 billion in revenue with only 17,000 employees [Information Week, 2000].
- The operational staff will evolve into a staff of knowledge workers - subject area specialists who work with minimum supervision and who are motivated by feedback and recognition from peers. Initially recognized by Peter Drucker [Drucker 1988], this is becoming very true in the evolving digital corporations. The knowledge workers of today do not need a great deal of supervision, and use "networking" of talent that does not necessarily follow organizational boundaries (recall the discussion of virtual teams earlier). The number of middle managers for knowledge workers can be decreased by increasing the span of control of each manager. The span of control principle initially proposed by Lyndall Urwick [Urwick 1952] suggests that no person should supervise more than 6 direct subordinates whose work interlocks. This classical principle does not apply in the case of knowledge workers.
- Widespread use of information technology introduces new interdependencies and responsibilities which need to be managed by middle managers. For example, the introduction of Internet and Web applications increases the interdependencies between various hardware, software, and

organizational units which are becoming the responsibility of middle managers. See the discussion on interdependency management in Section **Error! Reference source not found.**.

- The middle managers need to take a more active role in leadership, innovation, and stress management of the operational staff because the role of middle management is more of team leaders and asset managers who are managing the most valuable asset of organizations - their people. The middle managers may be evaluated based on the appreciation/depreciation of the human asset in a manner similar to the fixed asset evaluation. For example, a manager is considered a better manager if an asset (e.g., a plant) grows in value under the manager.

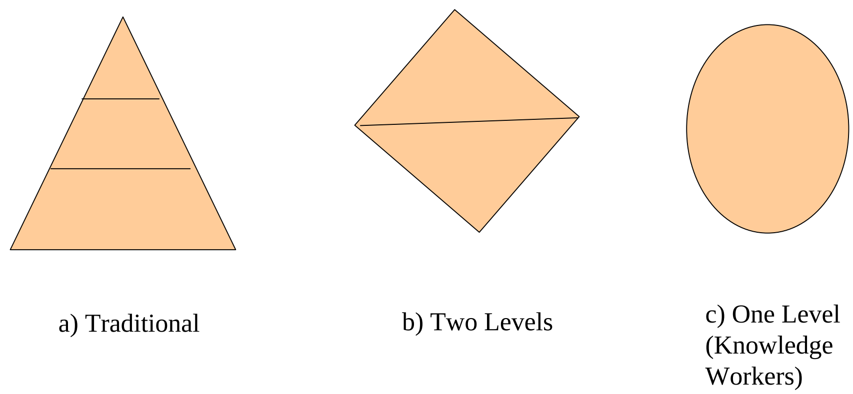

Figure 13-11: Three Forms of Organizational Structures

The role of top management is also changing due to information technologies:

- Information technologies have become an active tool for top managers to downsize and restructure organizations.
- Due to the availability of information about all aspects of an organization, top managers can have more centralized control.
- The decision making can shift from top management to middle management (decentralized decision making) for more responsiveness.
- Top managers do not just react to technology; they can use it to shape the organization.

It seems that the increased use of information technologies will continue to change the role of middle and top managers. Several predictions have been made since the 1980s when the role of IT on management was highlighted. Some have come true, the others have not so far (see the following sidebar).

"Information Technology and Tomorrow's Manager" – A View From The Past

Lynda Applegate, James Cash and D. Mills wrote a Harvard Business Review paper "Information Technology and Tomorrow's Manager" [Appelgate 1988]. This paper analyzed the Leavitt and Whisler paper and offered the following predictions for the twenty-first century (you decide how good their analysis turned out to be):

Organizational structure:

- Companies will have the benefits of small scale and large scale simultaneously (large companies will be able to react quickly like small companies).

- Even large organizations will be able to adopt more flexible and dynamic structures.
- The distinctions between centralized and decentralized control will blur.
- The focus will be on projects and processes rather than on tasks and standard procedures.

Management processes:

- Decision making will be better understood.
- Control will be separate from reporting relationships.
- Information and communications systems will retain corporate history, experience, and expertise.

Human resources:

- Workers will be better trained (perhaps some), more autonomous, and more transient.
- The work environment will be exciting and engaging.
- Management will be for some people a part-time activity that is shared and rotated.
- Job descriptions tied to narrowly defined tasks will become obsolete.
- Compensation will be tied more directly to contribution.

Time to Take a Break

- ✓ IS Planning
- ✓ Organizational Structures
- Development and Deployment
- Monitoring and Control

Suggested Review Questions Before Proceeding

- What are organizational structures and why are organizational structure design important in IS management?
- What are the tradeoffs between the classic organizational structures (functional, product, matrix) and which one would you choose for the widely distributed environments found in e-business?
- What are the main issues in organizational structures for the virtual and real-time enterprises?
- What is the essence of the centralization/decentralization debate – is it relevant in e-business?
- What is the impact of organizational structures on management roles?

13.5 Systems Development

13.5.1 Overview

;;; bring material from Laudon – systems development

So far, we have discussed how to plan and organize for distributed environments commonly found in e-business. Let us now turn our attention to the actual task of doing the work for which we have been planning and organizing (what a concept!). This task involves two service categories:

- Development and deployment of applications. This includes engineering of new and re-engineering of existing applications to satisfy business needs.
- Acquisition and installation of the enabling IT infrastructure. This includes the entire IT stack from networks to middleware services and application servers.

The organizational aspects of these two service categories are discussed in Sections 13.5.2 and 13.5.3, respectively. Each service category involves three issues:

- *The functions to be supported*. Examples of the functions are software development and testing, software purchasing, leasing, hardware/software installation, etc.
- *Type of components to be developed, acquired and installed*. Examples are application system modules, network devices, database managers, and middleware services.
- *Levels of support to be provided*. Support can be at two main levels: (1) consulting support in which a user is advised on what to order, how to order, and how to configure/install a component, or (2) "hands-on" support in which the service center actually orders, configures, and installs a component for a user.

In theory, an enterprise can support all functions, for all components at all levels. In practice, an enterprise makes choices in determining support levels due to resource and skillset shortages. In particular, many functions can be outsourced. Table 13-4 shows a framework that can be used to analyze and evaluate the acquisition/deployment activities of an enterprise. The rows of Table 13-4 show the service categories and the columns indicate the functions, the components and the support levels. This framework will be used to analyze the service categories in more detail in the following sections. For example, a company can outsource software development of specific applications or network operation of a remote site by using this table. Many companies are outsourcing maintenance of legacy systems to free their staff for new application development and letting companies such as EDS run the enterprise networks (see Section 13.5.4 for additional discussion).

Table 13-4: A Framework for Analyzing Development/Acquisition Support

Service Categories	Functions Supported	Components Supported	Levels of Support
Application System Development and Deployment	- Analysis - Design and architecture - Development/purchase - Integration and migration - Installation	- User interfaces - Programs - Databases	- Consulting - Hands-on - Tools and environments
Infrastructure Acquisition and Installation	- Analysis - Product evaluation - Pricing/policies - Installation and integration	- Network devices - Computing platforms - System software - Middleware	- Consulting - Hands-on - Tools and environments

13.5.2 Development and Deployment of Distributed Applications

Development and deployment of distributed applications for EB requires engineering of new and re-engineering of existing, including legacy, applications. Engineering of new applications to support EB involves the following generic functions:

- Specification and analysis of requirements that are driving new application development.
- Design of an application architecture which satisfies the functional, interoperability, portability and integration requirements and conforms to the necessary standards.
- Development of new application system components (programs, user interfaces, databases) and based on the middleware services (e.g., Web Services, .NET, J2EE).
- Development, purchase and/or customization of "adapters" that glue the new system components with existing applications
- Installation and configuration of new application system components
- Centralization/decentralization of implementation activities.

The re-engineering of existing applications requires a great deal of issues that include integration, data warehousing, and migration analysis. The "Architecture" and "Integration" Modules of this book discuss the application engineering and re-engineering issues in great detail.

These engineering/re-engineering functions can be performed by a centralized development/deployment group or can be decentralized. The main advantage of centralized development/deployment is maximization of developer time. According to the framework shown in Table 13-4, these functions can be applied to different application components (user interfaces, application processing programs, databases). The support may include consulting, hands-on support (build the application software), and tools/environment (e.g., CASE tools). The following scenarios illustrate the choices (we will consider outsourcing later):

- A completely centralized development/deployment group which performs all analysis, evaluation, implementation and installation for all application systems components. This represents a software house which develops/deploys all software in an enterprise. This group can enforce standards and corporate policies. However, this group falls apart quickly if it cannot keep pace with the demands to introduce new and modify existing systems quickly.
- A completely decentralized development/deployment operation where all functions for all application systems at all support levels are conducted by the users. This represents an information center or end-user computing option where the end users select and install their own packages (usually word processing, spread sheets, databases, web-based query processors and packaged applications) on their own workstations. This approach gives a great deal of freedom to the end-users but is not conducive to corporate standards and enforceable policies
- A distributed development/deployment operation which centralizes few functions for few components at few support levels. The rest of the functions are decentralized. For example, the centralized department may provide consulting and guidance on user interface design, software design and database design; leaving the implementation and installation to the users. This represents a technology transfer center which is responsible for overall direction for application development in the enterprise and is a good compromise between complete centralization and decentralization. The main management challenge is to decide what to centralize and what not to (so what is new!).

13.5.3 Acquisition and Installation of Enabling IT Infrastructure

The acquisition and installation of hardware and software needed to support the applications for e-business involves the following generic functions:

- Analyzing user requirements. The users of this infrastructure are the EB applications at C2B, B2B, and other levels.
- Evaluating and selecting vendor hardware/software which satisfies the user requirements
- Establishing pricing structures (e.g., bulk purchase rates, maintenance prices) with selected vendors
- Establishing procedures for administrative approval before an order is sent to a vendor
- Receiving and verifying ordered components
- Installing, testing, and configuring the ordered components.

In a manner similar to the applications development, these functions can be performed by a centralized purchasing/installation center or can be decentralized to end users. The main advantage of centralized acquisition/installation, as mentioned previously, is enforcement of standards and policies. Centralized systems can also direct the users to common software usage across all environments in an enterprise. However, centralized purchasing and installation can be quite slow in large organizations. In such cases, "regional" purchasing and installation may be more appropriate.

In addition, according to the framework shown in Table 13-4, these functions can be applied to different types of infrastructure components and can be provided at different support levels. For example, the infrastructure components to be ordered and acquired may be workstations (memory, I/O devices, CPU model), network hardware/software (LAN software, cables, modems, routers, bridges, gateways, etc.), and middleware packages (web servers and browsers, web gateways, distributed database managers, client/server packages, directories, and application servers for mobile and EC/EB applications). The “Networks”, “Middleware” and “Platforms” Modules of this book discuss the IT infrastructure in great detail.

A great deal of effort is needed to support the growing number of IT infrastructure components. The support can be at the consulting level only where the user receives guidance in selecting the appropriate components to be ordered and then receives instructions on how to install the systems. This may be extended to administration where all the selection, evaluation, installation and configuration is done by a central purchasing/installation group.

Naturally, the choice of centralization/decentralization depends on the type of components and the level of support. The following scenarios illustrate the choices:

- A completely centralized purchasing/installation center, which performs all functions for all components at all support levels. Due to complete centralization of all decisions and activities, this scenario is only appropriate for small enterprises.
- A completely decentralized purchasing/installation operation, where all functions for all components at all support levels are conducted by the users. This scenario is appropriate for large decentralized enterprises.
- A "distributed" purchasing/installation operation, which centralizes a few functions for a few components at a few support levels. The rest of the functions are decentralized. For example, the centralized purchasing/installation may just provide consulting and guidance on LAN acquisition and installation, leaving the actual ordering and installation to the users. This scenario may be appropriate for many enterprises.

13.5.4 Outsourcing the IT Infrastructure

Outsourcing, i.e., hiring someone else to do a job on your behalf, has been an attractive business practice for several years. A wide range of service providers (SPs) in the Internet economy are making it possible for companies to outsource many of their services. Simply stated, a service provider offers you a set of services based on an agreed upon contract. The services can be business services such as physical site security or technical services such as Web hosting. It is theoretically possible for a newly formed company to outsource *everything* by using a variety of service providers. That is the essence of a ***virtual enterprise*** -- it relies exclusively on outsourcing. Thus outsourcing is a very attractive choice for IT infrastructure in the planning process.

Different service provider models, centered around the Internet, are becoming popular to facilitate outsourcing. For example, businesses and consumers can rent services from service providers such as the following (see Figure 13-12):

- *Network service providers (NSPs)* that provide the network "pipe" (end to end network communication and routing services) for Ebusiness. Examples of NSPs are the Telecommunications companies that include a variety of local exchange carriers and long distance carriers.
- *Internet Service Providers (ISPs)* that support Web services and provide access to the public Internet. America Online is a well known example of ISPs.
- *Platform Service Providers (PSPs)* that provide the platform services (computing hardware, operating systems, basic middleware) needed to support eCommerce or other applications for buying and selling over the network. PSPs in essence are similar to the old "computing centers" that provided the computing hardware/software for business applications. Due to the emphasis on eCommerce, PSPs are also referred to as CSPs (commerce service providers). Examples of PSP/CSPs are Rightworks.com, CommerceOne, and Ariba.net.
- *Application Service Providers (ASPs)* host application components (mostly business aware) that clients use over a wide area network. A very wide range of ASPs have emerged in recent years with services that range from payroll to inventory control. For example, major software vendors such as SAP, Oracle, and Peoplesoft are becoming ASPs . We will discuss ASPS in more detail later.
- *Business Service Providers (BSPs)* that provide business services such as mail delivery, customer support, and building security.

Cost and time saving are the two basic drivers for outsourcing through SPs. Figure 13-13 shows the basic cost motivation. Let us take the example of a startup software company to illustrate the basic idea. This company needs to use a variety of applications such as payroll, inventory, purchasing, order processing, etc., to get started. Buying, installing, and running these applications and the underlying platforms would require an up-front cost even when there are none or very few customers. Outsourcing, i.e., renting these applications from an SP, can be much more economical on a per usage basis. However, as the customer base grows, the cost of renting may exceed the cost of owning as shown in Figure 13-13. In addition to cost savings, time savings can be a big factor in outsourcing – you can use services more quickly from a service provider than by struggling through your own purchase, acquisition, and install cycle. According to the ASP Forum (www.aspforum.com), building your own infrastructure needs at minimum 8 months to a year for a small company while it can be done in a matter of weeks by using SPs. For example, ASPs like Corio can support a new customer in 4 to 14 weeks for large applications that may require several months to purchase and set up. According to the ASP forum, customers can also save between 30 to 40% by using an ASP model.

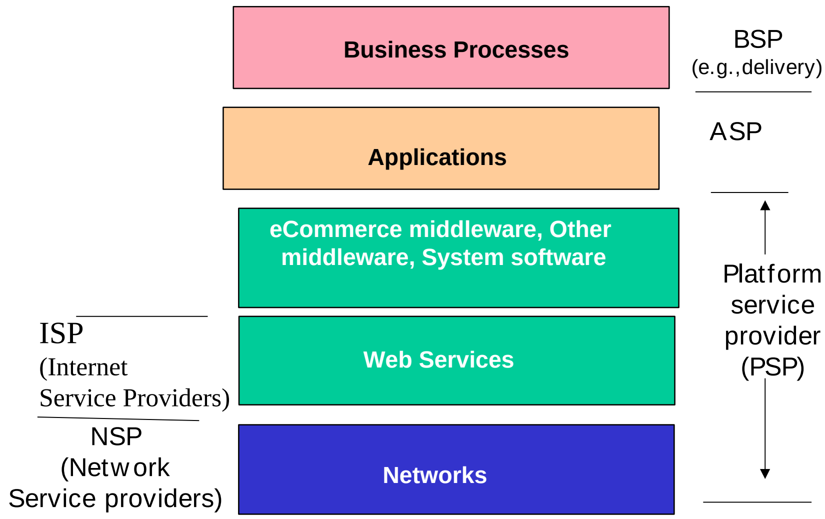

Figure 13-12: Types of Service Pproviders

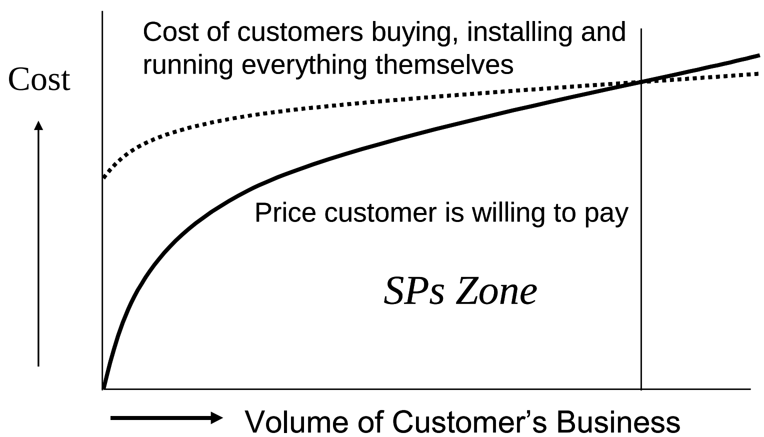

Figure 13-13: Cost Motivation for using Service Providers (SP)

Outsourcing does raise several management issues. For example, once your systems have been outsourced, how do you maintain control over your systems? Your customers still demand quality service whether you support the systems yourself or through a service provider. A successful working relationship with your SP is naturally essential. For example, a joint management of the outsourced assets needs to be negotiated. In addition, service level agreements (SLAs) need to be spelled out clearly as part of the contract and these, plus other, agreements need to be managed on a day-to-day basis. Finally, once a long range relationship with an SP has been established, then it is a good idea to help the supplier strengthen its operations. For these, and other outsourcing management issue, see [McNurlin 2001, Chapter 8). Chapter 2 of the Applications Module describes outsourcing options in detail. More information about different aspects of outsourcing can be found at the site (www.outsourcing-research.com).

Time to Take a Break

- ✓ IS Planning
- ✓ Organizational Structures
- ✓ Development and Deployment
- Monitoring and Control

Suggested Review Questions Before Proceeding

- What are the unique issues in the development and deployment of distributed applications?
- What is the role of outsourcing in development and deployment of IS? When should these activities be outsourced and when not?
- What are the unique staffing and training considerations to run a digital enterprise?.

13.6 Monitoring and Control of IT Assets

13.6.1 Overview

Once the systems have been developed and deployed, they need to be monitored and controlled on an on-going basis. This includes important issues such as security and fault tolerance of networks, databases, web servers, etc. For a systematic review, monitoring and control of resources in a distributed environment can be discussed in terms of the following three issues:

- **Type of resources to be monitored and controlled**. This could include the entire stack starting from networks to applications and business processes. As expected, e-business systems are based on a complex IT infrastructure that spans a multitude of sites and consists of wireless and wired networks, financial and customer databases, directories and catalogs, sophisticated middleware packages such as mobile application servers, mission critical applications, and the desktops, mainframes, and minicomputers that run the enterprise applications. These technologies need to be monitored and controlled as valuable assets because not only the information systems but also several business functions rely heavily on these technologies.
- **Monitoring and control functions to be supported**. Examples of the functions are fault management (detecting, diagnosing and recovering from faults), performance management (monitoring, controlling and predicting performance), security (protecting resources from unauthorized users), configuration management (defining, changing, monitoring and controlling), accounting (recording usage of resources and generating billing information), and operational support (help desks, backup and recovery, and automated operations).

- **Level of support to be provided**. Support can be at two main levels: (1) consulting support in which a user is advised on how to monitor and control the resources, and (2) "hands-on" support in which the service center actually monitors and controls the resources for a user.

Table 13-5 shows a framework that can be used to analyze and evaluate the monitoring and control of computing resources of an enterprise. The rows of Table 13-5 show the functions and the columns indicate the type of components and levels of support. This is very similar to the frameworks introduced earlier in this chapter (by now you must be used to them!). Sections 13.6.2 and 13.6.4 review the service categories in more detail. Many network and distributed applications management tools are being developed and integrated into "Management Platforms", discussed in section 13.6.3.

Table 13-5: Monitoring and Control

Service Categories	Functions Supported	Components Supported	Levels of Support
Fault Management environments	.fault detection .fault isolation .fault resolution	.network .hardware .application interconn. software software	.consulting .hands-on support .tools and .application
Configuration Management environments	.component description .access rights .interrelat-ionships .change management	.network .hardware .application interconn. software software	.consulting .hands-on support .tools and .application
Accounting and security environments .administrative	.encryption and privacy .authent-ication .alarms .access rights .audit trails	.network .hardware .application interconn. software .computers	.consulting .hands-on support .tools and .application software control
Performance	.performance monitoring	.network .hardware	.consulting .hands-on

Management	.performance analysis .performance tuning	.application interconn. software	support .tools and .application environments
Operational support	.helpdesk (hotlines) .operations .system administration .customer support	.network .hardware .application interconn. software	.consulting .hands-on support .tools and .application environments

13.6.2 Monitoring and Control Functions: Faults, Security and Performance

The particular issues in monitoring and control can be discussed in terms of the following services:

- Fault Management. Fault management is concerned with detecting, isolating, and correcting faults in the networks as well as the application systems. The basic goal of fault management is to provide smooth and fault free operations. The fault management functions needed depend on the nature of applications and the networks being managed. Since down-time is intolerable in most EB applications, the fault management must be proactive (i.e., it should forecast faults and provide support to prevent fault occurrence).
- Security Management. Security is concerned with authentication which verifies and controls the access of resources, confidentiality to assure privacy of data and the access to data, integrity to ensure that information is not altered or corrupted as it flows through a system, audit trails which record the various security related events, and other security services such as non-repudiation.
- Performance Management. The goal of performance management is to maintain system performance at levels which satisfy user response time requirements. The overall response time of the system should be maintained at acceptable levels even if the workload on individual system components (network cables, routers, web servers, databases, dictionaries, etc.) varies.
- Configuration Management. Configuration management facilitates the normal and continuous operation of distributed applications and the networks. It works with other management functions, such as fault and performance management, to correct or optimize the system's performance.
- Accounting Management. This involves recording usage of system resources and generating billing information

These services are known as ***FCAPS (Fault, Configuration, Accounting, Performance, Security)*** and are at the foundation of the 'Management Platforms" introduced in the next section. Although all of these services are important, security and fault tolerance are of particular importance in the modern digital corporations. We will discuss these two, with special attention to security, in the next chapters of this module.

13.6.3 Management Platforms – Technologies to Manage Technologies

Simply stated, a management platform is a collection of technologies that help enterprises manage their IT assets (networks, computers, databases, applications, middleware, etc,). Ideally, these platforms help in the management of ***FCAPS*** at all levels (from business processes to the network and computing hardware devices). These service categories can be discussed in terms of the framework introduced in Table 13-5. The first, and by far the most popular, example of management platforms is the network management platforms that were introduced in the late 1980s. At present, the management platforms monitor and control entire "systems" that consist of networks plus the hosts (computers, databases, middleware, system software, and applications).

Figure 13-15 shows an idealized view of a management platform that manages a large number of "subjects" (***managed systems***) in an organization. The managed systems are the IT resources that must be managed by an enterprise for its day-to-day business (e.g., networks, databases, middleware, computers, etc.). The management platform itself consists of many sub-managers (e.g., network services manager, middleware services manager, application managers) that manage individual services of the managed systems. ***Agents*** In each managed system keep the managers informed. For example, an agent for Oracle databases could keep track of Oracle database status and inform the managers about the health of these databases. The management agents supply information to a ***control panel*** for display and also take commands from the control panel to start/stop/reconfigure the managed systems. The terms distributed systems management and management platforms are often used interchangeably because management platforms are intended to manage all distributed system resources[3]. Many management platforms are commercially available at present. Examples are IBM Tivoli, Computer Associate Unicenter, HP Openview, and BMC Patrol. Management platforms are discussed in detail in the next chapter.

[3] The term "system" is used in IT to typically represent all IT resources such as applications, databases, the computers that house them, and the networks that interconnect them. These resources are, naturally, distributed at various sites.

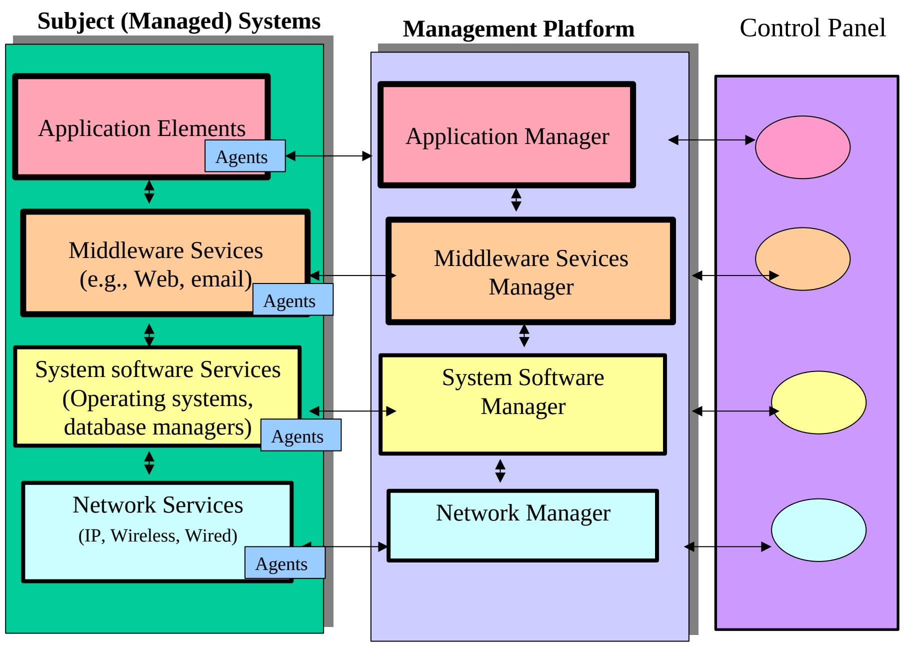

Figure 13-14: Management Platforms -- An Idealized View

13.6.4 Customer Contact and Operational Support

The customer contact and operational support is concerned with the day-to-day activities needed for a smooth operation. These services include the following:

- Help desk (hotline) support, where the users can call for information and to report problems with the system
- Operations, which involves system startup/shutdown, backup/recovery and failure recovery
- System administration, which involves user profile management and resource utilization monitoring
- Customer support, which shows the customers how they can best utilize the services.

These functions are usually performed by a customer support organizational unit which is the main point of contact between the users and information system services. According to the framework shown in Table 13-5, these functions can be applied to different component types and can be provided at different support levels. For example, customer support may be provided for workstations, for networks and for application systems. The customer services can be at the consulting level only where the user receives guidance in day-to-day operations. On the other hand, the customer service may be provided by one or more customer support organizational units, with staff and associated hardware/software tools. In large organizations, the customer service centers resemble control centers in the airline industry, with dozens of consoles and monitors. These centers are equiped with VOIP (voice over IP), web-based self help tools, and links to customer relationship management (CRM) systems.

These functions are difficult in distributed systems for two reasons: the large number of network and application system configurations to be supported, and the interdependencies between the various systems and subsystems. It is not easy to train and retain the user consultant and operations staff. For example, it may be necessary to consolidate different hotlines (network hotlines, IBM hotline, LAN hotline, Unix hotline, web services hotline, desktop services hotline, etc.) into a single unit so that the users call one number to get help. The single unit can maximize staff cross-training opportunities and can be used to provide performance and fault management functions. It can also serve as the central point for a consolidated CRM system.

Suggestion: We are going to start discussing something slightly different. This may be a good time to take a break

13.7 Review Questions and Exercises

1) Develop a table to show the main management processes and the tools available for each process.
2) Describe different levels of planning in organizations and describe the levels which are of importance in modern distributed systems.
3) List the major issues in organizing for modern distributed systems.
4) List the major issues and approaches in centralization/decentralization of distributed systems.
5) Describe the acquisition and deployment policies of a company that you are familiar with.
6) Describe the monitoring and control policies of a company that you are familiar with.
7) Consider an information system that you are familiar with and work through it as shown in Section **Error! Reference source not found.**.
8) List the management issues, in order of priority, that have not been addressed adequately in the current literature.

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13.9 Management Platforms

13.9.1 Introduction ;;;;

My boss in a previous job in the late 1980s used to say "There are always management solutions to the technical problems but there are no technical solutions to the management problems". He was fundamentally wrong! The emergence of "management platforms" that monitor and control enterprise networks and other resources most certainly go against his argument. In the real-time enterprise model being adopted by GE and other corporations, the real-time status of *business* activities critical to the company's day-to-day operations is displayed and acted upon. In case of GE, for example, a large screen displays an array of green, yellow, and red icons that represent the status of GE's operations around the globe (see Dave Lindorff, " GE's Drive to Real-Time Measurement", CIO Magazine, November 11, 2002). The goal of real-time enterprises is to monitor mission-critical operations such as sales, daily order rates, inventory levels, and other important activities across the company's different businesses wherever they are. The management platforms can be at the center of the real-time enterprises. What are these management platforms, what do they do, and why are they needed? These are the main questions that guide the discussion in this chapter.

Simply stated, a management platform is a collection of technologies that help enterprises manage their IT assets (networks, computers, databases, applications, middleware, etc.). Ideally, these platforms help in the management of ***FCAPS*** (Fault, Configuration, Accounting, Performance, and Security) at all levels from business processes to the network and computing hardware devices. The basic idea is to manage IT assets in a manner similar to management of any other corporate resource such as capital and buildings. Management of IT assets is of crucial importance to e-business because 50 to 80% of the enterprise business relies on the computers, the databases that reside on the computers, and the networks that interconnect them. The increased use of Internet, web sites, enterprise LANs, wireless networks, and web-based applications is highlighting the role of IT in modern organizations. Consider the disasters in the financial industry, stock markets, and airlines if their IT infrastructure failed.

As the reliance of organizations on IT has increased, the size (number of users, number of computers, number of lines, number of databases, number of applications, and number of middleware services) has also increased and so has the complexity (number of vendors, device types, interconnectivity options, voice/data communications, architectures and protocols, etc.). For example, corporate offices have to manage devices and databases that are hundreds of miles away from the central site (in fact, the corporate staff has never seen them). Due to the combined reasons of importance, size, and complexity, most organizations have realized that it is essential to manage IT assets as much as possible through “management platforms” that can help diagnose/correct the performance, security, and other problems before disasters occur. To meet this market need, management platforms from IBM, Computer Associates, HP, and others have emerged in the marketplace.

This chapter exposes the reader to the evolving area of management platforms that manage the enterprise networks and the enterprise systems that use the networks. Our objective is to define the main concepts and the terminology associated with management platforms, and describe the pertinent standards, products, approaches and techniques. The reader of this chapter should be able to answer the following questions:

- What is a management platform and why is it so important to enterprises?
- How have the management platforms evolved from network management to systems management?
- What are the main standards and technical approaches in this area?
- What are the main products, what do they do, and what are the open questions?

13.9.2 Management Platform Concepts

As stated previously, a management platform is a collection of technologies that support the following functionalities ***(FCAPS)*** at all levels (from business processes to the network devices):

- Fault management - detecting, diagnosing and recovering from faults
- Configuration management - defining, changing, monitoring, and controlling resources and data

- Accounting - recording usage of resources and generating billing information
- Performance analysis - monitoring current and long term performance of the system
- Security - ensuring only authorized access to system resources

We will use these functions throughout this chapter as a framework for describing and evaluating various management platform approaches and products. Sections 13.9.3 through 13.9.7 review these functions.

The first, and by far the most popular, example of management platforms is the **network management platforms** introduced in the late 1980s. At present, the management platforms monitor and control entire "systems" that consist of networks plus the hosts (computers, databases, middleware, system software, and applications). Figure 13-15 shows an idealized view of a management platform that manages a large number of "subjects" (***managed systems***) in an organization. The managed systems are the IT resources that must be managed by an enterprise for its day-to-day business (e.g., wireless and wired networks, financial and customer databases, directories and catalogs, mission critical applications, and the desktops, mainframes, and minicomputers that run the enterprise applications). The management platform itself consists of many sub-managers (e.g., network services manager, middleware services manager, application managers) that manage individual services of the managed systems. ***Agents*** In each managed system keep the managers informed. For example, an agent for Oracle databases could keep track of Oracle database status and inform the managers about the health of these databases. The management agents supply information to a ***control panel*** for display and also take commands from the control panel to start/stop/reconfigure the managed systems. The terms distributed systems management and management platforms are often used interchangeably because management platforms are intended to manage all distributed system resources[4].

In reality, these platforms can be extended to support real-time enterprises. As discussed in Chapter 5, GE, Intel, and many other corporations are adopting the real-time enterprise model in which the real-time status of business activities critical to the company's day-to-day operations is displayed and acted upon. GE's goal is to monitor, once every 15 minutes, GE's mission-critical operations across the company's 13 different businesses around the globe. The icons of up-to-the-minute *business* performance across the company are checked regularly by *agents* that send test transactions to exercise various business operations such as an online purchase. As compared to network management agents, these agents capture business related information such as the number of customers who have not paid their bills yet. Real-time companies are building digital nervous systems that connect all business processes to a management console (see Figure 13-16). An interesting research question is: can the current breed of management platforms as discussed in this chapter be extended to serve as "enterprise management platforms"?

[4] The term "system" is used in IT to typically represent all IT resources such as applications, databases, the computers that house them, and the networks that interconnect them. These resources are, naturally, distributed at various sites.

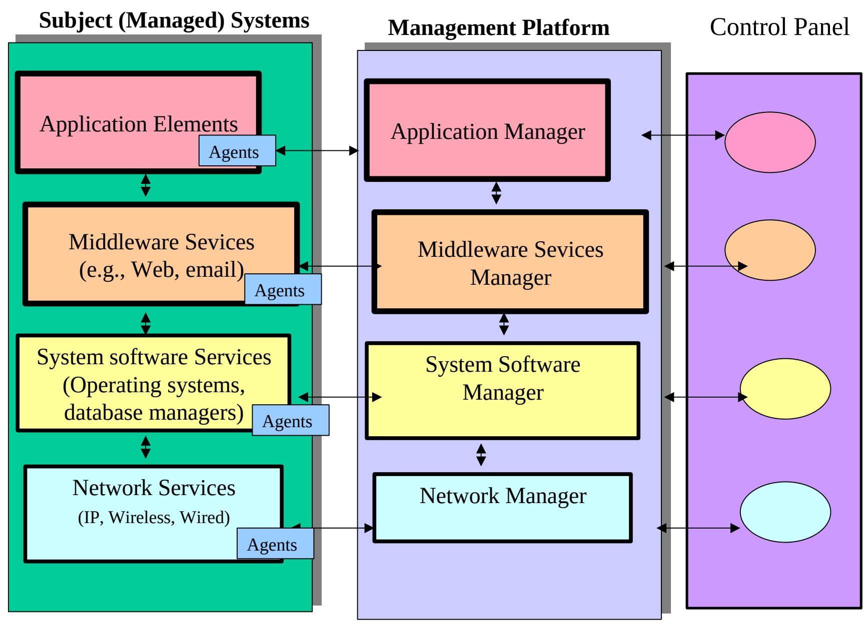

Figure 13-15: Management Platforms -- An Idealized View

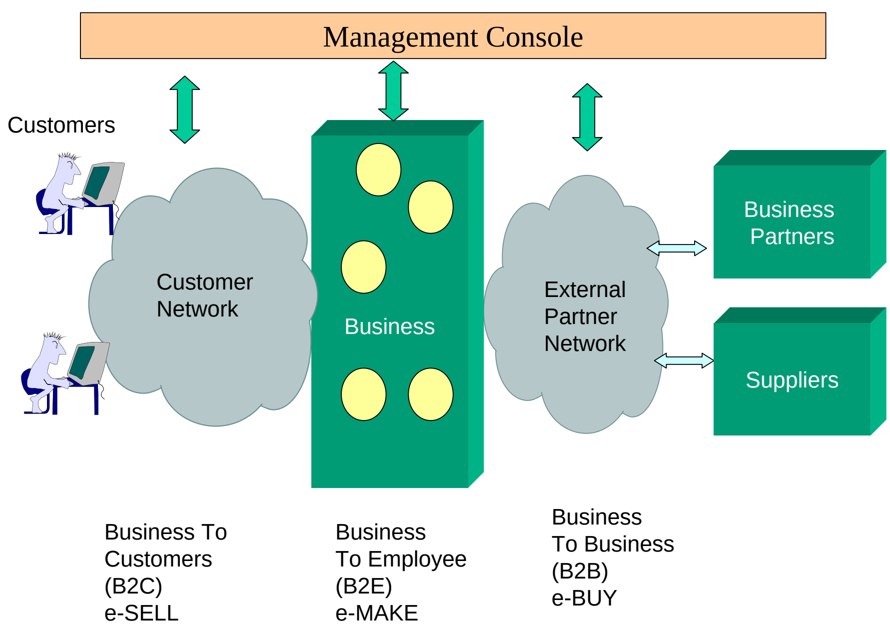

Figure 13-16: Conceptual View of a Real-Time Enterprise

The management platforms, as stated previously, are responsible for managing the FCAPS (Fault, Configuration, Accounting, Performance, Security) of the managed systems. Sections 13.9.3 through 13.9.7 review the FCAPS functions and Section 13.9.8 gives an architectural overview of the management platforms. Later sections of this chapter elaborate on these platforms. Many management platforms are commercially available at present. Examples are IBM Tivoli, Computer Associate Unicenter, HP Openview, and BMC Patrol. However, as we will see, most of these COTS platforms cover only a few of the FCAPS (mainly fault management) at only one or two levels (mainly network and computer hardware). Thus the conceptual view shown in Figure 13-16 is an idealized view at the time of this writing that serves as a good framework for discussion and analysis.

13.9.3 Fault Management Overview

Fault management is concerned with detecting, isolating, and correcting faults in the networks as well as the application systems. Since down-time is intolerable in most EB applications, the fault management must be proactive (i.e., it should forecast faults and provide support to prevent fault occurrence). The basic fault management functions are as follows:

- Fault detection which includes detecting faults in the individual components or the paths between the components, providing notification of the detected faults, and predicting faults before they occur.
- Fault isolation which includes determining the failing component and/or components which are causing the problem.
- Fault resolution which includes determining the corrective actions and then executing them if possible.

These functions can be performed by a centralized unit which remotely monitors the system for faults, or can be decentralized to end users. In addition, these functions can be applied to different component types and can be provided at different support levels. For example, fault management may detect and correct faults in workstations, network components (LAN hardware/software, cables, modems, routers, bridges, gateways, etc.), middleware services (web servers, client-server packages, etc.), and the application systems. Support can be at the consulting level only where the user receives guidance in fault detection and correction. Support may also be embedded in software packages which help users diagnose and correct their own problems or it may go a step beyond and heal the fault ("self healing systems"). Self healing and self-repairing systems are interesting areas of software research. See, for example, the ACM SIGSOFT Workshop on Self Healing Systems at Carnegie Mellon (http://www-2.cs.cmu.edu/~garlan/woss02/) and the International Workshop on Self-Repairing and Self-Configurable Distributed Systems (RCDS 2002) at Osaka, Japan (http://www.jaist.ac.jp/~defago/RCDS_2002/)

Fault management in distributed computing is a complex activity, especially if all components are to be managed automatically. It requires correlation of a large number of inputs from network devices and application system components to detect trends and isolate problem areas. This is an excellent application area for expert systems. As we will see later, many expert systems have been and are being built for network fault management. These tools need to be extended to distributed applications management.

It is important to emphasize the role of management commitment on proactive fault management throughout the enterprise. It is also critical to recognize that a collection of tools, no matter how sophisticated, is of little value without proper management vision and approach. As distributed systems depends to a great degree on network availability, network management tools and policies/procedures become increasingly important. A management approach to use these tools and environments effectively for proactive fault management is essential.

13.9.4 Performance Management Overview

The goal of performance management is to maintain system performance at levels which satisfy user response time requirements. Performance management includes the following:

- Performance monitoring to measure system activities (e.g., arrival rates, queues being formed, bottlenecks, performance thresholds)
- Analysis/prediction to assess the results and impact of performance measurement on response times
- Tuning to adjust resources (e.g., adjusting network traffic) to improve system performance

These functions can be performed by a centralized center which remotely monitors the system for performance bottlenecks. These functions can be applied to different component types and can be provided at different support levels. For example, performance management may detect and correct performance problems in workstations, network components, middleware services, and application systems. Performance management services can be at the consulting level only where the user receives guidance in performance measurement and correction. These services may be embedded in performance measurement software packages which help users diagnose and correct their own problems. A variety of performance monitoring, tracing, and prediction tools are becoming commercially available.

Performance evaluation in distributed computing systems is complicated due to the large number of interacting components. For example, in a large network, a message goes through several routes before it reaches its destination. It can be delayed at several points due to congestions at any of the intermediate stations or gateways. In addition, a relational database join between two tables residing at two different stations can send a burst of messages across the network which can cause network congestion. If many tables in the network are being joined across the network, then it becomes very difficult to predict and tune the system performance. Performance of realtime distributed systems is an area of great importance because in such systems performance degradation can cause serious problems. For example, in a flexible manufacturing system (FMS), a performance problem can bring a factory to a halt. Performance management in such environments requires a large number of inter-related variables, including communication problems due to noise and heat.

It is desirable to automate the distributed systems performance management as much as possible. Many tools for network performance monitoring are currently available. However, these tools have not been extended to include the issues of distributed applications management such as remote relational joins and client-server performance considerations. This is expected to be an area of future development.

An issue of particular importance is the performance of integrated systems ('system of systems problem"). In these systems, many systems are meshed with each other by using integration technologies discussed in the "Integration" Module. Consider, for example, an order processing system from SAP that is integrated with an inventory system from Oracle. The suppliers (SAP and Oracle in our case) provide many options which can be configured to tune and improve the performance of their own systems but who is responsible for the integrated system -- Oracle or SAP? It becomes the responsibility of the users to properly tune the integrated system for performance and manage its performance through appropriate monitoring tools and techniques. These tools are needed for any system. However, for integrated systems it is primarily the responsibility of the user of the system. The main difficulty is that without automated aids it is extremely difficult to monitor and tune the performance of a system that has been "assembled" from a variety of systems supplied by a multitude of vendors. Conformance to standards really helps in such situations.

13.9.5 Security Management Overview

Security services include the following major functions (PIAAA):

- Privacy (confidentiality) to assure privacy of data and the access of data
- Integrity to ensure that information is not altered or corrupted as it flows through a system
- Authentication which verifies and controls the access of resources
- Authorization which controls the access of information
- Accounting that includes non-repudiation to assure that a sender cannot say that he/she sent something and the receiver cannot say that it received something

A variety of tools and techniques have been introduced to address these and other security concerns. The key technology is encryption/decryption to scramble the data so that unauthorized users cannot understand it even if they can see it. Audit trails to record the various security related events for non-repudiation are a well established approach. In addition, security information management tools have been developed to provide administrative tools for creating and managing user profiles for access control. An important technique is security alarm reporting to send alerts about security violations.

These functions can be applied to different component types and can be provided at different support levels. For example, security may be enforced at workstations, at network access and at the application resource level. The security services can be at the consulting level only where the user receives guidance in security procedures. The service may be embedded in security software packages which automate the security management. In the absence of adequate software packages, administrative policies are usually introduced with appropriate penalties (if you are caught accessing unauthorized data, you loose your job and/or are subjected to criminal prosecution).

Distributed systems introduce many security risks due to the widespread use of workstations and networks which are accessed by hundreds of users. The information transferred over networks is also quite sensitive because it carries corporate financial and strategic information. Many security and authentication packages are currently available (e.g., Kerberos on Unix and Resource Access Control Facility on IBM mainframes). Protocols and standards for security in distributed computing are evolving. An early review of different authentication protocols in distributed systems was given by [Woo 1992, Fireworker 1992]. Standards for open systems security have progressed at two levels: security architectures and application security. The OSI security architecture, originally defined in the ISO document 7498-2 (1984), has been refined for Authentication, Access Control, Confidentiality, Integrity, and Non-repudiation. The next two chapters of this Module provide a detailed discussion of security issues.

13.9.6 Accounting Management Overview

The issue of accounting and billing in distributed computing is concerned with the difficult issue of allocating costs based on resource utilization. Most organizations have specialized accounting and billing procedures which need to be extended for distributed computing. The main challenge in this area is to determine the originator of resource utilization and charge him or her for the expenditure. The difficulty is that one exchange between two processes at two stations can generate secondary traffic messages, which are often difficult to associate with the original exchange. At the core of accounting management are different logs, with associated formats, that have evolved over the years to capture system activity. For example, the Object Management Group (www.omg.org) has defined different log formats, a common log format (CLF) exists for web servers, and router logs are kept by routers to keep track of IP traffic. Based on the activity recorded on the logs, different accounting methods are used to calculate the billing.

Numerous accounting management systems for distributed computing are commercially available from companies such as Computer Associates, IBM, and others (e.g., the Comprehensive System

Accounting package for Linux (http://oss.sgi.com/projects/csa/)). Most of these packages are sets of C/C++/Java programs and shell scripts that provide methods for collecting and reporting system utilization data. Typical accounting management systems monitor and report on the usage and efficiency of the computer system with reports for capacity planning and departmental and user billing. They provide the following capabilities usually through GUIs:

- Setting up an accounting system
- Generating system accounting reports
- Generating bills and, optionally, emailing them
- Generating reports on system activity
- Summarizing accounting records
- Showing system activity (i,e., how many jobs are running, how much is CPU utilization per job, etc.)
- Showing process time
- Showing CPU usage
- Showing connect time usage
- Showing disk space utilization
- Showing printer usage
- Offline archiving of accounting data
- User exits for site specific customization of reports

13.9.7 Configuration Management Overview

Configuration management for distributed computing facilitates the normal and continuous operation of distributed applications and the networks. It works with other management functions, such as fault and performance management, to correct or optimize the system's performance. Configuration management functions include the following:

- Keeping information about the release and version of the various hardware and software components of the environment (workstation software, LAN software, application software)
- Establishing and recording the interrelationships and the interdependencies between the various components of the environment (e.g., network configuration, application configuration)
- Establishing enterprise-wide standards for systems and subsystems to make system integration easier
- Clearly defining the functions and the interfaces between the components
- Specifying the guidelines and responsibilities for change management and control at the local as well as global levels.

These functions can be performed by a centralized configuration management system or can be decentralized to the end users. Some centralized configuration management is essential for the enforcement of standards and policies. However, "regional" configuration management is appropriate for large enterprises. These functions can be applied to different component types and can be provided at different support levels. For example, the components to be managed may be workstation files/programs, LAN software, and/or application files and programs.

13.9.8 Management Platform High Level Architecture

Figure 13-17 shows conceptually how overall system management for FCAPS can be achieved in large scale systems. Figure 13-17a shows a single level model in which a global (enterprise) manager directly communicates with the managed objects. A managed object can be a network cable, a router, a laptop, or a database. This model works well for small or homogeneous networks in which all managed objects communicate with the global manager by using the same protocol. Figure 13-17b shows a more realistic situation for large heterogeneous networks with different devices from different vendors. In this case, the enterprise manager communicates with different domain managers where each domain manager supervises its own network of devices (managed objects). This is called "tiered" or hierarchical systems management. The management commands are used to query status and startup/shutdown the managed objects, if needed.

Standards are needed in systems management to provide an enterprise wide approach. Standardizing efforts have proceeded in two general directions:

- **Management protocols.** These are the protocols that specify the communications between the objects being managed and the programs that are doing the management.
- **Application programming interface (API):** This is the interface that shows how the applications (network management or other) can invoke the management protocols.

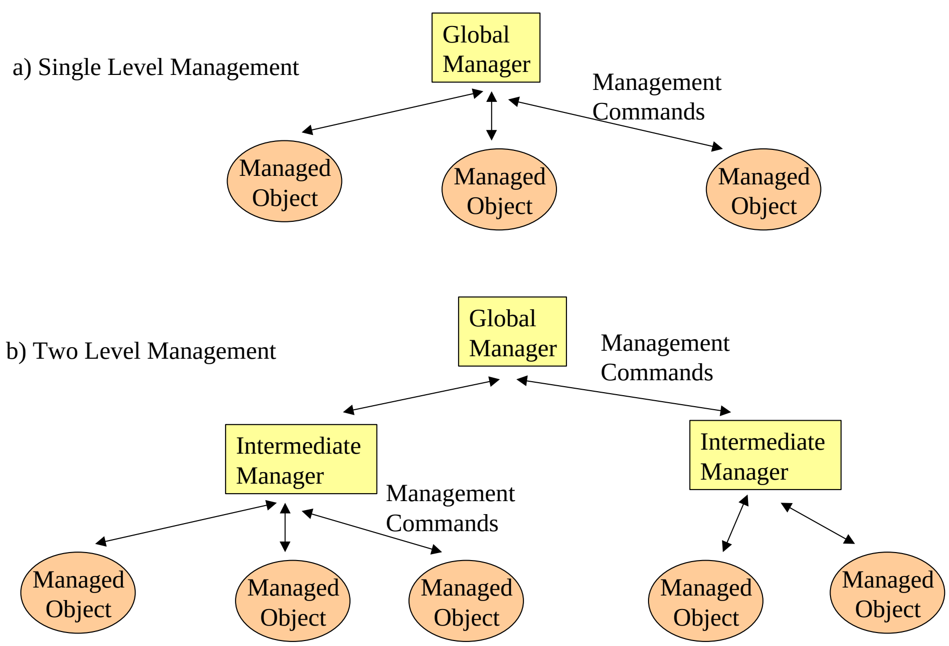

Figure 13-17: Conceptual View of Management Platforms

As we will see, standards in management protocols have been developed actively for network management. Best known examples are the Common Management Information Protocol (CMIP) by ISO (international Standards Organization) and the Simplified Network Management Protocol (SNMP) for TCP/IP based networks. These protocols view a network in terms of managing systems and managed systems (Figure 13-18). A ***manager*** is a software module which resides in the managing systems. An ***agent*** is a software module which resides in each managed system to monitor the status of ***managed objects***. For example, in an office network of 10 computers, each computer may contain an agent which monitors its managed objects such as disks and printers. A host-based manager may communicate with the agents periodically to obtain the status of the devices in the network. The manager-agent dialog is the basis of the management protocol standards. These standards define three things:

- What is the format of the management information and what are the rules for information exchange?
- How is the information transported between the managers and the agents?
- What specific information will be exchanged (what an agent can provide and what a manager can request)?

The first two problems are typical in any protocol standard development. The third problem, although not necessarily unique, is quite complicated in network management. The collection of management information that a manager or an agent knows is called ***Management Information Base (MIB***). A manager must know the MIB of its agents. We will discuss MIB in more detail in later sections.

A great deal of attention has been paid to API standards for network management. This is mainly because APIs make it possible for users and third party vendors to develop applications which use management information. IBM, for example, has provided APIs to NetView which, in turn, promotes software development around NetView. As more software is written, it becomes important to standardize the APIs so that this software can be ported to other environments.

In practice, many manufacturers of network devices provide management interfaces so that their devices can be integrated into existing management systems. For example, CISCO routers have management interfaces that allow companies to monitor, diagnose, and control CISCO routers in an enterprise network.

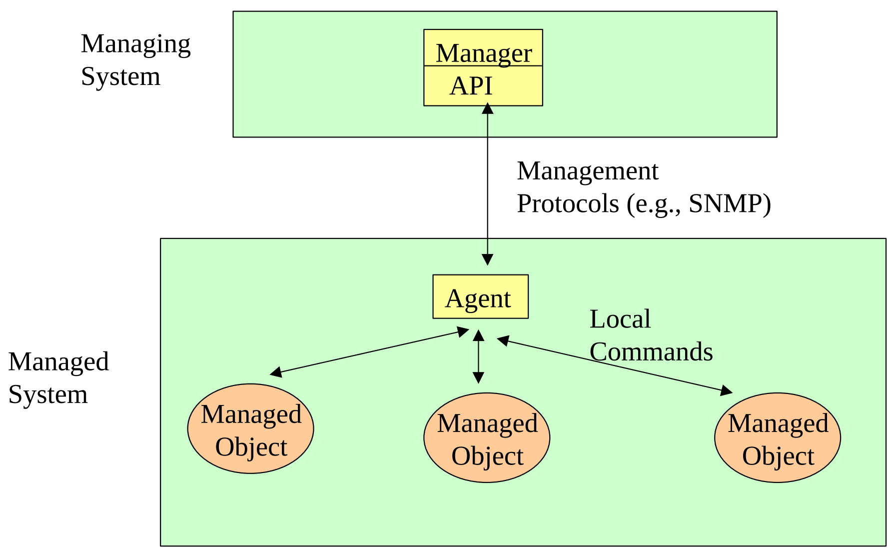

Figure 13-18: Network Management Communications

13.9.9 Organizational and Support Considerations

Although we will focus primarily on systems management tools and technologies, the organizational structures and the administrative processes to utilize the tools properly are equally important. Many administrators tend to collect the tools without sorting out the procedural and organizational details needed to use the tools. Ingredients of a successful management system are as follows (see Figure 13-19):

- A Systems Management Center (SMC) where the experts monitor, diagnose and control all the enterprise systems. A control panel is an important part of SMC.
- An integrated toolset which gives the SMC personnel timely information for decision making. The management toolset behaves as a management information system and/or decision support system. It is desirable for the SMC personnel to access the toolset from a single workstation with a common user interface.
- Policies and procedures about how the SMC will handle normal as well as emergency situations and describe how the SMC personnel will work with the personnel assigned to computer hardware/software diagnostics. For example, if a user cannot access a network resource, who will they call first?

In addition to an SMC, the functions of network planning, administration and security must be recognized and delegated to proper organizational units. In some cases, these functions may be assigned to properly trained SMC personnel and/or tools. In other cases, these functions may be assigned as additional responsibilities to corporate planning and security groups. For large, multisite organizations it may be appropriate to conduct these functions through committees which oversee these areas.

Due to the complexity of the management systems, several techniques are being employed to model and analyze management applications. Object oriented analysis (OOA) shows particular promise because network components (e.g., nodes, links, workstations, modems, multiplexors, communication controllers, etc.) can be viewed as objects. In addition, different types of devices can be represented as instances which inherit common properties from object classes. The object oriented approach has been adopted by the ISO/OSI Forum for specifying network management standards. We will discuss this issue in Section **Error! Reference source not found.**.

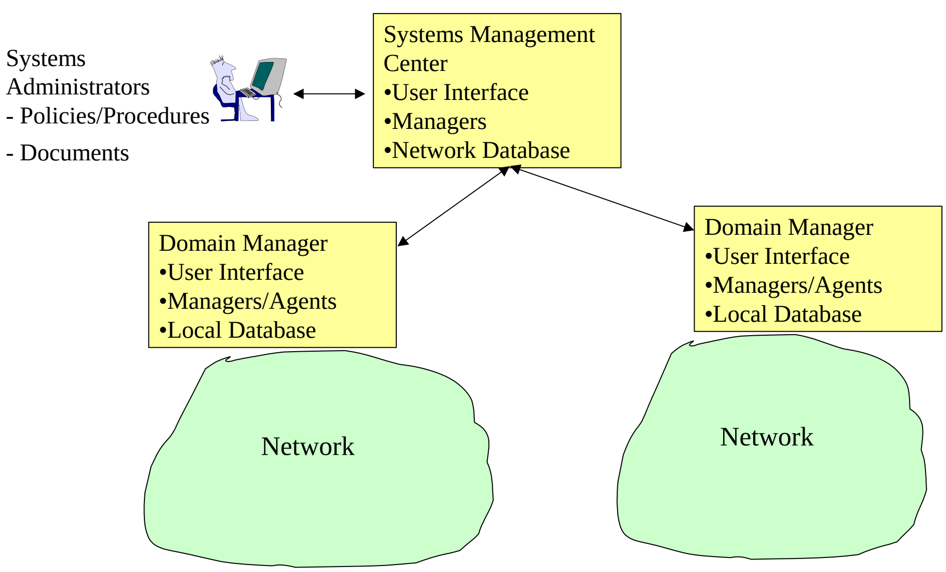

Figure 13-19: Systems Management Center

We should comment here about the trend toward open architectures, especially for network management. The ISO/OSI network management standards allow users to develop their own applications for special purposes. In addition, the proprietary network management systems provide application program interfaces (APIs) for user programs. It is important for organizations to understand the financial as well as legal aspects of developing user application programs. An early discussion of the legal pitfalls in network management was given in [Sapronov 1990]:

> "… integration of the network management product with other products on the network may violate intellectual property rights in the interfaced products or, equally troubling, may violate restrictions on the use of the interfaced products and thereby expose the user to substantial liabilities."

This article made the interesting case that the open standards are not copyrighted, thus the interfaces built around open systems do not create any legal problems. This appears to be the main reason why open protocols such as SNMP have succeeded in the marketplace.