Open Systems: Feasibility and Uses

by

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ABSTRACT

The purpose of this thesis is to examine the development and implementation of open systems. There is presently a need to develop computer systems based on standards, with a universal plan that will facilitate greater connectivity between hardware, software, and various parties. In the past, rapid developments have occurred in the computer and information technology fields without such a plan, creating many isolated, and often incompatible, proprietary systems.

The United States Navy has historically developed proprietary computing systems. However, with the rate of technological change increasing dramatically, forcing organizations to develop systems that are capable of interoperating with each other and easy to maintain, the Navy also needs to focus on open systems development.

This research concentrates on commercial open systems development. The Navy can benefit by incorporating commercial products into its systems to create open environments. Thus, organizations and corporations aimed at developing, implementing, and achieving open systems are examined. Although it may be technically possible to develop these new computing environments, other issues also need to be considered. Consequently, this thesis considers institutional issues that must be addressed if these systems are to be implemented successfully.

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CHAPTER 1

INTRODUCTION

INTRODUCTION

The purpose of this thesis is to examine the development and implementation of open systems. The United States Navy can benefit from creating environments where openness exists. Although the Navy has separated itself from the mainstream commercial world in the past, today, with rapidly changing technologies, there is a need to move away from proprietary system development. The Navy needs to focus on the creation of systems based on commercial off-the-shelf (COTS) components. Thus, this thesis focuses on commercial organizations and corporations attempting to achieve openness. In addition, several successful implementations of information technology are examined. Although most of these are commercial in nature, parallels can still be drawn to the needs of the Navy.

BACKGROUND

The term "open," as it relates to computing systems, has become very prevalent this decade in the information technology field. However, although many developers, vendors, and organizations use the term frequently, it often lacks a universal meaning. A formal definition of open systems, given by the Institute of Electrical and Electronics

Engineers (IEEE) is the following:[1]

"Systems that implement sufficient open specifications for interfaces, services, and supporting formats to enable properly engineered components to be utilized across a wide range of systems with minimal changes, to interoperate with other components on local and remote systems, and to interact with users in a style which facilitates user portability."

To further define open systems, the IEEE defines open specifications as: "Consensus based standards that are extensively documented, to which any vendor can build hardware or software products. Generally, such standards are the product of International, National, and professional organizations (e.g... International Organization for Standardization (ISO), American National Standard Institute (ANSI), IEEE), or consortia (e.g... X/Open) or common practice (e.g... Internet protocol suite)"

"Open specifications provide a framework for an open system, but do not guarantee one. Proper engineering is necessary."

The rate of change in the computer and communications industries today is remarkable. This change also forces changes in society. Information technology (IT) is changing the way individuals interface with each other, creating new opportunities for global connectivity, and sparking fundamental changes in the way organizations conduct

[1] Kowalski, Norman W. "Transition to Open Standards, Engineering an Open System, Getting Open Systems Benefits." 1995: 5.

business. In fact, IT amounts to one-half of United States firms' annual capital expenditures.[2]

In order to streamline operations and become more efficient, many companies are turning to new emerging information technologies. With this increased utilization of various computing environments, interoperability is a major concern and challenge. Companies and organizations need to be able to operate within their own structure and also externally with suppliers, vendors, regulatory bodies, and numerous other groups. The trend towards developing open systems, where interoperability is crucial, is becoming prevalent in many industries today.

Interoperability, as pointed out in the IEEE's formal definition, is a key part to achieving the successful development and implementation of open systems. However, there are many additional requirements to certifiably achieve openness. Open systems must have the following characteristics:[3]

- **Interoperability** - the ability of two or more (similar or dissimilar) computer systems and their software to exchange and use information that has been exchanged.
- **Compatibility** - the general ability of two applications to coordinate with one another in their operation, even if not originally designed to do so.
- **Scalability** - the ability of applications to be configured to allow operation on platforms ranging from micros to mainframes.

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[2] Keen, Peter G. W. Every Manager's Guide to Information Technology. 1995: 2.
[3] Kowalski 13-14.

- **Portability** - the ease with which an application or hardware component can be transferred from one hardware or software environment to another.
- **Maintainability** - the qualities that improve the ability to maintain the application by eliminating interface uniqueness for parts of application code.
- **Reusability** - the ability to reuse portions of one's applications software/hardware in the generation of another application.
- **Vendor Independence** - standards must be created and adhered to, avoiding the development of incompatible proprietary systems.
- **Technology Insertion** - providing stable vendor target paths for technology and modular insertion.

OUTLINE OF THIS THESIS

This thesis first examines how the need for open systems has emerged by studying the historical development of the computer and information technology. In Chapter 3 more recent developments and trends in the IT industry are examined. Object technology, client-server systems, and enterprise architecture planning are all examined in this section. With this base knowledge of open systems and computing in the 1990s, several organizations and developers, who are focused on building open systems, are examined.

First, in Chapter 4 the Object Management Group, which is a non-profit organization dedicated to establishing standards for interoperable software, is examined. This group is the world's largest software development consortium, composed of developers, vendors, and end users. Although this group has greatly expanded its functions and services that it offers to its members, its original focus and core mission is to develop an architecture allowing for interoperability. The Object Management Group has developed a framework supporting communications between various applications, which may be written in different languages and located on different operating systems. Details pertaining to this and other OMG activities will be discussed.

In Chapter 5 a very different attempt to develop open systems is investigated. Unlike OMG's non-profit, consortium-based approach, the corporation Sun Microsystems is focusing on gaining an extensive market share to promote its new computing language called Java. The company originally set out to develop a new and simpler computing language -- one that could be used extensively on the Internet for web pages. However, this has expanded into an entire Java technology platform. Their future vision involves imbedding Java code in various computing and communication devices and gadgets, enabling extensive communication capabilities over complex networks. Additionally, Sun Microsystems is in the process of having their standards recognized by the International Standards Organization. This is all discussed in Chapter 5.

In Chapter 6, The Open Group, which is an international non-profit organization, is examined. This group is similar to the Object Management Group in some regards. Both organizations coordinate the activities of and receive input from various players in the IT industry, including computer manufacturers, software vendors, end consumers and users. However, The Open Group's primary focus is to help increase the reliability and security of the Internet. This type of development demands a high level of openness. The Open Group is also recognized around the world as a premier conformance tester of software, determining if software products meet compatibility criteria.

After examining these various attempts to develop and implement open systems, Chapter 7 discusses their work and contrasts it to the formal definition of open systems described earlier in this chapter. Comparisons are also made between the different organizational approaches to develop and promote openness in the computer world.

Although the technical challenges of developing open and interoperable systems may be overcome, there are several institutional barriers to the development of such systems. Chapter 8 examines some of the key institutional issues which need to be addressed and dealt with as these technical systems are developed, implemented, and operated. Furthermore, the Navy has needs which extend beyond most industry groups that must be taken into account.

Finally Chapter 9 draws some conclusions about this research and explains how the United States Navy could benefit from the utilization of open systems.

CHAPTER 2

A HISTORICAL OVERVIEW OF THE EVOLUTION OF INFORMATION TECHNOLOGY

This chapter describes the evolution of the computer and information technology. Four key time periods are defined and major advancements and developments within these eras are discussed. This historical framework helps to point out and establish the need for open systems.

INFORMATION TECHNOLOGY'S EVOLUTION

The evolution of information technology can date back to the introduction of the computer into the workplace in the1960s. In fact, this evolution can be grouped into four eras:[4]

- 1960s Data Processing
- 1970s Management Information Systems
- 1980s Information Innovation and Support
- 1990s Business Integration and Restructuring

DATA PROCESSING

During the 1960s computers emerged in various industries. These large and very expensive centralized, stand-alone systems had very little capability. In this era,

[4] Keen 9.

computers were primarily used to automate data processing, such as accounting functions. Applications were developed individually, and the machines were extremely costly to run and maintain. There was also a strong cultural resistance to this new technology. In many firms the personnel in charge of daily computer operations were very isolated from both the business executives and the actual business processes of the company. Non-computer corporate leaders, who were educated in an era before computers were prevalent, viewed the machines as a source of trouble and did not recognize their potential value.

MANAGEMENT INFORMATION SYSTEMS

As with many new technological advancements, difficulties were encountered along the way. The computer developers of the 1960s promised glorious things; however, the machines often fell short of these great expectations. This led to a refocusing of the computer industry in the 1970s. Now the aim was to better manage information and meet business managers' needs more appropriately.

This was difficult to accomplish considering the technology was still in its youthful stages.[5] During this period, the machines were still very large and expensive propriety systems. Furthermore, these systems were designed to produce vast amounts of data. However, buried in all these figures was the information that was of real value to managers. Also, the calculations performed took a considerable amount of time and often lagged real world development, making the results much less useful.

This period did see the emergence of outside parties developing generalized

[5] Keen 15.

software. Programmers began developing general applications, which were not specific to a certain company's needs. This period was also host to the introduction of data base management systems (DBMS). Data was cataloged by extensive indexing techniques for its time. But, most DBMS were quite costly. Computers were also capable of performing multiple tasks at the same time. Thus, time sharing systems were created to facilitate maximum outputs from these expensive machines. Now various users, connecting via computer terminals, could log on to the same machine to perform specific tasks. Although the technology could not process more than one task at a time, it was able to break up the processes into infinitely small intervals and continuously work on these small segments of multiple requests one after another.

During this era, the gap between business leaders and information systems staff continued to exist. There were significant battles over funding and cutting costs. Many executives were still very skeptical about the use of computers in the workplace. Even though the machines were now producing loads and loads of data, it was not in a very useful format that business leaders could use. Consequently, sometimes the output from the machines was not used at all.

INFORMATION INNOVATION AND SUPPORT

The Information Innovation and Support era of the 1980s marked considerable change. Offices began investing in personal computers and software, which were considerably less expensive. These microprocessors were very cost effective compared to the larger older centralized, time-sharing machines. The capability and low costs of these machines amazed some executives. Ironically, the management information systems staffs fought the emergence of these new processors. Their expertise and knowledge of the old systems was no longer needed. The personal computer bridged the gap between technology and the businessman, placing a vast amount of capability at their fingertips. Furthermore, developing IT was viewed as a worthy cause to gain a competitive advantage.

Parallel advancements in telecommunications enabled this shift. Distributed systems, where individual workstations where linked to a central processor, became more prevalent. The local area networks (LANs) were an inexpensive way to achieve connectivity within an office building. Innovations flourished; however, this was only at a local level. In the 1970s, the computer systems staff controlled development centrally. Now, with these decentralized systems no longer relying on this technical staff, development occurred rapidly and without coordination across the various departments within organizations. Departments purchased different proprietary systems to best meet their immediate needs. For daily operations within their operating group, things ran smoothly. However, as the various business functions of firms overlapped and a need arose to share information across these departmental boundaries, a huge problem existed. Not only could the different systems not be linked together successfully, often files from one system could not be read or used by another system. At the same time, supporting a variety of operating platforms was becoming very costly.

BUSINESS INTEGRATION AND RESTRUCTURING

There was a need for integration, the development of standards, and formation of architecture to control the growing incompatibility problems. A central coordination of key IT infrastructures with decentralized autonomy in decisions about applications was needed.[6] In the Business Integration and Restructuring era of the 1990s there is a thrust to hedge against the costs associated with incompatibility. Presently, the trend towards developing standards to create open systems has taken center stage.

It is challenging to develop standards that allow both existing proprietary systems and newly develop systems to interoperate. Furthermore, accomplishing this without limiting the capabilities of new technological advancements also poses some additional difficulties. Many standard setting groups, some of which are later examined in this research, attempt to bring relevant parties togcther to deal with these challenges. It is not uncommon for vendors, developers, industry users, and standard organizations to meet to create standards for the information technology field.

Simultaneously, businesses are redefining and reorganizing their structures. Some rigid hierarchical systems of the past are being replaced by working environments where collaboration and teamwork are the norm. IT is a strong enabler of this change. Once again, the information technology teams have the support of the business executives. The need to integrate and develop standards is strongly supported by the upper level management because it will greatly reduce operating costs.

The technology continues to grow. First, electronic data interchange (EDI) has enabled the electronic forwarding of documents, like purchase orders for example, eliminating many paper-intensive systems. The parallel advancements in telecommunications have assisted in continued change. The Internet's emergence has paved the way for widespread change in the IT industry. Individuals can now be

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[6] Keen 25.

connected with the world from their own home. Business organizations view the Internet as a necessary development field in order to remain competitive in the next millenium. In fact, between 1998 and 2000, business-to-business electronic commerce via the Internet is expected to grow from $3.2 billion to $134 billion.[7] This technology is also enabling the development and implementation of advanced logistical systems. For example, just-in-time inventory systems and quick response systems have allowed producers to greatly cut inventory costs and increase customer service levels.

Once again, new developments in the telecommunications industry continue to enhance the capability of IT systems. Growth in cellular wireless communication, advanced low earth orbiting satellite systems, and tracking devices, provide the opportunity for greater connectivity and global coverage. With this growth in information technology and its prevalence increasing dramatically in the business world, a strong division between those embracing and utilizing the new advancements and those resisting changes is growing. As this gap widens, companies without any IT competency may falter.

The present rate of change is extremely fast, creating a high level of chaos in the IT industry. New IT products, replacing older versions, are now introduced with frequencies of less than one year, some as few as a couple of months. The challenge of allowing for this pace to continue and still maintain a common ground where all the systems can interoperate with not only each other, but also older proprietary systems, and systems that will be developed in the future is enormous. The notion of open systems is very respectable; however, truly achieving openness is a difficult process.

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[7] Mottley, Robert. "Spinning supply chains via the Internet." *American Shipper.* Nov. 1998: 28.

This chapter has provided a historical overview of the evolution of information technology up to and including the 1990s. In the next chapter, a more detailed examination of recent developments in the IT community is presented. These new developments are becoming key elements in the development and implementation of open systems.

CHAPTER 3

DEVELOPMENTS IN THE 1990s

Chapter 2 described an overview of information technology's evolution, dating back from the 1960s up to the present time. In this chapter, more recent developments in the IT industry are examined. Object technology, client-server systems, and enterprise architecture planning, which are all described in this chapter, are important to the development of open systems today.

OBJECT TECHNOLOGY

Computing systems in the past were focused on data and procedures. Today, a shift is being made to develop systems that focus on the uses the data might have and that are also concerned with the business processes involved. Object technology is a real world based system where computer objects mirror real objects. Such systems are developed based on a building block approach, with each block (object) able to function both independently and in an integrated manner with other objects. Users can create, manipulate, and use these objects in several ways. Computer objects, which may be databases, software routines, videos, photos, music, or communication commands,[8] can be linked together to model real world interactions. This allows existing objects to be reused to perform new and more complex functions. Each object performs its own unique function and may relate to a set of other specified objects, without ever knowing

[8] Keen 202.

any of the details about the other objects' functions. Thus, the objects truly are independent, allowing one to be changed without affecting others.

For example, there may be a set of three objects. One performs a calculation, one tabulates, while the other graphs the results. If the calculation object is altered to perform a more advanced function, the other objects will still tabulate and graph the results. The change makes no difference to them; their function remains the same.

CLIENT-SERVER SYSTEMS

Assisted by telecommunication advancements, the IT industry has the ability to interconnect computers across many traditional departmental and geographic boundaries. This has allowed system designers to link fairly inexpensive personal computers (clients) with more expensive shared file server machines. In these systems a user can make a request at the client side to obtain data or perform a service. Then without any effort on the individual's part, the message is linked to a server and the task is performed, and the result returned. The diagram on the following page describes this type of system.

In these systems, clients, which are fairly powerful machines by themselves still performs many of the functions. However, the servers handle demands which are too great for the individual machines to handle, such as data management and maintaining system-wide security. This is a significant difference from the central mainframe systems with "dumb" terminals, which did not have any processing capability.

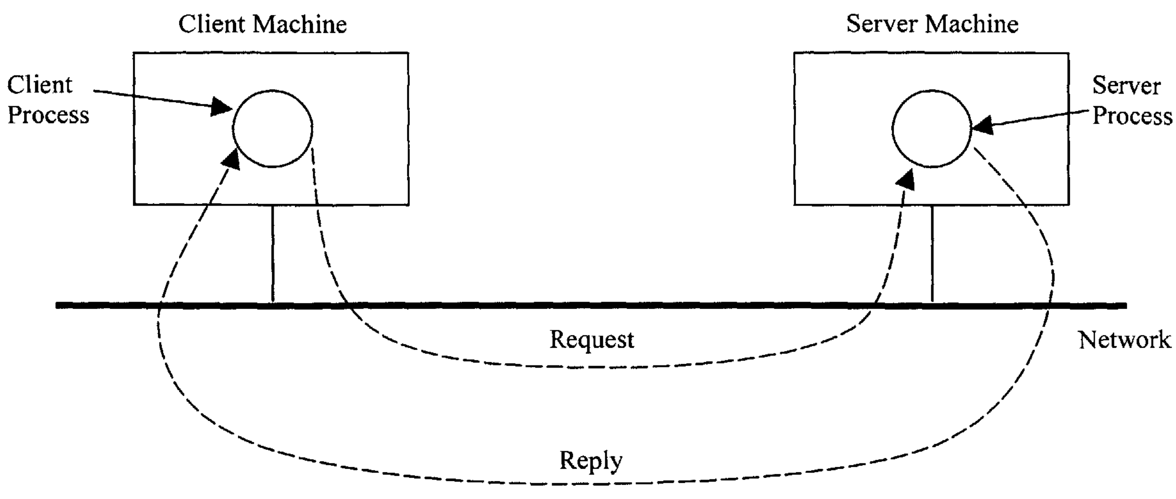

Figure 3-1

The Client-Server Model[9]

This system is generally more cost effective because there are relatively few servers and many less expensive client units. Within this type of system, expansion is also easier to manage and less expensive. In the past, when increasing computing ability and storage capacity, a mainframe system needed to be completely replaced once it reached maximum capacity.

In a client-server model, information sharing is more easily accomplished. As opposed to local networks, where only department members were interconnected, this type of system can provide a means for the entire organization to access data, equipment, and programs. In these distributed systems, however, the user is only aware of the hardware they are physically using. The necessary steps to create needed linkages, the

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[9] Tanenbaum, Andrew S. Computer Networks. 3rd Ed. Upper Saddle River, NJ: Prentice Hall PTR, 1996: 4.

operating decisions required to perform the tasks demanded, and the transport and routing of information and results is transparent to the user. In effect, a distributed system is a software system build on top of a network. This software gives the system a high degree of cohesiveness and transparency.[10]

ENTERPRISE ARCHITECTURE PLANNING (EAP)

Information systems of organizations and companies are continuously challenged to provide access to accurate data in a useful format that can be shared across an enterprise. As technology rapidly advances and businesses continue to grow, this can be an enormous task. Steven H. Spewak's Enterprise Architecture Planning provides a method for organizations to develop a long-range plan to meet the future needs of their information systems.[11] The EAP process is aimed at developing systems that are business driven and concerned with how the data is used to support the business.

As the author states, "Enterprise Architecture Planning (EAP) is the process of defining architectures for the use of information in support of the business and the plan for implementing those architectures." The mission of information systems (IS) is quite simply to provide quality data. Thus, the EAP process can be thought of as planning for quality data. EAP deals with the first two steps in John Zachman's framework of information systems architectures, focusing on the "ballpark view" and the "owner's view."[12] The actual design and construction of a system is outside the realm of EAP.

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[10] Tanenbaum 2.
[11] In this section, frequent citing of the author's words and diagrams are made from the source: Spewak, Steven H. Enterprise Architecture Planning. New York: John Wiley & Sons, Inc., 1992.
[12] John Zachman's Information Systems Architecture Framework is widely accepted in the I.S. Community.

In order for enterprise architecture planning to work, the company's management must be committed. The process will demand time, people, resources, and capital. Also, the leadership within the organization needs to be dedicated, as well as strong. EAP is well suited for organizations with long term goals, team approaches to management decisions, quality management programs, and the willingness to invest in new products and procedures, which lead to savings or increased revenue in the future.

EAP is different from past methods of systems planning. It is described as being both business driven and data driven. The architectures are founded on a functional business model, which is "a knowledge base of what the business is and what information is used to conduct the business." In addition, "these architectures support the needs of the business, not the requirements of individuals and without regard to the artificial limitations of organizational boundaries." EAP also defines all the data needed to support the business first.

The EAP process can be summed up in the following steps (which are shown in a diagram on the next page).

1) Planning Initiation

2) Business Modeling

3) Architecture Development

4) Implementation/Migration Plans

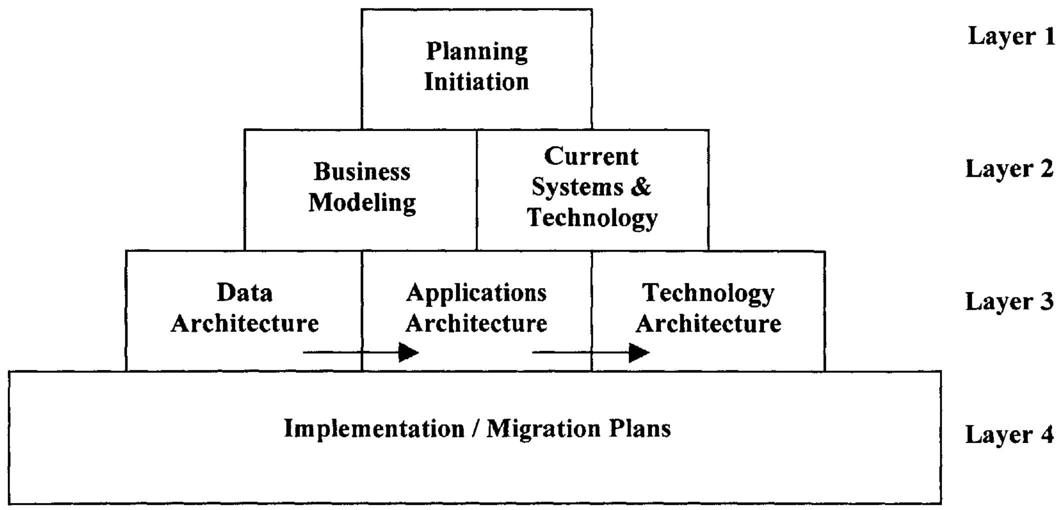

Figure 3-2

Components of Enterprise Architecture Planning

1) Planning Initiation

In this step, the objectives of the EAP process are determined. A planning methodology is adapted, and the team is chosen and trained about the EAP process. From successful cases in the past, teams were generally composed of both system management and business people. In addition, if funding is available, the possibility of hiring consultants should be strongly considered. A schedule and workplan are developed during this phase, and the tools needed for the EAP process (PCs, software programs, etc.) are obtained. Also, and perhaps most importantly, funding and the company's commitment for the project are confirmed.

2) Business Modeling

The business model defines and describes the functions that the organization performs. It also determines the information used by each business function. One of the results of this step is a matrix demonstrating the relationships between the business functions and the organizations within the business that perform these functions. (A sample matrix is shown on the next page in Figure 3-3.) This business model is stable over time and is independent of who performs the function, and also, where and when the function is performed.

3) Architecture Development

Before the architectures are actually developed, an information resource catalog (IRC) is composed. This catalog documents and defines all the systems and technology presently being used by the enterprise. It gives the EAP team an idea about what actually is already in existence, and it provides a baseline for long range planning.

The data architecture defines the major kinds of data, called entities, used by the business. An entity "represents a person, place, idea, thing, or event that is important to the business and about which data must be stored." These data entities have some relationships to one another, and this is depicted in an entity relationship diagram. A data to business function matrix is also created. This demonstrates the amount of sharing of data among business functions. (On page 26, a sample database entity-to-function matrix is presented.) In addition, the data in the matrix is categorized as being created (C), updated (U), and/or referenced (R) by each function.

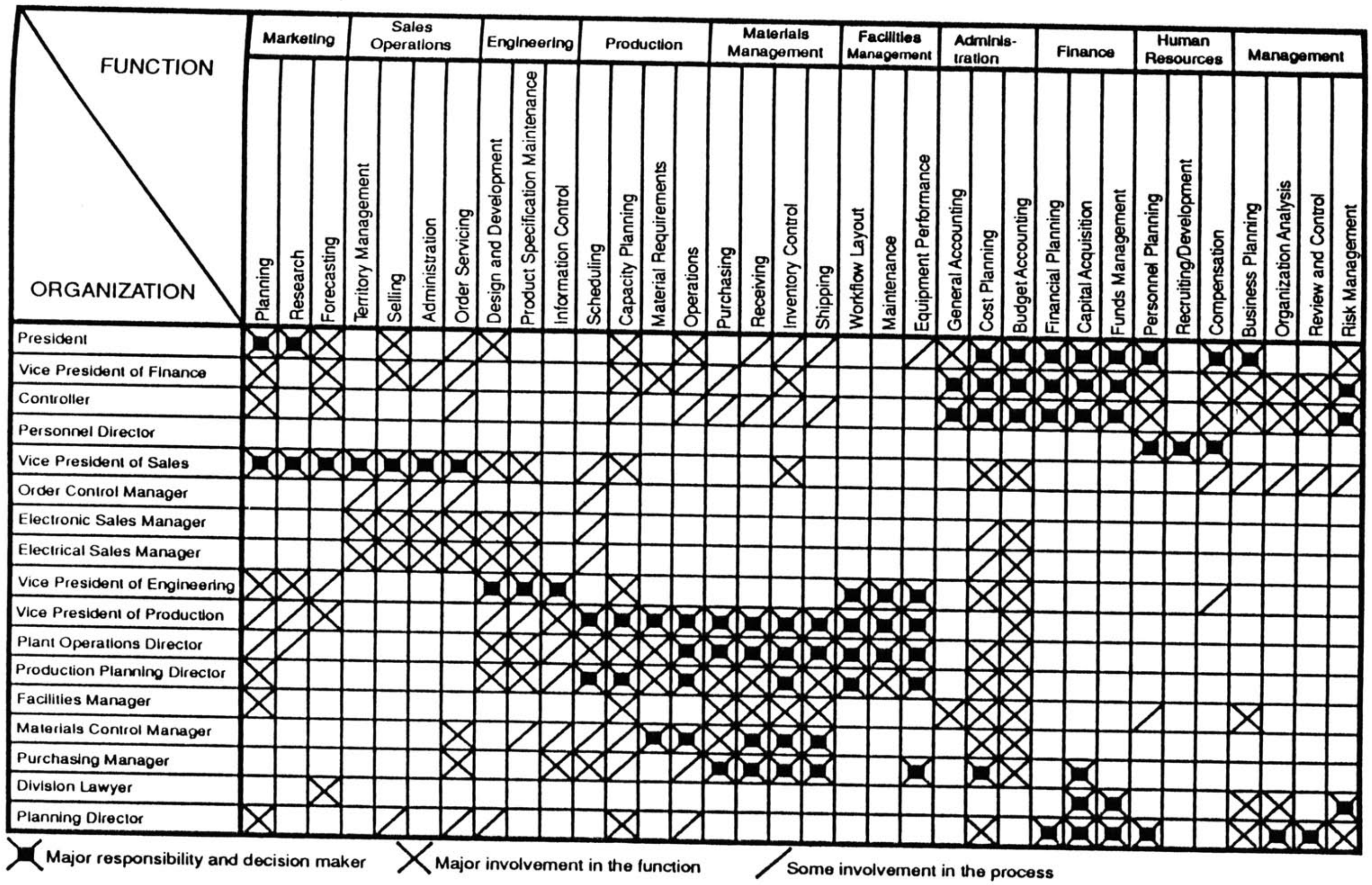

Figure 3-3

Sample Matrix: Business Functions to Organizational Units♦

♦ Reprinted from IBM's *Business Systems Planning*. 1984: pg 34.

FUNCTION / ENTITY-->	MARKET	FILE	SALES REGION	PROMOTION	CLIENT CONTACT	CLIENT PROSPECT	CASE	CHARGE SCALE	CONSULTNT	DISTRICT MANAGER	COMP PLAN	EMPLOYEE	TERRTRY ASSGNNT	TERRITORY	SERVICE CONTRCT	SUPPLMTY ORDER	CATALOG	JOB	JOB PROD INFO	CLASSIF CODES	PRODUCT TERM	VENDOR	PURCHASE ORDER	BINDERY	DESIGN REGION	INVENTORY	PRINTER	PRODUCTN AREA	PAPER	PAPER INVENTRY	PRINT & BIND ORD	RECPIENTS	CARRIER	SHIPMENT	DISTRBUTN	CLIENT REP
MONIT-COMPITION	R					R																														
REVISE-PRODUCTS	R	CUR		CUR		R		R									R			R	R			R								R	R			
PRODUCT-PLAN	CUR	R		CUR		R		UR													R			R								R				
PRODUCT-APROV		R						R																R												
PLN-USE-TECH	R					R																										R				
DEV-STRAT-BUS	R		CUR			R		R																								R				
ADVERTISING				CUR																		CUR														
COORD-PROD ADV				UR	CUR	UR																														
CONSULTING							UR																													
DETRM-MKT-STRGY	R	R		R																																R
RESEARCH	UR	R			UR	R																										UR				
SALES TRAINING	R	R							UR	UR		UR										R														
SERV-ENG-TSK-FS				R		R		R	R	R																						R				
CORD-ANN-MK-CNL				R		R		R	R	R		R																				R				
DIST-SLS-RPTNG			R		UR	UR	UR	R		R	UR		R	R	UR	UR	UR	UR																		
RGNL-SLS-RPTNG			R		R	R	R	R		R	UR		R	R	R		R		R																	
BUSINESS-RPTNG			R		R	R	R	R		R	UR		R	R	R		R																			
PREP-CHG-SCL-PROB								CUR																												
RESOLV-SLS PROB		R	R			R				R	R		R	R	R		R																			
GEN-NEW-SALES		R	UR	R	CUR	CUR	CUR	R	UR	UR			R	R			R	R		R					UR											
LEAD-IDENT	R			R	CUR	CUR				UR			R	R																						
SUSPECT-IDENT	R			R	CUR	CUR				UR			R	R																						
FILE-SALES		R		R																		R				UR						CUR	R	CUR	UR	
MONIT COMMISNS			UR						UR	UR	CUR	UR	UR	UR	R																					
PROC-COMPLAINTS		R	R		R	UR			UR	UR			R	R	R	R	R	R	R	R	R	UR		UR	UR		UR	R								R
SLS-CALL ACTVTY	R		R	R	CUR	UR	UR		CUR	CUR		CUR	CUR	CUR	R																					
WRT-CONTRACT-CPT		R	UR		CUR	UR	UR	R	R	UR			UR	UR	CUR	CUR	CUR	CUR	CUR						UR											
ESTB-CLS-POLICY			R						R	R					R		R	UR	UR	CUR				R	R											
DEVELOP-INDEXES		R	R		R				R	R					R		R	R		R	CUR			R	R											
PREP-SEL-DATA		R													R		R			R	R	CUR	CUR													
BINDING		R			UR												R	R	UR			CUR	CUR	UR	R	CUR	UR		R	UR	CUR					
CLNT-SVCS		R			UR	R			R	R					R	R	R	CUR	UR			R		R	R			R								
PREP-REVNU-RPTS																R	R	UR	R			R	R		R		R									
CATALOG-DESIGN					R				R	R							R	UR	CUR						R			R								
CATALOG PROD					R				R	R							R	UR	CUR			CUR			R			R								
DES PROD RPTS					R				R	R							R	UR	CUR						R			R								
MONIT COSTS					R					R						R	R	UR	UR			R	CUR		R		UR	R								
MAN-CLI-CONTACT					UR					R					R	R	R	UR	UR			R			R		R									
MONT-MFG ACTVTY																R	R	R	R			CUR	CUR	CUR	CUR		CUR	CUR		R						
PAPER CTL																						CUR	CUR				R		CUR	CUR	R					
CUSTOMER SVCS															R											R						CUR		UR	R	
DISTRB FILES		UR			R										R									R		UR						R	CUR	CUR	CUR	
ESTB-RCPNT QUAL		R																														UR				
IDFY QUAL RCPNT		R																														UR				
MKTLST-CPY DIST		R			R										R							R										UR				
BUYLINE																						CUR														
BUYLINE-OPERAT					CUR	R									R		R				R															CUR
PRODUCT LINE					UR	R																CUR										R				
VERIFY WHOS NEW					UR	R																CUR										R				
EXT-COUNCILS					R	R																CUR										R				
CONTRACT PROCSS			R		CUR	R		R		R	R				UR		R			R																
CREDIT COLLCTNS			R		R	R				R					R																					
NON-CNTRCT CHGS					R	R										R	R		R			R		R	R		R		R		UR					
PAID-DISTRB		R																														UR	R			

Figure 3-4

Sample Matrix: Database Entity-to-Functional Relationship

The application architecture "is a high level description of the capabilities and benefits of all applications to support the business." Its primary purpose is to define the applications needed to manage the data and support the business functions. Like other EAP definitions, the applications are as independent as possible and based solely on the business model and data architecture. Once again, following the same procedure as before, a matrix can be created. This time the database entities are related to applications. Listings are created to examine functions that are being supported by more than one application. This helps to determine whether an overlap or duplication of applications exists.

The technology architecture "defines the major kinds of technologies needed to provide an environment for the applications that are managing data." These platform definitions will support the business with a shared data environment. In this section, reference is made to an open systems concept as a possible technology platform. This, of course, explains that the operating systems must be portable, scalable, interoperable, and compatible.

4) Implementation/Migration Plans

Naturally, after all the time and hard work that has been expended developing the architectures, a plan must be formulated to implement them. This plan, which is usually long term, will be in excess of five years. A sequence and schedule for the implementation of applications must be prepared. Spewak emphasizes, "applications that create data should be implemented before applications that use data." Using the data-to-applications matrix an implementation plan can be formulated. (This is demonstrated in

Figure 3-5.) Cost/benefit analysis should also be performed.

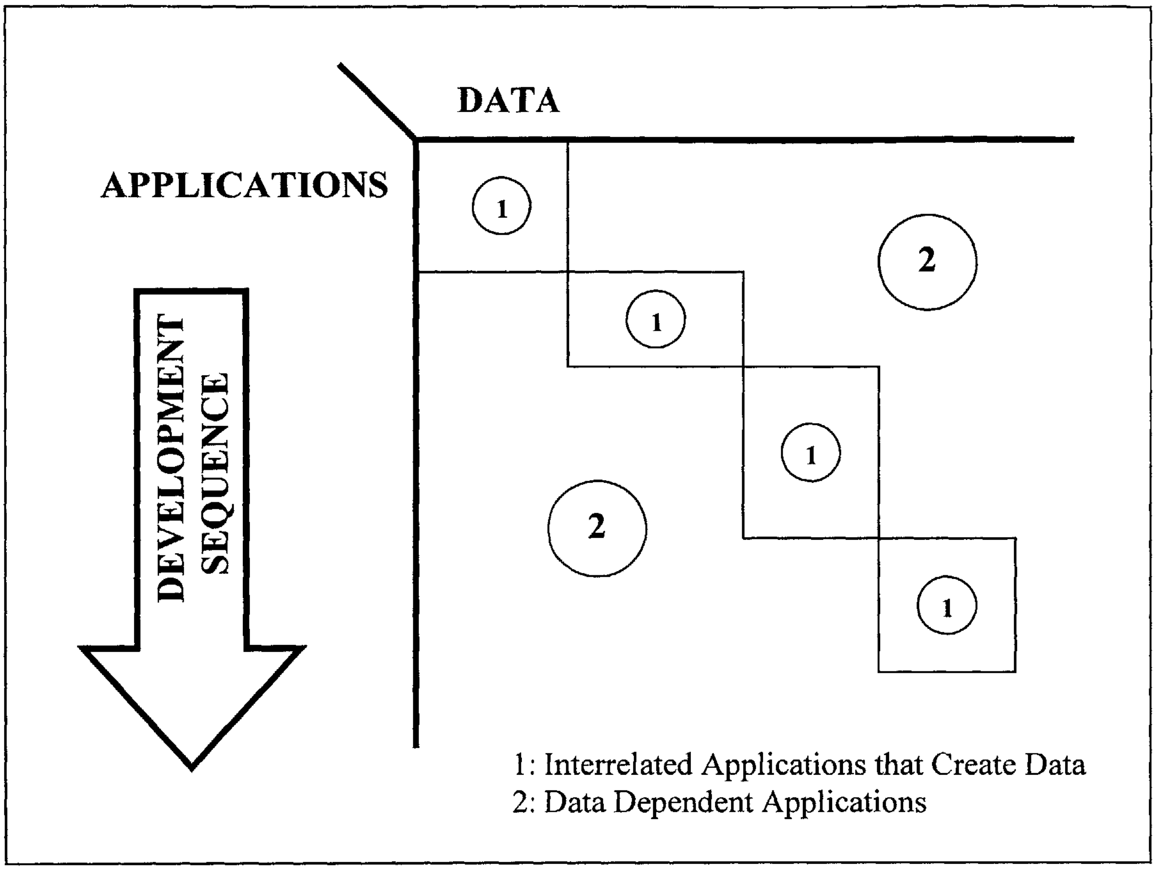

Figure 3-5

Implementation/migration plan application sequencing matrix

It should also be noted that the EAP team always has to consider the time and funding constraints involved with the process. An 80/20 rule may be imposed. Where 80% completeness and accuracy in each phase of EAP is "good enough to produce reasonable, feasible architectures and plans."

OPEN SYSTEMS AND INTEROPERABILITY

As discussed earlier, innovations in computers and information technology have flourished during the past decade. However, much of this development has been very fast paced and lacked any universal plan, creating many isolated and often incompatible and proprietary systems. In order to reduce the costs associated with supporting multiple networks and various software applications, and to improve connectivity across traditional operating environment boundaries, these "islands" of computing technology need to be linked together.

Achieving this interconnectivity can be very difficult. One issue blocking the widespread development of open systems is the existence and development of proprietary systems by vendors. Open systems need to be vendor independent, where standards are established and followed. This development of standards can be extremely difficult and is also hampered by the fast rate of change of information technology. Thus, these systems need to also be adaptable and capable of adjusting to changes in technology. The issue of creating standards is discussed in greater depth in Chapter 8.

Interoperability is a key element in achieving the successful development and implementation of an open system. However the additional requirements to certifiably achieve openness, which were described in Chapter 1 and are listed below, are also essential.

- **Interoperability**
- **Compatibility**

- **Scalability**
- **Portability**
- **Maintainability**
- **Reusability**
- **Vendor Independence**
- **Technology Insertion**

The term "open" is a flashy new adjective in the world of information technology and data management today; however, claims of being open are not always true. For a system to be certifiably open, interoperability, compatibility, portability, scalability, and the other characteristics mentioned above must be achieved. Many consortiums and groups are claiming to be open after developing standard interfaces. In order to determine if such systems are truly open, this issue demands investigation. Open systems can be considered a key element in the future of the information technology field. It is predicted that they will come into existence through a combination of committee definitions, de facto standards created by user demand, and vendor decisions about which committee and competitor standards to follow.[13]

Additionally, although linking various computing environments may be technically feasible, other issues can inhibit the development, implementation, and utilization of open and interoperable systems. There are several institutional factors that must be addressed, which are examined in Chapter 8. But first, the next three chapters examine different ways organizations are attacking the issue of open systems

[13] Keen 204.

development. Included in these chapters are several case studies describing real world implementations of interoperable systems.

CHAPTER 4

OBJECT MANAGEMENT GROUP (OMG)[14]

BACKGROUND ON OMG

Object Management Group (OMG) is an organization of software vendors, developers, and users. The mission of its approximately 800 members is "to promote the theory and practice of object technology for the development of distributed computing systems." These distributed computing systems link numerous components together, allowing applications and data to be stored locally and accessed and used from remote locations. OMG provides a common architectural framework for object oriented applications based on widely available interface specifications. The organization also establishes industry guidelines and object management specifications to provide a common framework for application development. These specifications detail the necessary standard interfaces for distributed object computing.

The Object Request Broker (ORB) (commercially known as CORBA – Common Object Request Broker Architecture) provides an infrastructure that allows different applications to interact, independent of who designed them, from local or remote locations. If users are in compliance with CORBA standards, interoperability as well as portability is guaranteed over a network of heterogeneous systems. The ORB functions as a middleware that establishes client-server relationships between objects.

OMG was originally focused on interoperability and the development of CORBA; however, the boundaries of OMG have certainly grown. OMG now has supporting

[14] This chapter was written with the assistance of Jon Siegel's "CORBA Fundamentals" course notes, Worcester Polytechnic Institute's Office of Continuing Education, May 21-22, 1998.

services and facilities which make using CORBA even easier. Additionally, industry domains (or vertical markets) have been formed at the Object Management Group to bring key players with similar interests and goals together to develop industry-wide standards.

INTEROPERABILITY

OMG has taken the stance that specialized and diverse software and hardware is a reality. Companies may also have legacy systems, which cannot be replaced without a great amount of effort and high costs. The key is to develop a way so that all these various systems, which are utilizing different hardware and software, and are written in numerous languages, can interoperate. The answer is to use component software that has been designed and built on standard interfaces. Then, with middleware based on CORBA (Common Object Request Broker Architecture) standards, heterogeneous systems can communicate with each other. OMG has developed specifications which detail the standard interfaces necessary for distributed object computing.

Object technology is the driving force of OMG's development of CORBA. Objects are software components which contain data. They can also manipulate this data. Systems based on object technology have clients (which are really other software components) that send requests to objects. These objects then in turn send return messages with their responses. Requests never pass directly from clients to object implementation; rather, the CORBA architecture connects a client to the object implementation via a commercially available Object Request Broker (ORB). However, this ORB is isolated in the sense that there is an Interface Definition Language (IDL) interface at its junction points with both the client and the object implementation. These interfaces, which must be coded in OMG's Interface Definition Language, are called stubs and skeletons. Originating at a client, a request would pass through an IDL stub to a commercial ORB, and then through an IDL skeleton to the object implementation.

OMG released the CORBA 1.1 version to the public in 1991. This defined the Interface Definition Language (IDL) and the Application Programming Interfaces (API) that enable client-server object interaction within an Object Request Broker (ORB). (See Figure 4-1 below.) The key to OMG's IDL, which is now an ISO standard, is that it isolates an object's interface from its implementation.

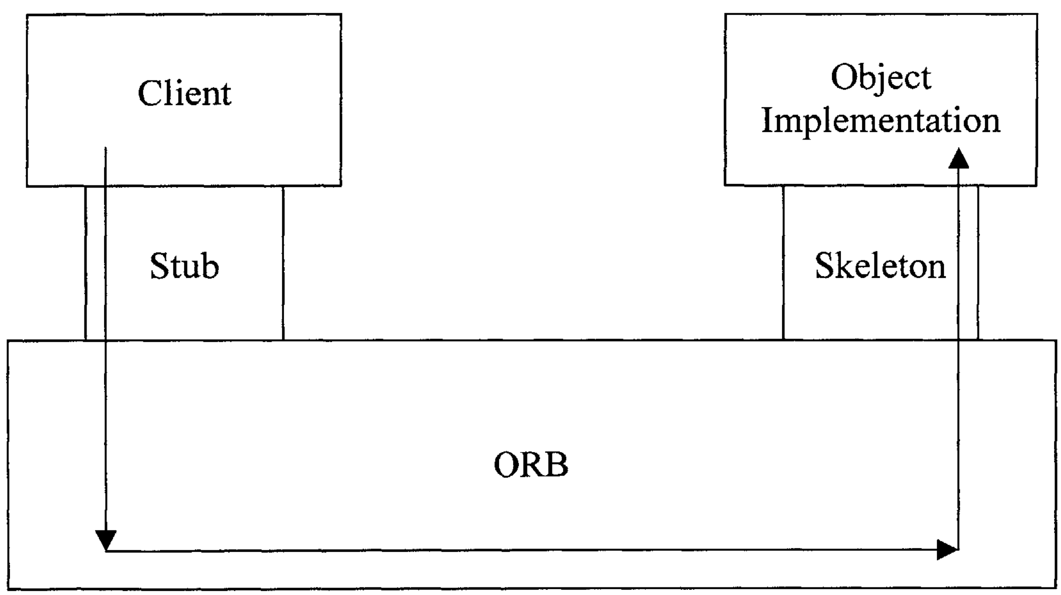

Figure 4-1

Local Object Implementation via an ORB

The 2.0 version of CORBA takes interoperability a step further by specifying how ORBs from different vendors can communicate. (See Figure 4-2 on the following page.) The Internet Inter-ORB Protocol (IIOP) specification in CORBA 2.0 is considered to be the cutting edge in technology by industry leaders such as Netscape, Oracle, and IBM. There are several commercially available ORBs that conform to CORBA standards. As long as an ORB understands OMG IDL, that is that it is based on CORBA standards, they will be able to communicate with each other. Thus, on a network, a client's local ORB will be able to connect to another ORB via a common backbone, such as the Internet, to locate a remote object implementation. Both the object implementation and the client are unaware whether invocations are made locally or remotely. This is truly amazing, a large-scale network with several ORBs can allow for complete interoperability, connecting numerous clients and object implementations.

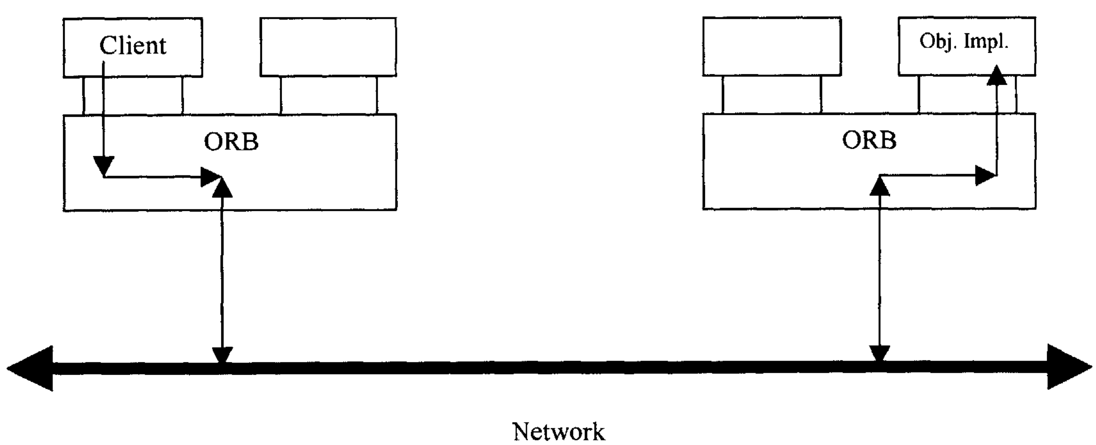

Figure 4-2

Remote Object Implementation: ORB to ORB Communications

OMG is currently working on CORBA 3.0, which will enhance the existing architecture even more and enable the complete Internet integration and support for legacy systems. This version will have many additional features including support for distributed components, quality of service features, and new messaging support.[15] This version will also help to integrate modern programming languages like Java with CORBA.

SECURITY

Obviously, with any distributive system environment, security is a major issue and concern. (Although security is examined here in regards to the CORBA platform, the issue of security will be discussed in Chapter 8 along with other institutional issues.) This is especially true with large scale companies investing heavily in new hardware and software, who need to maintain a handle on who has access to what information. Even at a greater risk is information in transit between different operating systems. Making the security issue even more challenging, these systems are comprised of many components, have numerous interactions between the components, have unique boundaries of trust, and are continually evolving. Since the Object Management Architecture supports a wide variety of different security policies, OMG defined a security reference model, which provides a framework for building a security policy. OMG has developed a security service and security protocol definition, which are now being implemented by ORB vendors worldwide.

[15] Object Management Group. Website: www.omg.org "Object Management Group Outlines CORBA 3.0 Features." Sep. 9, 1998.

OMG's *Security White Paper* details the requirements for a security system.[16] This paper was the basis for OMG's security service and security protocol definition. In this document, a full list of requirements for a security system is discussed in depth. OMG has developed two levels of security functionality. Level 1 provides security for applications that have limited requirements in terms of access control. This level also provides security for applications that remain unaware of such a security system. Whereas, Level 2 offers security protection where the applications can control what objects are accessible to specific users. This gives the applications control at the object invocation.

In a simple client-ORB-target pathway, the security service can be demonstrated. With Level 1 security, there are two ORB enforced "checkpoints," at the client node and at the target node. At these points, a check is performed before the request is passed along, and a record in the audit log is maintained. With a Level 2 security system there could also be client and/or target enforced checkpoints, where security-aware applications are utilized. Also remember that additional security checks to authenticate the user can be applied even before a request is made on the client side.

OMG is presently improving upon its security framework, developing the Trusted Computing Base (TCB). This system will utilize the existing security services and will also include parts of ORBs, object adapters, communications software, and additional components, which all need to be "trusted." The TCB will help to minimize the security functionality required in clients and object implementations. This security system will

[16] For a free copy of OMG's *Security White Paper* email a request to document@omg.org.

also permit different levels of trust, depending on the environments in which the objects are running in.

OMG STRUCTURE

As previously mentioned, OMG is a composed of over 800 member companies. This is the largest software consortium in the world, with offices in the U.S., Germany, Japan, United Kingdom, Italy, Australia, and India. Approximately one-third of its membership is based outside the U.S. borders, including companies from the Pacific Rim, Europe, and South Africa. The actual full time staff of OMG is very small (only 27 employees). This is because all of the interface standards are developed externally by its industry members. This seems to be a real strength of the organization. Its members are developing, adopting, and implementing the standards which best suit their industry's needs and will allow their companies to operate more efficiently.

OMG specifications are adopted at meetings, which are hosted by various member companies and held six times a year. At each meeting, every subgroup of OMG meets. There is also time allotted for the interaction of related subgroups on certain projects.

THE ADOPTION PROCESS

The process starts with a Request for Information (RFI) to determine what type of software is commercially available from vendors. A Request for Proposal (RFP) follows this step. This allows time for gathering details and descriptions of the available software. Also, to insure that the CORBA specifications will represent what the industry favors, letters of intent from companies are collected, establishing a corporate direction. OMG's Task force and end users evaluate and make recommendations about the RFP, while the business committee also conducts an examination of the proposal. There is then a board decision based on the collected recommendations.

The adopted standards are available to both members and non-members alike. Object Management Group publishes the interfaces that are adopted by the various subgroups.

OMG DOMAINS

When OMG was first established, it concentrated its efforts on the CORBA architecture and developing its Interface Definition Language (IDL). However, after this started to be used in various industries, a need arose to standardize interfaces within specific industries. Thus OMG's technical committee was reorganized into two distinct groups. One of the committees continues to deal with platform issues, while the other deals with domains (or vertical markets). There are currently eight domain tasks forces working under the guidance of the Domain Technology Committee, including:

- Business Objects
- Finance
- Electronic Commerce
- Healthcare
- Telecommunications
- Manufacturing
- Transportation
- Life Sciences
- Utilities

There are also six Domain Special Interest Groups. These special interest groups are in charge of running essential programs at OMG, but they do not adopt technology on their own. At times, these groups will work in unison with other domain task forces to adopt technology in their specific fields. Some special interest groups include Distributed Simulation, C4I (Command, Control, Communications, Computers, and Information), Geographic Information System, and Autonomous Decentralized Systems.

There are various levels of company membership within domains. Some members contribute to the development of standards; some have auditing power, while others join as influencing members. Considering all levels of membership, OMG has seen a 70% increase in participation in its domain program in the past year.

RECENT REQUESTS FOR PROPOSALS (RFPs) AT OMG

There are numerous Requests for Proposals in progress, which will be voted on in the future by the various domains that make up OMG's Domain Technical Committee.

Business Objects Domain Task Force RFPs

There is a lot of work being completed within the Business Objects Domain at OMG. One of the domain's RFP deals simply with business objects. There are the separate submissions to this RFP, including the Business Object Facility/Architecture, Business Object Facility Interoperability, and a Set of common business objects. The business object domain is also working on the stubs for another RFP: Workflow Management Facility. There is also a Calendaring Facility RFP. This strives to create uniformity in generic business and financial calendar functions.

Telecommunications RFPs

OMG is also very active in the telecommunications industry. A project involving the control and management of audio-visual streams has just been completed. The Telecom Domain is also working on CORBA/Telecommunications Management Network interworking and notification service. There is also an RFP for CORBA/Intelligent Networks interworking. This proposal also addresses long distance toll free calling using intelligent networks and SS7-based networks and systems. Another RFP in this domain is the Telecom Log service. This is a logging service based on ISO/ITU (International Standards Organization/International Telecommunication Union) work, which will probably be useful to other domains as well.

Manufacturing RFPs

The manufacturing domain is working on RFPs involving both Product Data Management (PDM) Enablers and Manufacturing Enterprise Resource Planning. PDM specifications support the development of a strategic product plan, product business plan, and product definition. They define product marketing configuration and rules. In addition, they develop product design and both process design and procurement agreements. The specification also supports coordinating design change and evaluating product design, as well as implementing production changes. And finally, the specifications develop product service methods and service distribution plans. In this RFP, there are eight PDM enablers: request for engineering action, engineering change order, manufacturing implementation, document management, product structure definition, effectivity of products and occurrences, configuration management, and test, maintenance, and diagnostic information.

Healthcare RFPs

The healthcare arena is also very active at OMG. CORBAmed RFP1 deals with master patient identifier. Frequently in hospitals, different departments use separate databases, creating a need for interoperability. In the United States, an individual's hospital record is usually electronically filed using a social security number. However, a real problem exists if a person is from another country and seeks medical attention or does not have a social security number for some other reason. If the hospital which cares for him assigns an identification number, this number is only good locally at the particular hospital. What if this person needs medical attention elsewhere, and the records regarding his past medical history need to be retrieved? It is also significant to note that this could be a matter of life and death. If the person was unconscious and allergic to various medicines, the doctor in charge must have this information. This RFP develops a process to generate a listing of the best possible matches to the correct patient's file, ranked in order of probability.

Another Healthcare RFP is Lexicon service, which deals with issues regarding terms for healthcare concepts. The domain is also working on RFPs for electronic claims and clinical observations. The Pharmacy Interaction RFP is developing the interfaces to enable pharmacies to inquire of insurance companies about an individual's policy before the label for a prescription is even printed in the store. Security is an essential element with medical records, so this domain is also working on a healthcare resource access control RFP. This RFP is based on CORBA security specifications. Finally there is a healthcare Data Interpretation RFP, which is concerned with the integration and transformation of clinical data.

Financial RFPs

The financial domain task force is also developing several RFPs at OMG. This domain is currently developing a Currency, a Party Management Facility, and an Agreement, Contract RFP. This finance domain is also working with the Business Object domain on the Calendar/Business Calendar RFP.

Transportation RFP

The transportation domain is busy developing the interfaces for its Air Traffic Control Display Manager Interface RFP. This is being supported by air traffic control agencies in both the United States and Europe. The CORBA-based interfaces meet the challenge of insuring interoperability for air traffic control systems, which collect radar and transponder data and display this information on a screen, in a useful format for air traffic controllers.

Electronic Commerce RFPs

The E-Commerce domain task force is also active at OMG. Their electronic payment RFP will support a framework for the integration of multiple payment methods under CORBA, including credit card, electronic cash, and bartering. Extending the E-commerce architecture, there is an RFP for the development of a Negotiation Facility.

This domain is also working alongside the Healthcare Domain, in developing the Electronic Claims RFP.

Life Science Research Domain RFP

In OMG's newest task force, the Life Science Research Domain is working on the biomolecular sequence analysis RFP. The basis building blocks of life, DNA, RNA, and protein are all sequences. This task force is creating the interfaces to enable the representation, manipulation, and analysis of these sequences.

Domain Special Interest Groups are also developing standard interfaces at OMG. The Distributed Simulation special interest group is working on standardizing military simulation architecture.

SUCCESSFUL COMPANY EXAMPLES

There are many companies using CORBA successfully today. Success stories are continually updated on OMG's website. This section highlights some of them. (It should be emphasized that there are many more!)

Boeing

As the largest manufacturer of passenger aircraft, employing over 100,000 staff members worldwide, and building and supporting over 250 planes per year, Boeing Commercial Airplane Group greatly benefits from extensive IT systems. Each plane is composed of 3,000,000 parts, and until recently the multiple design and manufacturing systems have been isolated and not able to interoperate with one another. With the limitation of Boeing's mainframe based systems, the company realized that it was time for a change.

Boeing set out on a project which became known as DCAC/MRM (Define and Control Airplane Configuration / Manufacturing Resource Management). The decision was also made to use off-the-shelf applications, as opposed to developing unique in house applications. Boeing turned to client/server technology that has increased efficiency and decreased the cycle time required for product developments. Under this system, pieces of data within the company are managed and updated at a single location, creating a Single Source of Product Data (SSPD). This integrated system greatly cuts cost and time in the building and designing of planes and offers a much greater amount of flexibility. The product development cycle will be reduced four-fold, to a mere six months. The system also provides sufficient support to engineers and other staff members requiring details about specific airplanes.

The proposed deployment of this new system is scheduled to service 70 different sites with over 45,000 users. With this large-scale project, Boeing was able to choose the latest third-party software available from various vendors and integrated these technologies using Orbix's ORBs. Orbix, developed by IONA Technologies, was the first ORB to support the CORBA standard. With the adoption of CORBA, the system is an open architecture based on standards. By using Orbix's ORB and developing interfaces with OMG's Interface Definition Language, applications can communicate to each other. In addition, CORBA has become so widely accepted that vendors were willing to make their products CORBA-compliant to assist Boeing (and keep their business) as they developed this new system. Jim Maloney, Boeing's DCAC/MRM system integration manager states, "It's a mark of the growing acceptance of the CORBA standard that such a large, mission-critical project can go ahead with the full backing of several vendors willing to adapt their software for the CORBA environment."

The CORBA/Orbix system is able to tie together numerous software packages in this new IT system, including product data management (PDM), enterprise resource planning (ERP), and computer-aided project planning (CAPP). The system's central ORB integrates a centralized data center, which is capable of handling 9,000 users at a single time. SDRC's Metaphase product tracks and organizes the system's stored data, while a Local Area Network (LAN) connects more than 200 Unix application servers.

Perhaps Boeing's senior vice president, Tom Schick, sums it up best by declaring, "Taking an object-oriented approach based on CORBA will help reduce the time it takes us to integrate our computing applications. We chose IONA because of its approach to CORBA compliance. Orbix will help us link the different applications together, enabling us to perform as a single integrated system."

Port of Singapore

As one of the world's largest ports, Singapore has several hundred vessels calling on its berths at any given time. To cope with this tremendous amount of volume, the port is now in the process of automating cargo handling systems at its marine terminals. This system uses software based on Orbix. The project involves the automation of dockside cranes. Shoreside personnel will be able to control cranes from a remote location, via control screens and televisions. The port is using APPLI-BUS middleware developed by

Sillicomp, which provides CORBA compliance. So, this solution is interoperable and may be utilized with other environments and port installations worldwide.

CNN Interactive

As a division of Cable News Network, CNN Interactive is the largest development group in CNN. This group, which employs 150 people, is responsible for the dissemination of all non-broadcast news for CNN. The organization has several machines at its headquarters and worldwide, running multiple platforms. They are also responsible for distributing news to outside buyers. This involves providing information to approximately 150 different websites and over 65,000 users in other news organizations.

It is an enormous challenge to take news content in text, video, audio, and electronic formats, store it, and then disburse it to CNN's internal locations and to outside users. This is made even more complicated because CNN's clients are all using different hardware and software. CNN Interactive needed to build an operating environment, which would allow them to gather, store, and disseminate news.

CNN turned to CORBA. This project has allowed them to tie together clients and servers, including Windows and Macintosh desktops, Windows NT, Sun Solaris and Netscape server platforms. News is received in the various formats, wrapped into CORBA objects, stored, and then retrieved by clients using a variety of platforms. An additional benefit of CORBA is that clients and servers may be built simultaneously, and then OMG's Interface Definition Language interfaces can link them together.

The project has been very successful, and CNN Interactive currently utilizes CORBA on six major systems. They are also developing several other projects that will be based on CORBA standards. In the future, a CNN "poll server" will tabulate voting that is now done on CNN's website. Also, CNN's broadcast division is so pleased with CNN Interactive's success with CORBA, that they are now considering using it themselves.

Chevron

Chevron Corporation, one of the world's largest petroleum companies operates in nearly 100 countries and has workforce of 43,000 employees worldwide. This companies is in the midst of a $US2.5 million project that will link the company's desktop systems and World Wide Web browsers to geographical, seismic, and historical drilling information. This information is currently stored in various databases which represent a large range of server technologies. Orbix and CORBA are being used for this system integration project. Chevron is able to use a variety of software from vendors and also in house applications.

In addition, Chevron is working with Petrotechnical Open Software Corporation (POSC), which is a non-profit oil industry consortium that establishes and promotes standards for a distributed object architecture within the petroleum industry. Chevron is also working with its competition, including Shell, in the OpenSpirit Alliance. This alliance, which is a group of oil companies and software vendors, is developing an open distributed framework for sub-surface interpretation and analysis.

LG Electronics

With annual sales totally more than US$8.9 billion, the Korean electronic manufacturer, LG Electronics, is building a new real-time video server system. Internet Service Providers, supplying "Education-on-Demand" services are building this video system for use. The system conforms to CORBA and Digital Audio-Visual Council (DAVIC) standards. (DAVIC is the global standards group that maximizes the interoperability of digital and audio-visual applications and services worldwide.) The system allows consumers to request a list of available video services over the Internet from a service gateway, using a client browser running on Windows 95 or NT. The service gateway, which is updated by a video server, processes the client's request. A list of available services is then generated. The consumer then chooses and initiates a selected service to be played back.

The project manager for this system, Bae-Guen Kang, states, "In order to provide a fast and reliable video system, we needed middleware that was flexible, highly scalable, and had proven itself in situations with a high volume of transactions. Orbix has the best services and platform coverage and is known as the most reliable and advanced product in making software work together. Orbix also allowed us to ensure that our system complied with the CORBA and DAVIC standards, which is essential for a video system today."

Federal Express

Federal Express, one of the leaders in overnight deliveries, has an extensive computerized shipment status tracking service. The company can determine the status of any package in its delivery network. This is also very useful for its customers who use FedEx Powership automated shipping systems. In the past all tracking information was stored in a central mainframe system. However, with millions of packages and thousands of concurrent requests, the performance of this system was less than optimal.

FedEx is now developing an intelligent information system where delivery data is captured and maintained at the local level. FedEx has chosen to use ParcPlace's Distributed Smalltalk product. This environment allows FedEx to handle the complex domain objects which are part of the delivery tracking system. The new system is composed of local databases which intelligently communicate with the rest of the distributed network only when it is necessary. This enables the local, real-time updating of delivery information. Also, local distribution centers are free to configure their database in ways which best meet their specific needs. This obviously leads to greater system performance, with additional flexibility. FedEx plans to use standards like CORBA and the Internet to mix and match different object technologies throughout the system.

Broadvision

As a company that provides software for on-line marketing and selling, Broadvision allows businesses to earn profits from Internet and broadband network services. Their Interactive Commercial Management System (ICSM) called "One-to-One," creates a secure and private environment where a direct connection between a buyer and seller is made. The system is being built using CORBA and Orbix to provide strong interfaces with a good distribution model.

Motorola

Motorola, Inc., one of the world's largest providers of electronic services for worldwide markets is an active member in the US$3.4 billion Iridium Project. Iridium, Inc, which is an international consortium of telecommunications and industrial companies, is working to develop the world's first wireless communications network. This international group includes member companies from Canada, Africa, the Middle East, South Africa, the United States (including Lockheed, Motorola, and Sprint), Europe, and the Pacific Rim.

The IRIDIUM Global Cellular Network, when completed, will provide worldwide wireless telecommunication services capable of supporting voice, facsimile, data, and paging services. The system will be comprised of 66 satellites orbiting the Earth at low altitudes, approximately 420 nautical miles above the ground. These satellites will be connected through cross-links to ensure complete global coverage.

Dr. David Costillo, the lead software designer of the System Control Segment of IRIDIUM explains, "Early on in this project we realized we would need to take a distributed, object-oriented approach in developing this critical software and saw CORBA as the basis for the best solution... The principles CORBA and Orbix are based on are well established..."

U.S. Navy

The United States' Navy must deal with numerous logistical challenges. Vessels are at sea for prolonged periods of time, traveling great distances, and executing a variety of missions. Databases keep track of maintenance schedules, repair facilities, available parts, and suppliers. The Naval Undersea Warfare Center (NUWC) in Keyport, Washington acts as the fleet support center for submarines. The center has a variety of clients, which require access to logistics data, across that U.S. This data is in turn, used to make decisions regarding fleet maintenance, support, and procurement.

The Navy's logistic databases have multiplied throughout the years. Unfortunately, with various manufacturers' products and different versions of a product in use, these databases have also become noncompatible. NUWC had to deal with creating a system that would integrate different types of databases, which resided on a variety of platforms. DataBroker produced by I-Kinetics, and IONA's CORBA ORB Orbix, were the solution. This allowed the center to take advantage of the language and platform independence provided by DataBroker and CORBA. Paul Winkle, the project manage of the NUWC's Information Technology Group, explains how the NUWC can now "use the same database Application Programming Interface (API) for accessing multiple databases from multiple platforms and multiple languages." Now other naval centers are able to gain access to their databases via the Internet.

Independence Blue Cross

An independent licensee of the Blue Cross Blue Shield Association, Independent Blue Cross provides health care to its 2.8 million members. The company's 4700 employees process more than 5.7 million claims and respond to 3.2 million customer inquiries annually. Independent Blue Cross deals with claims involving hospital expenses, outpatient care, home care, and other institutional services. The company now uses IONA's Orbix and CORBA to manage the contracts and claims that are received via the company's Electronic Data Interchange (EDI) system. Requirements for business applications and clients built on Windows, as well as UNIX platforms, are all supported by the system.

Wells Fargo Bank

Distributed object-oriented middleware allowed Wells Fargo Bank to develop a customer information system that enabled its representatives to view a customer's entire bank relationship, with the existing systems they had. The Customer Relationship System (CRS) was developed with the assistance of The Cushing Group and Digital Equipment Corporation (DEC). By using DEC's ObjectBroker, which is in compliance with CORBA standards, a system was developed that could serve customer and account objects. These objects were executed on the existing mainframe to retrieve customer relationship and account data. Wells Fargo has expanded this Customer Relationship System to include ATM's, Internet banking applications, and access from the bank's interactive voice response unit. The architecture also supports real-time accounting applications.

Numerous examples of various organizations and companies using OMG's CORBA standards have been detailed above. Many industries, including manufacturing, mass media, transportation, and healthcare, have been able to successfully improve there connectivity and interoperability using the Common Object Request Broker Architecture.

This chapter has described OMG's attempts to create open systems and has cited numerous real world developments and implementations. The Object Management Group's strength is boosted by its widespread membership, allowing various players in the IT and computer industries to take an active part in the formulation and development of standards. The next chapter, however, will examine how one corporation is attempting to promote its newly developed computer language and technology platform to create open computing environments. This approach is very different than that of the Object Management Group's. Yet, if their products are considered to be in the mainstream of the IT world, it is possible that they might be excepted as industry standards.

CHAPTER 5

SUN MICROSYSTEMS' JAVA

In the last chapter the Object Management Group's non-profit, consortium-based approach was investigated. In this chapter, a different attempt to develop open systems is studied. Unlike OMG's non-profit, consortium-based approach, a corporation focusing on gaining an extensive market share to promote its new computing language and corresponding technology platform is examined.

BACKGROUND

Java, developed by Sun Microsystems Inc., is a fairly new object-oriented computer language that was first released in May 1995. Sun Microsystems describes Java as, "a simple, object-oriented, network-savvy, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, dynamic language." Although these may seem like a flashy description, this language, which was modeled from the C++ language, attempts to simplify and streamline programming. Like other object-oriented systems, the Java platform concerns itself with data objects and the various interfaces to the data. Thus a building block approach can be utilized, where new objects can be created by adding to existing code as opposed to rewriting everything from scratch.

Java has been used extensively for the Internet, incorporated into many large scale Web browsers. An important feature of the Java platform is the Write One/Run Anywhere executables. In essence, this new language is platform-independent. This allows Java programs written on one type of hardware or operating system to run unmodified on almost any other type of computer.[17] Java technology allows the same application from any kind of machine -- a personal computer, a Macintosh computer, a network computer, or even new technologies like Internet screen phones.[18]

JAVA'S INTEROPERABILITY

Emphasizing all of the advantages of utilizing the Java platform, Sun Microsystems feels that its use will continue to grow. As this occurs, developers will continue their efforts to have Java technology accepted as a world standard. In March 1997, Sun Microsystems applied to the International Standards Organization for recognition as a publicly available specification (PAS) submitter. The PAS process at the ISO is used to facilitate the acceptance of industry standards into the ISO. Sun Microsystems will continue their thrust to have Java accepted as an ISO standard.

Certain portions of the Java Technology platform exemplify how Java enables an interoperable environment. Applets, which are mini-applications written in Java to run on compatible web browsers (i.e. Netscape Navigator), help the Java platform provide an interoperable environment over the Internet. It must be emphasized that these applets are not stand-alone programs and can only run within Java enabled Web browsers. However, these applets are machine independent. Thus, once referenced by a browser, the Java applet can run on a Macintosh, Windows, and various other operating platforms. As Java becomes more widespread, its interoperability will increase.

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[17] Fritzinger, J. Steven, and Marianne Mueller. "Java Security." Sun Microsystems, Inc. 1996: 1.
[18] Sun Microsystems, Inc. Website: java.sun.com. "What is the Java Platform?"

One shortcoming of applets is that they are isolated. An applet on a web page has a limited amount of connectivity. It can not talk to the web page itself or other applets. However, the recent development of Java Beans has overcome this technical barrier. Java Beans, which are platform-independent and written in the Java language, are part of an HTML document and similar to applets. However, unlike applets, these components are objects capable of communicating with each other and the web page. Java Beans facilitate the development of client-server applications on the Web. In a similar fashion to objects, beans can be reused and combined to build new applications.

JAVA SECURITY

Java's focus on client-server computing over large networks, like the World Wide Web, raises serious security concerns. The Java security model, which is discussed below, is continually being enhanced as the technology continues to be developed and grows.

Java's applets are an additional burden to the already complex security challenges. A user can now import applets from a Web site. The Web page's executable code (the applet) bypasses the traditional security boundary of the company. Thus, once inside the system, this code, if configured to cause harm, could be capable of altering and/or stealing information and spreading viruses in the local machine as well as the entire company network. In order to protect against such activity Sun Microsystems has place strict limits on applets.[19]

- **Applets cannot read from or write to the local disk**

[19] Fritzinger 2.

- **Stand-alone windows created by applets are clearly labeled as being owned by untrusted software.**
- **Applets are prohibited from making network connections to other computers on the corporate intranet.**

The limits placed on the applets are often referred to as a "sandbox" security system. That is, within the box, the applets is capable of performing anything it wants. However, outside of the boundary of its box, the applet cannot read or alter any data.[20]

JAVA: RECENT DEVELOPMENTS AND FUTURE VISION

Developers at Sun Microsystems recognize that it is fairly inexpensive to install silicon chips in microcomputer devices. These "smart" devices, such as portable telephones, pagers, televisions, handheld mini-computers, smart credit card, and automobiles should all have the capability to be connected to a global network. Java is working to develop devices that will have Java code embedded in them. This will allow these different devices to communicate with each other and additional operating systems via the Internet. Thus, in the future users will be capable of accessing both information and applications from remote locations by utilizing any device capable of connecting to the Internet.

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[20] Fritzinger 4.

JAVA TECHNOLOGY SUCCESS STORIES

Although its still in its infancy, there are many organizations turning to Java technology, which provides a means to connect various computing systems and lower operating costs. The following section describes some successful business implementations of this technology.

Sony

As a global leader in the electronics world, Sony has sites that span the world. Coordinating communications and data flow between Sony manufacturers, their suppliers, and other parties in the supply chain was an extremely difficult task. The manufacturer wished to create better linkages within its organization and between members in the supply chain in order to have up-to-date inventory records, reduce inventory levels, cut production costs, and gain an ability to move products to the market faster. However, Sony's manufacturing data systems were fragmented, lacking global connectivity. Additionally, because of this segmentation, the tracking system data was often manually keyed into the various systems multiple times. With these numerous disconnected information systems in place, Sony was faced with the challenge of creating an interoperable system.

Sony turned to Java technology. Working with various software developers, Sony created the Workflow Information Network Global System (WINGS) application. This Java technology creation integrated the information flow in Sony's supply chain on a worldwide scale. The system is designed as a multilevel client-server environment, linking corporate databases, numerous servers running Oracle database management systems (DBMS), and clients, which are mostly PCs. Java certified Applix AnyWare application product provides the path between the mainframes and the PCs. Java was ideal because of its ability to interconnect systems regardless of the different application platforms they are built on. This new system connected Sony's legacy systems and linked personal computers to enterprise databases, helping it cut costs and improve its competitive advantage. Susumu Shimizu, an engineering manager with Sony, summed up the program by stating, "With the WINGS system, the lead time from receiving a customer order to the delivery of the product to the customer was reduced by 15 days. The indirect costs were also reduced by 30%."

The Co-operative Bank

The Co-operative Bank, with its philosophy of "banking anytime, anywhere, 24 hours a day, at a time and place convenient to the customer," utilizes the Internet to provide on-line banking options for its customers. At the heart of this on-line banking system is Sun's Java technology platform. The system applications and security system run on Sun Enterprise servers. Under a client/server system the bank utilizes the Internet for its home page, an Intranet for communications within its boundaries, and an Extranet linking the bank to its important customers and business partners. Their Internet banking services, based on the standard Java platform, offer a variety of interactive linkages including mobile phone and satellite television connections. One of the advantages of Java is its portability -- these new applications can be used throughout the bank's operating system.

FJ Benjamin

This retailer headquartered in Singapore is a player in the apparel and home fashion industries. With stores spread across eight countries in the Asian Pacific, there was a need to coordinate inventory efforts. In this very competitive, time sensitive industry, information technology can help to streamline operations. However this information must be timely and accurate! FJ Benjamin had a system in place where point-of-sale information from the stores was not sent to headquarters until the end of the day. There was a need to provide managers with real-time inventory information so that improved ordering, shipping, and stocking of goods could be accomplished.

Java's Write-Once, Run-Anywhere capabilities were able to allow FJ Benjamin to utilize their legacy systems, connecting the Singapore headquarters with the rest of the enterprise. Now important sales and inventory information from the stores is continually updated at the headquarters. Additionally, the personal computers at the headquarters, acting as clients in the system, can connect the executives to any locality. This solution has benefited FJ Benjamin, allowing them to make more timely decisions about inventory and purchases, and helping to hedge against costly stockouts.

FJ Benjamin also plans to expand their present technologically advanced system. Working with Sun Microsystems, it plans to develop electronic commerce capabilities, allowing shoppers to shop on the web and at kiosks. The company envisions placing kiosks, which would be virtual shopping centers, at public places, such as airports. As more individuals and organizations choose to purchase goods electronically, FJ Benjamin is positioning itself to be a leader in the next generation of electronic commerce.

Edward Jones: Retirement Planning System

As a financial service company with more than 3800 branch offices spread across the United States and Canada, Edward Jones needed to improve its information systems. The organization chose to shift from a centralized mainframe-based system to a distributed client-server system based on the Java platform. The branch offices were all outfitted with Sun Enterprise servers. This enabled branches to increase response time because applications could now be run locally. Additionally, provisions were made to allow branch offices to access legacy applications stored at the company headquarters.

In addition to this new client-server system, the client units in the branch offices were upgraded with new graphical interfaces. Investment representatives were able to advise their clients faster and display outputs in useful graphical formats. Additionally, what if scenarios and contingency plans could be simulated with ease on this new system. (The "work" was being completed locally in this distributed system on the newly installed servers.) Since the company chose to utilize the Java platform, upgrades will be very manageable and will expand the magnitude of the system. Edward Jones also plans to increase its use of Java products to allow for the remote accessing of data from different platforms, including Unix workstations, PC desktops, and X-terminals. Eventually, this investment company also plans to use Java to leverage a Web-based investment service, allowing clients to monitor portfolio activity, obtain stock quotes, and take advantage of analytical investment tools all from the comfort of their home.

Although Java is in its youthful stages and continues to emerge into the market place, some success stories, which have been detailed above, demonstrate its potential.

Sun Microsystems has the potential to enable the creation of significantly complex networks in the future if Java code is successfully embedded in numerous computing and communication devices.

The next chapter examines another organization aimed at promoting open computing. However, unlike Sun Microsystems and more like the Object Management Group, this non-profit organization coordinates the activities of and receives input from various players in the IT industry. But, their focus is centered on the development of the Internet, believing that its development is the key to open environments in the future.

CHAPTER 6

THE OPEN GROUP

In Chapter 5, Sun Microsystem's Java language and technology platform was studied. It served as an example of a company attempting to promote open systems on its own. In this chapter, the mission and activities of The Open Group is examined. Unlike Sun, The Open Group is a non-profit making organization dedicated to open computing over the Internet.

BACKGROUND

As an international organization, The Open Group, which incorporates the former X/Open and Open Software Foundation organizations, brings together all the key players in the Information Technology industry. Coordinating the activities of computer manufacturers, software vendors, and consumers, the organization's mission is to help in creating a reliable and secure global information infrastructure. The combined annual budget of The Open Group's membership exceeds $55 billion.[21] Thus, it is a very significant voice in IT development. Rather than creating this network itself, The Open Group focuses on helping organizations work together to establish standards for open computing, always trying to ensure interoperability. The Open Group's trademark, the IT DialTone, is "targeted to make IT infrastructure as trusted and easy to use as the telephone." It will provide services to ensure that the Internet can function as a secure and reliable infrastructure. This will allow the Internet to be the backbone for commerce,

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[21] The Open Group. Website: www.opengroup.org/membership/.

information sharing and collaborative work throughout the world. The Open Group tests software products to determine if they meet compatibility criteria. In fact, they have worked with OMG, ensuring that the standard interfaces being developed do indeed support interoperable platforms.

IT DIAL TONE

As stated above, the IT DialTone's goal is to make a strong and reliable IT infrastructure. The Open Group feels that the Internet is the best source to create an effective, trusted global information system. It is predicted that by the year 2000 there will be 180 million employees accessing 163 million sites. Significant issues that must be addressed are as follows:[22]

- **Performance** - It is extremely difficult to guarantee performance on the web. Without this type of guarantee some businesses are hesitant to utilize the Internet as a means of connecting on a global scale.
- **Security** - Although a certain level of security can be maintained, through the utilization of encryption, additional security is needed to encourage widespread use of this technology. This is especially true if large value transactions are to occur over the Internet.

[22] The Open Group. Website: www.opengroup.org/itdialtone/whatis.htm.

- **Privacy** - Even though encryption is helping to improve security, there are issues involving how these encrypted systems are managed and maintained.
- **Transaction Management** - There needs to be an effective way to receive immediate confirmations of completed transactions over the Internet.
- **Searching** - The actual interface with the user needs to improve so that those not technically literate are able to use the technology with ease. Furthermore, a universal directory, as opposed to today's segmented directories, needs to be established.

THE OPEN BRAND

The Open Group awards the Open Brand to products that conform to industry standards. Part of The Open Group's function is to serve as a testing organization for software products, ensuring compatibility and conformance to standards. This encourages and helps to facilitate the concept of open computing. The letter "X" is used to identify branded products, which have met the organization's criteria. This marking is a guarantee made by the vendor to the purchaser. The Open Brand guarantees the following:[23]

[23] The Open Group. Website: www.opengroup.org/registration/wotis.htm.

- **The product works**

  The product conforms to the specification. The vendor is bound by a trademark license agreement.

- **The product will continue to work**

  Throughout its life a registered product is guaranteed to remain conformant.

- **If there is a problem it will be fixed in a prescribed timescale**

  As with any new technological advancement, glitches may arise. Under this agreement the vendor is held accountable to correct non-conformances in a timely manner.

Simply stated by The Open Group of the X/Open brand, "It is a mark that indicates confidence in the vendors' ability to stand behind their registered products and provide a commitment to buyers." The Open Brand system takes the burden away from the purchaser. Organizations can now eliminate or greatly reduce in-house conformance testing and simplify their procurement process. Furthermore, multi-vendor systems are able to achieve interoperability.

THE OPEN GROUP CASE STUDIES

Many industries have benefited from the work of The Open Group. Many organizations have contributed to The Open Group's projects and have also used the results to improve their own operating systems. Below are a few examples.

The Government of Norway

In a joint venture, The Ministry of National Planning and Co-ordination and The Norwegian Association of Local and Regional Authorities are teaming up to create the Public Sector Network. This Internet-based system will help to change Norwegian public administration from a bureaucratic paper-based system to a user-friendly on-line system. This will allow the Norwegian public, where 35% of the population now uses the Internet, to interact with the government via this electronic media for taxation, welfare and various other public administration needs. This will obviously help to streamline government operations and cut costs considerably.

To connect numerous government agencies and different operating environments, an open approach based on standards is essential. This is why The Open Group is taking an active role in this project. They have been testing and examining the specifications and technologies that will guarantee that this new system is compatible with its IT DialTone. The Public Sector Network will also allow for the integration of new technologies from a broad range of vendors as they become available.

Litton/PRC

As an information systems specialist, Litton/PRC was very active developing computing environments based on open standards. However, the time came for them to change their own internal system. The company shifted from a centralized mainframe based system to an open client/server environment. To support this new distributed computing system, fiber optic circuits and servers were installed.

Due to this change, much more information is circulated electronically, cutting down on the need to distribute hard copy documents. Employees can now also access the system to perform such tasks as changing their benefit package. In the past, this process would have taken weeks to complete, requiring personnel to fill out numerous paper forms. Additionally, some electronic data interchanges (EDI) have been established with companies that Litton/PRC regularly conducts business with, including FedEx and Staples. Incidentally, since Litton/PRC has upgraded to a new system, it also has rid itself of the year 2000 bug, which is a significant threat to numerous legacy systems.

<u>Hong Kong Jockey Club</u>

The Hong Kong Jockey Club, which was founded in 1884, operates two racecourses. Although this club is more than 110 years old, information technology is at the core of its operations. A system was needed to handle thousands of bets, with amounts totaling over 275 million Hong Kong dollars for a single race, in a short period of time. In the past, the Jockey Club relied on an information system developed by a single vendor. With new emerging technologies in the early 1990's, the Hong Kong Jockey Club turned to The Open Group for advice and education about Distributed Computing Environments (DCE).

A new object oriented system was designed to handle a transaction rate in the low thousands per second, but this can easily be scaled to handle 6000 transactions per second. Bets are handled by 11,000 operators who are on the telephone, at the two racecourses, and at the 125 off-track betting branches. There are also transactions processed from handheld betting terminals at the track. The system, based on standards, is scalable, flexible, able to support heterogeneous multi-vendor systems, and is secure. Hong Kong Jockey Club executives estimate that the new system, which has been running since December 1996, has already created a savings of well over $100 million.

United Kingdom Department of Social Security

The UK's Department of Social Security (DSS) maintains 2,000 branch offices and employs over 93,000 individuals handling numerous claims and matters daily. Such an organization needs a secure information technology system. The DSS is in a transition stage, moving away from a highly fragmented information system to a more unified, open system. The UK desires to concentrate its efforts on the services it will be capable of providing and is determined to outsource the application development and utilize a public infrastructure. As with any user of a public infrastructure, but especially a government organization, security is a top concern. This is where The Open Group has become involved, offering support to the DSS as it develops its technology platform. In particular, the Open Group's IT DialTone focus on security has been the basis for numerous forums and discussions.

Again, like in the previous two chapters, successful implementations have been detailed. In the next chapter, an examination of open systems and interoperability as it relates to a comparison of the Object Management Group, Sun Microsystems, and The Open Group is completed.

CHAPTER 7

EXAMINATION OF OPEN AND INTEROPERABLE SYSTEMS

The search for systems that are truly "open" is a very challenging one. Many systems in place and developmental work being completed today do not represent real open systems. However, there are numerous interesting projects involving the creation of systems where interoperability is possible. Legacy systems are difficult to replace, and specialized software can sometimes best meet the specific needs of an organization, so the trend has been to develop standard interfaces. The challenge today seems to be focused upon how to utilize expensive legacy systems that cannot be immediately replaced. The innovation of the 1980s occurred so rapidly that many disconnected, incompatible system have been left behind for the 1990s. Now, as the time and business needs change, there is a need to better coordinate activities and communications both internally and externally between organizations. Although these systems are not open in the sense that they support specialized hardware and software, they do create an environment where interoperability can exist.

Specifically, the Object Management Group's work concentrates on interoperability. CORBA has facilitated connectivity between heterogeneous systems. However, there is still a need to focus on developing the middleware (stubs and skeletons) to permit this interoperability. Sun Microsystems Inc. has been successful in developing a simple, object-oriented language. The Java platform, although in its early stages of development and implementation, promises to become a driving force in the information technology field, permitting the creation of large-scale networks. That is, provided that Java code becomes used more extensively and is embedded in devices such as mobile telephones, handheld computers, and other gadgets.

While Sun Microsystems focuses on extending the Java platform and embedding Java code in many devices, The Open Group concentrates its efforts on the Internet to create open environments. This may provide the means for open systems in the future. However, the performance level and security of the Internet need to be improved.

It is also important to realize that the organizations studied are dependent upon one another to a certain degree. As discussed in Chapter 6, The Open Group also serves as a compatibility tester of software. This organization has worked with the Object Management Group to ensure that the standard interfaces being developed do indeed support interoperable systems. Furthermore, Java and CORBA object technologies are being utilized to develop web-based, client-server environments. In fact, a CORBA/Java ORB (object request broker) has been developed. This will help to allow for complex, web-based, business-to-business as well as consumer-to-business transactions to occur. It turns out that CORBA and Java can be used in a complementary manner. It will be interesting to see how the Object Management Group as a non-profit organization and Sun Microsystems, a corporation, interact and coordinate developments as this linkage between their products expands.

In the future, the development of open systems may become more prevalent. As legacy systems are finally phased out, replacement systems, which have been developed based on standards, can help to facilitate this transformation. Additionally, moving to a more open environment would allow organizations to enjoy the additional benefits of openness, including maintainability and scalability. New applications will be able to be inserted into an operating system, which is based upon accepted standards, without having to write additional interface code. Middleware is needed today to facilitate interoperability… will it be needed in the future? If true open systems can be developed it will no longer be needed.

However, even though the technical challenges of developing open and interoperable systems may be overcome, there are several institutional barriers to the development of such systems. The next chapter examines some of the key institutional issues which need to be addressed and dealt with as these technical systems are developed, implemented, and operated.

CHAPTER 8

INSTITUTIONAL ISSUES

As this thesis has demonstrated, there are numerous interoperable computing systems in various industries in operation today. Although the technical challenges of developing these interoperable systems may be overcome, and perhaps even true open systems may be developed some day, there are several institutional barriers which also need to be addressed. This chapter examines some of the key institutional issues which need to be addressed and dealt with as these technical systems are developed, implemented, and operated.

BACKGROUND

The marvels of astonishing technological advancements are not enough for successful system implementations. There are also numerous institutional issues which must be considered. The first portion of this chapter focuses on some more universal institutional issues, namely:

- **Security**
- **Privacy**
- **Fraud**
- **Global Standardization**
- **Resistance to Change**

After these institutional issues are examined, a section is dedicated to special needs of the Navy. The United States Navy has needs that extend beyond most industry groups, and these must be taken into account.

SECURITY

Open systems present a complex security issue. These large networks that span across traditional company and geographic borders, which often include public networks, demand a certain level of security. However, this is extremely challenging to both create and maintain.

In distributed systems, objects often interact in complex manners. This is different from the traditional and simplistic client-server interaction of the past. Now, a server of one object may be the client of another object. Objects may be implemented by using another additional set of objects, which are in some way connected. So, it is essential that the architecture for a security system be independent of these intricate object interactions. That is, the architecture does not need to be concerned with how all the objects are intricately interacting.

General security requirements for a system include:[24]

- **Consistency**

  The security model must be capable of handling legacy as well as new systems in a consistent and standard manner to ensure portability across all platforms.

[24] Siegel, Jon. CORBA Fundamentals and Programming. New York: John Wiley & Sons, Inc., 1996: 235.

- **Scalability**

  This model also needs to provide security for all systems, from locally operating systems to large international systems.

- **Availability**

  Security must be available across an entire system. Piecemeal security, where a "steel door and grass hut" situation may be created is not effective to maintain system-wide security.

- **Business Requirements**

  The security system should be appropriate for the organization it protects. For example, a small Internet-based company does not have the same business or security needs as an international electronic commerce institution.

- **Regulatory Requirements**

  Like any industrial creation, security systems must fall within parameters established by the government. For example, there are controls on what can be exported, limitations on confidentially, and regulations involving the use of encryption. (The use of encryption will be discussed in the Privacy section of this chapter.)

- **Enforceability**

  A security system is only as strong as its most vulnerable point. The goals of a security system -- to protect, to provide privacy, etc. -- are only effective if they capable of being enforced. (This is related to the topic of fraud which is discussed later in this chapter.)

- **Portability**

  The security system should be able to protect various hardware and software environments.

- **Usability**

  This system must also be user friendly. The user should only be required to log on to the system once to access information and services.

- **Evaluation Criteria**

  A secure product must meet assurance criteria. (There are various international criteria for assurance.) This gives the user confidence in the effectiveness of the system.

- **Performance**

  An expected performance level for a security system must be maintained.

- **Flexibility**

  An organization's needs are going to change with time. Likewise, security needs will also change. The system needs to be flexible and adaptable to allow for these changes without creating the need to totally reconfigure the security platform.

- **Adherence to Standards**

  The security system, just like the entire operating system must adhere to accepted standards. (The institutional issue of standardization is discussed later in this chapter.)

- **Interoperability**

  Similar to the systems they are protecting, the security measures should be able to span across traditional operating environments and protect various communications between different systems.

- **Maintainability**

  Also, in most cases, the administration of such a system should be simple. Rather than assigning control to individual objects or users, such a security system should deal with groups, making the administration process easier and less expensive.

A security system has these key features:[25]

- **Identification and Authentication**

  Users need to be identified to ensure that they are who they claim to be. This can be accomplished several different ways. Smart cards, retina scanners, thumb print readers, or passwords can be used to identify users. In order to keep the number of logons required to one, the system should be capable of accepting the credentials of a user who has been authenticated outside the operating environment.

- **Authorization and Access Control**

  A framework to access information must be established to determine what objects each user may access. Depending on security clearances, groupings,

[25] Siegel 239.

and other levels of specifications, users will be granted access to certain objects. It should also be possible to assign access privileges to an object.

- **Security Auditing**

  A security system should be able to maintain an audit trail, even if the user has made several calls between objects. Then, in the event that something does go wrong and a breach of security occurs, the individual responsible may be held accountable. It is also very important that the audit trails are stored in a secure environment, to guard against unauthorized modification and deletions.

- **Non-Repudiation**

  Non-repudiation gives users irrefutable evidence of electronic transmissions. For example, the recipient of a transmission can be provided with proof of the origin of the data. This guards against third party intervention while information is in transit between locations. Also, to protect the sender, proof that a specific party received the data which was sent can be provided.

- **Secure Communication**

  When information is in transit, it is more vulnerable. This data in transit between objects is often traveling over insecure or less secure communication service pathways. The information needs to reach its correct destination and maintain its confidentiality, so security of communications needs to be end-to-end, without relying on the security in the communications service that is used. This will guard against fraudulent activities of individuals creating false locations and intercepting data. (Fraud is discussed later in this chapter.)

- **Cryptography**

  Cryptographic technologies are a necessary element to ensure trust and security in electronic communications. Both encryption and digital signatures are two important applications of cryptography. Digital signatures can help to prove the origin of the data (authentication) and verify whether the data has been altered (integrity). Encryption, which is a technology that encodes computer files, can help to keep data and communications confidential.[26]

- **Administration Tools**

  Like any operating system, the security system needs an administration plan. Secure information must be maintained in some type of organization and an overall security policy needs to be in place for the system. Additionally, the system needs to be able to handle changes in its policy. Throughout the lifetime of the system, security policies will be altered, deleted, and created.

PRIVACY

As mentioned above, one of the goals of a security system is to provide privacy to its users. That is, the security measures should guard against undesired parties from using the system and also protect data in transit between operating environments. Identification and authentication, which were discussed above, help to provide a means where only designated individuals gain access to secured systems and data.

Encryption, which is the process of encoding text using special algorithms, can be utilized to maintain privacy while communicating over public networks such as the

[26] "Towards A European Framework for Digital Signatures and Encryption." 1997: 1.

Internet. This is essential to maintain privacy. Public networks such as the Internet are relatively insecure systems by themselves. An experienced hacker could easily monitor communications over the network, listening for financial statements or credit card numbers for example.

In every-day-life many electronic files, such as medical records and financial information, are encrypted. There are various levels of encryption (commonly ranging from 40 to 128 bits) that organizations may choose to utilize. Within the United States borders, most of the transactions completed over the Internet are protected by 128-bit encryption. It is a widely accepted belief that strong encryption, like the 128-bit technology, is needed to protect privacy and ensure security. This encryption technology is sold throughout the world. In the United States encryption technology is available on line via the Internet as well as at retail outlets.

In some systems where encryption technologies are utilized, the user of the system has complete control over the coding and decoding of electronic files. Before information is sent through the network, it is encoded at a certain level. Then, the receiver on the other end, who must authenticate himself to the system and possess the proper decoding devices, in order to gain access to the information, retrieves the information. This is accomplished without the intervention of any additional parties.

However, another type of encryption system involves storing "keys" with approved third parties. Keys are similar to passwords that grant access to encrypted material. The possibility of a code breaker gaining access to information is related to the key length. The greater the key length, the more possible combinations for a key exist. Thus, longer keys have a much lower probability of being decoded by a hacker as compared to smaller keys. The following table demonstrates the relationship between key length and the number of possible key combinations.[27]

Key Length	Possible Keys
40 bits	1,099,511,627,776
56 bits	72,057,594,037,927,900
90 bits	1,237,940,039,285,380,000,000,000,000
128 bits	340,282,366,920,938,000,000,000,000,000,000,000,000

Figure 8-1

Relationship between Key Length and the Number of Possible Keys

In a key recovery system, individuals would recovery the necessary key from a secure and trusted third party (or government) to decrypt the desired information once it has been received. The security of this system largely rests with the institution holding the keys.

Although encryption is widely recognized as an adequate means to ensure privacy while communicating over public networks, there is significant debate in the United States about exporting encrypted products and messages beyond the nation's borders. The government presently imposes strict export controls on encryption technology. This concern involves the ability of the government to maintain national security and public safety, but still allow American citizens the protection granted by utilizing strong

[27] Americans for Computer Privacy. Website: www.computerprivacy.org/glossary 2.

encryption products. Any development of an open system that would cross the United States jurisdictional boundaries will need to address this issue.

FRAUD

The security systems also attempt to prevent fraudulent activities from occurring. In any operating system, whether its open, interoperable, or otherwise, breaches in security can occur. However, in an open or interoperable system, where an array of components are interconnected over a vast network, the concern about fraudulent activity multiplies. Additionally, even those who have proper access to the systems may misuse applications and data.

As discussed in the previous two sections, there are measures to guard against these undesired activities. Identification and authentication components of a security system should be in place to guard against outsiders from gaining access. Encryption should be used to protect information while it is in transit over networks. Furthermore, audit trails should be maintained, so that if a problem does occur it can be traced to a source.

GLOBAL STANDARDIZATION

In the beginning of this thesis, a formal definition of open systems was discussed. A portion of the definition described open specifications as, "consensus based standards that are exclusively documented." The definition further commented on standards, stating, "...standards are the product of international, national, and professional organizations." From Peter Keen's work, an open system standard must:[28]

- Be fully defined to allow vendors and suppliers to work from the same definition.
- Be stable, presenting vendors and suppliers with a fixed target.
- Fully publish its interfaces so there are readily accessible.
- Not be subject to control of any one player.

Obviously an open system will be based on standards; however, the development of standards is not always a simple process. The process of developing, agreeing upon, and implementing standards imposes an institutional barrier, hindering the development of open systems.

Defining standards on an international level takes a considerable amount of time. Numerous parties in the field must be brought together, and all these groups may have different ideas and opinions about what a standard should specify. Moving from the initial stages of accepting input, through the development phase, to the final version and implementation of a standard, can be quite a lengthy process. This is a significant problem in the IT community because the rate of the technological change is very high. It is extremely challenging to develop standards that can stand the test of time. Also, because the process of standardization is a time consuming one, the possibility of standards becoming obsolete quickly, or even before the implementation phase, is significant.

[28] Keen 204.

Although baseline standards may exist, some vendors may develop standard products with some additional non-standard features. It is becoming widely accepted that standard-based products are necessary for the future; however, some of these vendors are still focused on maintaining a "captive" customer base. The introduction of products with non-standard features will obviously challenge the possibility of creating open and interoperable systems.

Additionally, this thesis has noted different ways that the computer industry attempts to define standards. As in the Object Management Group and The Open Group's cases, a large consortium of diverse players, including software developers, system designers, and end users, work together to converge upon industry standards. Other approaches, such as Sun Microsystem's, attempt to have a proprietary development become the standard. Although this is an entirely different approach, it is a possible route to take. In the past, for example, the operating system DOS, first developed by Microsoft, became a standard for most personal computers.

RESISTANCE TO CHANGE

In industries across the globe, information technology will continue to become an important element in the way companies conduct business activities. The world as a whole is transforming itself from a resource-based society to knowledge-based society.[29] Information is power, and in many systems, including production, distribution, and retail operations, it is as important as the physical materials. Competitive advantages can be gained with the successful implementation of information technology. However, many

[29] Vanroye, K. and W. A. G. Blonk, "The creation of an information highway for intermodal transport," *Maritime Policy and Management* 25:3, 1998: 263.

industries are at times slow to respond to the potential that these information technologies present. Several issues related to this resistance to change are noted below.

- **Technologies will extend beyond traditional business boundaries.** This new interconnectivity can connect numerous parties and enables the sharing of information among multiple organizations. This demands top-level management commitment to lead companies through very difficult cultural changes. Furthermore, this change will not come easily, especially in traditional industries.
- **Significant investment is required in these highly computerized systems.** This demands the need to focus on long-term goals, causing companies to resist change. These systems can be costly and the benefits are not immediately realized. Additionally, industries competing solely on cost, where other level-of-service variables are not very significant, will not look favorably at the high costs. If competition is fierce, and margins are low, adopting new technology to add value to service will not be a high priority of many companies and organizations.
- **Fear of expensive systems quickly becoming obsolete is very significant.** With a high rate of change in emerging technologies, this concern is strong. Alongside this issue is the concern of universal interoperability. It is extremely challenging to get various computing environments to communicate with each other. Many emerging technologies attempt to address this issue and previous chapters have outlined some truly interoperable systems;

however, in practice not all systems have been successful. With any technological advancement there are going to be glitches and barriers to overcome, but when these systems are responsible for controlling billions of dollars worth of assets and worldwide enterprises, an even greater concern is created.

- **The human element may resist change.**

  "Why change systems, I was just getting proficient with the current system, and there seems to be nothing wrong with it." Many individuals will take this stance because a new system means a change from their present, more comfortable, environment. In addition, a new system will take some time to become accustomed to it. A good human - machine interface is essential for a successful implementation.

NAVY CONCERNS

Above and beyond the scope of many computing systems developed for the private sector, the United States Navy has special needs. These make the development and implementation of an open system even more challenging. Some significant issues that must be considered for the Navy are the following:

- **Heightened Security Measures**

  Obviously, many naval functions are directly linked to national security. Breaches in security are far more serious and must be avoided. This can greatly increase the cost associated with building and maintaining a robust security system. But, the system must be capable of fending off potential terrorists and guard against improper behavior during both wartime and peacetime. There is definitely a significant amount of vulnerability in using a large-scale network for defense purposes. Now, not only are other countries considered potential enemies, but rather, independent web-based terrorist groups must also be taken into consideration.

- **Classification**

  Related to the need for a higher level of security, a significant amount of naval information is classified and needs to be protected. Further complicating this challenge is the existence of numerous classification levels, far more than organizations in the private sector have. This classified material should only be accessed by authorized personnel. Thus, the systems must understand who has access to what information, and not grant access to unauthorized internal employees or undesignated third parties. A solution the Navy can use to control classified material is have separate Local Area Networks (LANs) for different levels of classification. In the case of unclassified information, conventional corporate security measures may be utilized. That is, a user would be required to enter a password to access the system, which would be protected by a security firewall. This prevents the average person from gaining access, but is by no means appropriate for classified material.

- **Ability to Work During Wartime**

  The computing networks must be able to maintain their high level of functionality during times of national crises and war. Can the Navy rely on a public infrastructure, such as the Internet, for mission essential communications during wartime? What contingency plans would need to be developed if the Navy chose to use the Internet for such purposes and it was taken out of service or infiltrated by terrorists during wartime? These are serious questions that need to be addressed. If the development of open systems depends on a high amount of interconnectivity that establishes numerous connections, can a public network be used safely for national defense communications?

Presently, the Internet is viewed as a highly insecure network in its infancy. In order for the Navy to rely on it for mission critical purposes, advancements must take place to make it more stable. But, the Navy will ultimately use the public infrastructure heavily, including commercial telephone lines and satellite systems.

The IT 21 (Information Technology for the 21^{st} Century) initiative is focused on improving the connectivity of the United States Navy for the next century. The program plans to connect shore-based locations with fiber optic networks and commercial telephone lines. In addition, efforts are being made to connect the ships with sea-to-satellite communications to the Internet and also to establish pierside connections to onboard unclassified networks. However, using such an advanced network system will provide enemies the ability of attacking the United States without ever landing troops or missiles on U.S. soil. So, these systems, based on commercial-off-the-shelf (COTS) components, need to be able to withstand the pressures of wartime and fend off any malicious activities.

Although it may be technically possible to develop interoperable and maybe even open systems, there are additional non-technical considerations that must be addressed. This chapter has focused on some key institutional issues that need to be considered as open systems are designed, developed, and implemented. It is important to remember that great technological products are not a guarantee for successful system implementations, and that there are many other related issues which need to be considered.

CHAPTER 9

SUMMATION AND CONCLUSION

Information technology developments in the 1990s have flourished. The use of the Internet is growing at astounding rates, while the cycle times for new versions of hardware and software products is now measured in months as opposed to years. With this rapid rate of technological advancement, a universal approach is needed to insure that present and future developments will be compatible with existing systems and systems yet to be designed.

This thesis has investigated the topic of open systems. In Chapter 2 the history of the computer and information technology was explained, and Chapter 3 described some more recent developments in this highly dynamic industry. This set the stage and demonstrated a need for systems that are open. The rapid technological developments and implementations of the past have caused systems to be isolated and incompatible. Now, as organizations need to be interconnected within their boundaries and externally with customers, suppliers, regulatory bodies, and numerous other parties, systems must be able to interoperate. However, this thesis also explained how interoperability is only one key element in a truly open environment. Additional attributes, such as portability, scalability, and maintainability, are also essential.

In Chapters 4, 5, and 6, a study of some important commercial work that is striving to create open environments was discussed. It was interesting to see different approaches to a similar goal. Some organizations are non-profit, choosing to create a forum of IT professionals and users, to develop standard based solutions, while others are profit-making corporations attempting to push a product into the mainstream so that it becomes an accepted standard. Throughout these chapters, several successful implementations, including a system designed for the Naval Undersea Warfare Center, were discussed.

In Chapter 7, the different organizations previously presented were compared and contrasted. Here, it was also noted that there is some sharing and cooperative development between the parties. The work of these groups was explained to have some key elements of open systems. Most significantly, interoperability is being achieved in many cases. However, relating back to the beginning of the thesis, there are several other elements also important in open systems. None of the systems examined were truly open in the sense that they met all these system parameters.

Even though it is technically possible to assemble highly interoperable systems, and it might be feasible to develop open systems in the future, there are other additional concerns, which must be addressed. In Chapter 8, several institutional issues were examined. Great technological advancements do not necessarily lead to successful system implementations. The issues presented, like security, global standardization, and resistance to change, must be considered when designing, implementing, and operating these systems.

The United States Navy, along with other organizations and companies that rely on extensive IT networks, can benefit by striving to develop open systems. A significant part of this development would involve the use of commercial off-the-shelf components, which are designed to adhere to specific standards. The benefits of open systems, which were described in the thesis, are worthy of the effort. Namely, reduced life cycle cost, including operational and maintenance costs, can be a significant saving. In addition, the ability to insert new technology, as it is developed, into an existing system so that it will function in a flawless manner is a tremendous advantage. Information sharing between portions of organizations that where once unable to be connected can facilitate greater productivity and a higher level of awareness within one's organizational borders. However, a significant challenge is that these systems are expensive and the benefits are not instantly realized; in fact, it can take years.

It appears that at the present a focus is centered upon dealing with legacy systems. Organizations have invested heavily in the past in these systems, which are often isolated and very expensive to maintain. But at the same time these systems cannot be totally replaced in a cost-effective way. Thus, the challenge to incorporate these older systems into an interoperating system-wide computing environment is time consuming and difficult. Several developments to aid this interoperability have been discussed. However, in the future, when the legacy units become a thing of the past and are finally replaced, newer components, which have been designed according to open standards may provide a means to create certifiably open systems. Of course the institutional issues, discussed above, will always need to be considered.

The future of the Information Technology world is quite fascinating. The possibility of being connected to the rest of the world from a mobile telephone, a handheld computer, or an automobile, for example, is amazing. But such development needs to have a master framework, and components need to be designed based on strict standards if open systems are to become a reality in the next millenium.

ACRONYMS

ANSI	American National Standard Institute
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
BIR	Business Integration and Restructuring
C4I	Command, Control, Communications, Computers, and Information
CAPP	Computer-Aided Project Planning
CEPT	Conférence Européenne des Administrations des Postes et Télécommunications
CRS	Customer Relationship System
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-the-Shelf
DAVIC	Digital Audio-Visual Council
DBMS	Data Base Management System
DCE	Distributed Computing Environments
DES	Data Encryption Standard
DoD	Department of Defense
DP	Data Processing
EAP	Enterprise Architecture Planning
EDI	Electronic Data Interchange
EDT	Electronic Data Transfer
ERP	Enterprise Resource Planning

ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
HTML	HyperText Markup Language
ICMS	Interactive Commercial Management System
IDL	Interface Definition Language
IEEE	Institute of Electrical and Electronics Engineers
IIOP	Internet Inter-ORB Protocol
IIS	Information Innovation and Support
IRC	Information Resource Catalog
ISO	International Organization of Standardization
IT	Information Technology
ITU	International Telecommunication Union
ORB	Object Request Broker
LAN	Local Area Network
LEO	Low Earth Orbit (Satellites)
MIS	Management Information System
MRM	Manufacturing Resource Management
NUWC	Naval Undersea Warfare Center
OMG	Object Management Group
PAS	Publicly Available Specification
PC	Personal Computer
PDCD	Portable Data Collection Device
PDM	Product Data Management

PIN	Personal Identification Number
RFI	Request for Information
RFP	Request for Proposal
SSPD	Single Source of Product Data
TCB	Trusted Computing Base
TCP/IP	Telecommunications Communication Protocol/Internet Protocol
WAN	Wide Area Network
WINGS	Workflow Information Network Global System
WWW	World Wide Web

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