LAN/WAN Integration: Internetworking + Application Interoperability

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INTRODUCTION

Computer networking is currently in its third stage of evolution. During the first stage large mainframes were accessed by local and remote dumb terminals. The second stage could be characterized as Local Area Network (LAN) complexes with one or more physical LANs interconnected in a local environment. English author John Donne once said that "No man is an island". In the 1990s one can describe the third stage as the interconnection of these LAN islands via Wide Area Networks (WANs) to form enterprise networks.

The physical topology of these networks had a major impact on the networking and application protocols developed for their respective environments. For example, IBM originally developed System Network Architecture (SNA) for a mainframe centric environment; and Novell's Netware was initially designed for a LAN environment.

The major emphasis in the early days of interconnecting computers was networking issues. The early architectures were developed by computer vendors to support their specific product line (e.g. SNA, DECnet). The development of the Open Systems Interconnection (OSI) Reference Model[1] in the late 1970s by the International Organization for Standardization (ISO) was planned to be the basis for a suite of international standards to be used by all to interconnect heterogeneous computer systems. This lofty goal of a utopian single set of ISO standards has not only failed to appear, but has been superseded at the transport and network level by the ubiquity of the Transmission Control Protocol (TCP)/Internet Protocol (IP).

The OSI Reference Model defines a seven layer model that deals only with the interconnection of heterogeneous computer systems. It defines the services offered by each of the lower six layers to their respective higher layer. However, it does not define an interface to the top or application layer of its model. With the advent of enterprise networks supporting distributed applications (e.g. client/server computing), one requires more than just communications standards. Recognizing this fact, ISO, as well as many other organizations, has expanded its area of responsibility to include Open Distributed Processing (ODP).

ISO defines the following: "Distributed processing is concerned with the operation of systems constructed from a wide range of hardware and software components and with evolution of such systems. ODP is concerned with standardization to support component migration and portability, implying standardization of programming interfaces, including Application Program Interfaces (APIs)"[2]. ISO has already developed a standard for the Basic Reference Model of Open Distributed Processing[3] to be the framework for the standardization of ODP.

Users interconnect their LANs and WANs to support their applications. This distributed environment requires more than communications standards. This paper addresses the services required to support distributed processing and the various activities to develop the "standards" to provide these services. It comprises six major sections in addition to this Introduction. ISO's Approach to ODP describes the ODP Reference Model and the seven aspects of a distributed system. The Open Software Foundation's Distributed Computing environment is discussed in the next section. This is followed by a brief discussion on Middleware. The important topic of Evolution in the Marketplace is discussed next. The Enterprise Network goal architecture is described in the penultimate section; and the final section contains Conclusions.

ISO APPROACH TO ODP

Before ISO started to develop standards for systems interconnection, it first developed the seven layer OSI Reference Model. As stated in ISO 7498, "the Reference Model of Open Systems Interconnection establishes a framework for co-ordinating the development of existing and future standards for the interconnection of systems and is provided for reference by those standards".

It should come as no surprise that ISO is taking a similar approach for developing ODP standards. Currently, the major emphasis in ISO and the Telecommunication Standardization Sector (formerly the CCITT) is to produce an agreed Basic Reference Model of Open Distributed Processing (RM-ODP). Reference 3 states that " RM-ODP defined the technical basis for ODP standards, and relates to other ISO Reference Models, and existing standards, including communications and data management standards". This means that underlying infrastructure for these ODP standards will be the ISO layer standards (e.g. Transport Protocol[4] and File Transfer, Access and Management (FTAM)[5].

The areas of concern for ODP standardization are shown below in Figure 1[6].

Using this figure as a starting point, ISO has defined 7 (a magic number ?) aspects which are of concern for a distributed processing system. These are as follows:

- Process aspect: information processing structure and functions;
- Storage aspect: structures and functions for the retention of information;
- User access aspect: presentation and input of information;
- Communication aspect: structures and functions for information exchange;
- Identification aspect: controlling the naming of objects;
- Management aspects: facilities to define, refine, modify, schedule and maintain resources;
- Security aspects: policies, requirements, models and mechanisms to support desired security qualities.

These 7 aspects are partitioned into two categories. The first describes aspects of systems requiring distribution (process, storage, user access); and the second defines aspects of systems that enable distribution (communication, identification, management, security).

Since ISO is currently attempting to obtain consensus on the RM-ODP, one should expect to wait a number of years before seeing ISO ODP standards and implementations.

DISTRIBUTED COMPUTING ENVIRONMENT (DCE)

Since users today require an environment that supports distributed processing, the Open Software Foundation (OSF) was founded in 1988 to acquire and develop the technology required to create a vendor-neutral computing environment[7]. The OSF has members from system vendor, software vendor, end user, government agency, research center and university communities. OSF does not actually develop technologies, but evaluates technologies for inclusion in its defined DCE.

The technologies of interest to OSF are depicted in the DCE Architecture shown in Figure 2[8].

As can be seen in Figure 2, the DCE is a layer of software that resides between a computer's application program and operating system. The six DCE components are as follows[9]:

- Remote Procedure Call (RPC), which distributes application execution,
- Distributed Directory Service (Naming), which provides a single naming model throughout the distributed environment,
- Threads, which control the flow of information within applications,
- Time Service, which synchronizes all clocks on a network,
- Distributed File System, which gives users access to remote files, regardless of their geographical location,
- Security Service, which provides a secure means of communication that ensures both data integrity and

privacy, and prevents unauthorized access to the distributed environment.

It is important to note that DCE does not cover OSI layer 4 and below nor applications which are not core services for the distributed application environment (e.g. electronic mail services).

The technologies selected by OSF for the DCE were obtained from an open selection process where vendors were requested to submit candidates to a DCE Request for Technology. Two of the major requirements for the submissions were that implementations must be written in ANSI C and be conforment with the IEEE standard 1003.1 (POSIX) system interface specification. This implies that the OSF DCE is strongly influenced by UNIX.

MIDDLEWARE

What is middleware besides being the latest buzzword in the computer industry. Middleware is "a layer of software that sits between an application and the network, and manages the interaction between disparate applications across the heterogeneous computing platforms. Most middleware products support a high-level programming interface and a set of services such as directory, naming and authentication. Middleware basically shields application developers from the complexities of underlying networks and operating systems".[10] OSF's DCE fits this definition of middleware and provides a RPC service which is one of the two main types of middleware. The other major type is message-passing.

Although DCE supports only RPCs, both RPC and message queuing provide valuable services as middleware products. RPCs are better suited for tightly coupled applications where integral components of a single program are dispersed across multiple processors. Message queuing is better suited for loosely coupled applications where two or more independent applications communicate in a store-and-forward manner (reference 10).

Message APIs

APIs play an important role in message passing. The messaging API provides a common interface that allows users to send messages and files from within their applications without having to exit the application. The major problem is to select from the variety of messaging APIs that are supported by different vendor camps. For example, a group led by Microsoft favors the Messaging API (MAPI), whereas a Lotus Development Corp. backed effort is pushing the Vendor Independent Messaging (VIM) interface.

The hope is that the X.400 Application Program Interface Association (XAPIA), a consortium developing APIs for X.400, will develop an API that will become the standard messaging interface that is excepted in the marketplace. Similarly, one can hope for a dominant marketplace standard for other application interfaces like network management and database access.

EVOLUTION IN THE MARKETPLACE

Both ISO, see Figure 1, and OSF have recognized the fact that the integration of LANs and WANs to support distributed processing requires more than just communication standards (e.g. OSI standards). This has also been recognized by vendors that have concentrated on the PC centric LAN environments. Since the majority of end users utilize PCs (Macintoshes included under the PC umbrella) as their client machines, it is important to reflect on the evolution of the PC LAN/WAN environment for both networking and application interoperability. Since email has been available from the heyday of mainframe computers, it will be examined as a typical application.

Transport and Network Layer Evolution

Originally network and transport layer protocols for the LAN environment were developed to support only that environment. Little or no thought was given to an enterprise network. One of the more popular PC LAN networking architectures is Novell's NetWare.

Originally Netware supported the Internetwork Packet Exchange (IPX) and Sequence Packet Exchange (SPX) at the network and transport layers respectively[11].

With the advent of enterprise networks vendors had to consider more than just departmental LANs and interconnected LANs. Proprietary Network and Transport protocols that had been developed for this LAN market were not able to satisfy the requirements of the enterprise network. A vendor independent standard was needed to meet this requirement. Since ISO products were not readily available, TCP/IP became the world's defacto standard transport/network protocols.

Network operating system vendors like Novell want to protect their installed base of proprietary protocols and also compete in the enterprise network arena (i.e. also support TCP/IP). This has been accomplished by the development of an interface that supports a variety of transport stacks. An example of this is the Transport Level Interface (TLI) which offers a standard interface for a variety of transport stacks.

When the TLI is implemented, a client could establish a connection to a local NetWare server using SPX/IPX; and then establish a separate connection to another user using TCP/IP.

The use of TLI is a good interim solution when one has to accommodate legacy systems. However, it complicates the security and management aspects of the enterprise network. Security is complicated because each networking protocol often implements its own unique security features (e.g. the ISO Network Layer Security Protocol). Similarly, system management is complicated because all the different network and transport protocols have to be monitored and controlled. Therefore, the long term goal should be the maximum use of a single transport protocol stack.

Electronic Mail Evolution

The evolution of email systems has followed the same evolutionary path as computer networking. Early email systems were implemented on mainframe or minicomputers. Users used dumb terminals or PCs emulating dumb terminals to access email services. With the introduction of LANs, email systems evolved to make use of the benefits of this new technology. A major interoperability problem arose because a number of vendors offered incompatible LAN based email systems. Since no one email system achieved market dominance, a number of email islands sprung up in most major organizations.

Faced with the transition to an enterprise network, organizations are faced with the problem of integrating these email islands to allow any user to exchange email with other users within, and often outside, the parent organization. This transition requires a common glue that can tie all these email systems together. This glue is the international X.400 messaging standard[12] developed by the CCITT. This standard is supported by almost all major computer and communications vendors; and is the one ISO standard that has currently achieved marketplace acceptance.

In order to accommodate legacy email systems, X.400 is often used as an email gateway or server. This X.400 server translates the diverse proprietary email messages and address formats into X.400 formats. X.400 Message Transfer Agents (MTAs) can then be used to transfer the messages from one location to another. At the destination location, another X.400 server translates the message into the format of the receiver's email system.

In addition to translation of message formats, synchronization of directories is also required to support enterprise email. Similar to the use of X.400, the goal global directory service of most organizations is X.500[13]. Since X.500 implementations are not currently readily available, vendors have developed their own solutions to the directory synchronization problem. An example present day solution is the Directory Exchange (DX) supported by Retix (and others). DX uses X.400 messages to allow the proprietary directory systems to update a centralized copy of all directory information which is contained in a Directory Exchange

Server. An example email enterprise configuration is shown in Figure 3[14].

This figure depicts the integration of three different email systems (cc:Mail, Microsoft Mail for PC Networks and Microsoft Mail for Appletalk Networks) with the required gateway and MTA functions.

The utilization of X.400 gateways solves the immediate problem of integrating legacy email systems (not unlike how TLI solves the multiple Tranport profile problem described earlier). However, the security and management problems for a configuration as shown in Figure 3 are horrendous. That is why most organizations plan to migrate to a target architecture based solely on X.400 and X.500. The target Messaging and Directory Architecture for many corporations is depicted in Figure 4[15].

As can be seen in this target architecture, the enterprise network is only based on X.400 and X.500. Users have made the transition from their proprietary LAN email systems. However, since some users on the Internet are still expected to be using Simple Mail Transfer Protocol (SMTP) for the foreseeable future, a SMTP gateway is also provided.

ENTERPRISE NETWORK GOAL ARCHITECTURE

The goal architecture for an enterprise network is shown in Figure 5. This architecture contains the functions described in both the RM-ODP and OSF's DCE. In order to fully integrate LANs and WANs into an enterprise network one requires interoperable services for communications, graphics, APIs, messaging, naming, etc. Impacting all these services are the overarching security and management services. Cost effective security and management can only be achieved when these other functions have been standardized.

The operative word is *INTEROPERABILITY.* The goal of achieving interoperability through the use of mandated ISO standards has not been achieved in the real world. These interoperable systems must also be cost effective and satisfy user requirements.

Since a single set of interoperability standards is not presently available to implement an enterprise network, organizations have to use multiple product types to support a specific function. A good example is Systems Management where organizations today have to support proprietary, de facto (e.g. Simple Network Management Protocol - SNMP) and ISO (e.g. Common Management Information Protocol - CMIP). A typical illustration of this current situation is IBM's networking blueprint shown in Figure 6[16].

One can see from this figure, that IBM supports its own standards, defacto standards and ISO standards. However, one has the opportunity today to select standards for a few functions that have achieved worldwide market acceptance. This is illustrated in Figure 7. These are TCP/IP for the transport profile, X.400 for messaging and X.500 for directories. These standards should be used in any enterprise network in lieu of any other protocols that perform similar functions. For the other functions, one will most likely have to support several products (e.g. SNMP and CMIP) until a consensus is reached in the marketplace.

CONCLUSION

In the early days of computer networking issues like interoperability, security and systems management were not major issues. Since dumb terminals were used to access mainframes or minicomputers, one was primarily concerned with securing and managing these centralized hosts. The advent of LANs complicated the problem by providing the capability to interconnect smart machines. Because no single vendor's product realized market dominance, departmental LANs within an organization were often implemented with incompatible proprietary protocol stacks.

Today organizations are faced with the difficult task of integrating these departmental LAN islands into an enterprise network that will provide end-to-end robust, secure, reliable and manageable services.

The dream that ISO will provide a single set of interoperability standards that will meet all the requirements of an enterprise network is nothing more than a pipe dream. Although initiated in the 1970s, the only ISO standards that have received wide acceptance in the marketplace have been those that originated in the CCITT (e.g. X.25, X.400, X.500).

The major factor used for selecting a protocol for inclusion in an enterprise network should be wide acceptance in the marketplace and (if possible) implementation by multiple vendors. These would truly be Commercial Off-The -Shelf (COTS) products. These products could be proprietary (e.g. Microsoft Windows for PCs,), de facto standards (e.g. TCP/IP) or ISO/CCITT standards (e.g. X.400, X.500).

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FIGURES

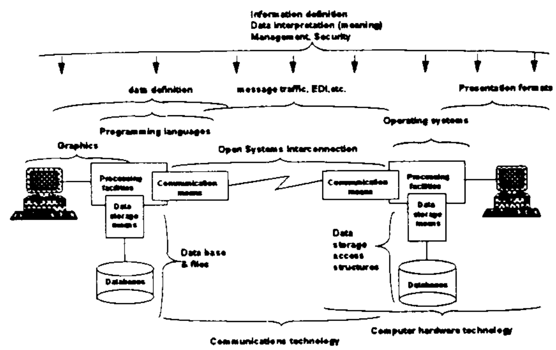

Figure 1. Areas of concern for ODP standardization

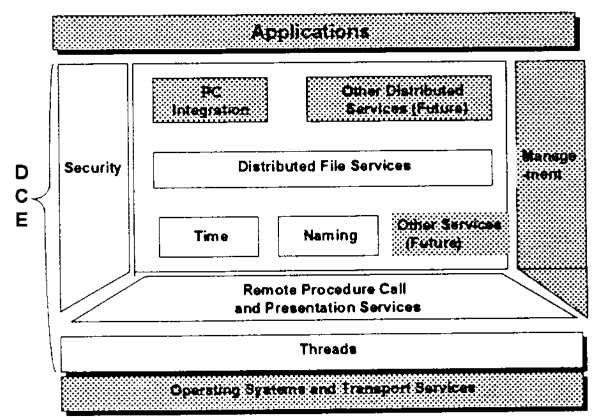

Figure 2 OSF Distributed Computing Environment Architecture

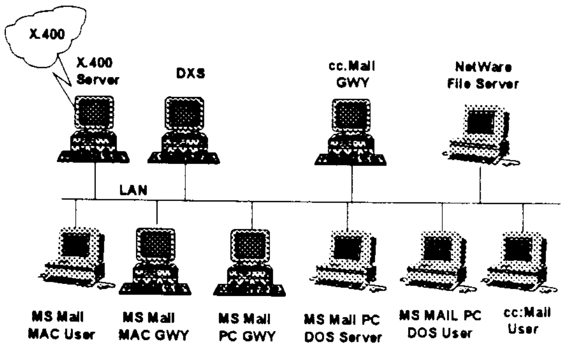

Figure 3. Integration of 3 Different Email Systems

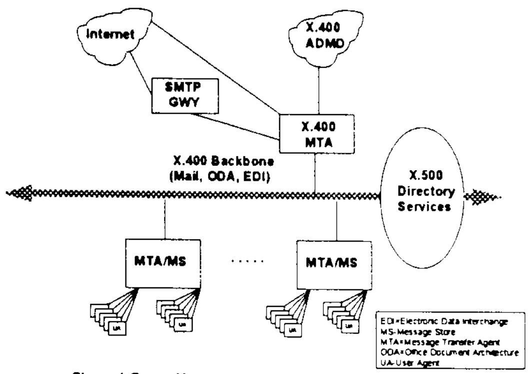

Figure 4. Target Messaging and Directory Architecture

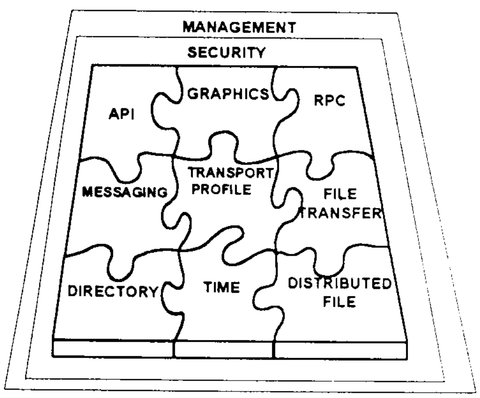

Figure 5. Enterprise Goal Environment

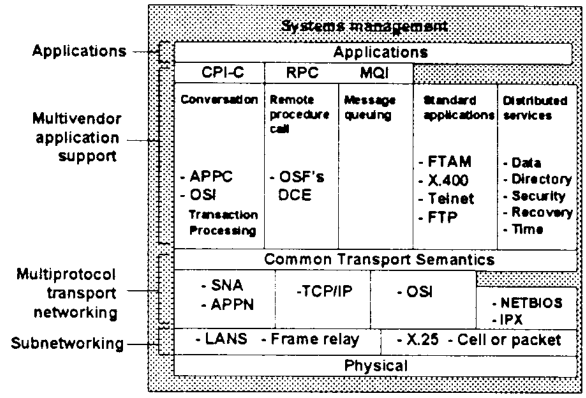

Figure 6. IBM's Networking Blueprint

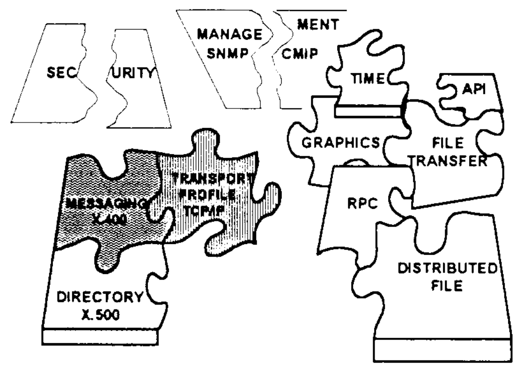

Figure 7. Current Status of Enterprise Network Standards