Planning, Designing, and Operating Local Area Networks

By

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INTRODUCTION

Computer resources, until the 1980s, were normally centralized in a mainframe or stand-alone environment. These resources were relatively expensive and difficult to operate since they lacked a graphical user interface and were not designed to be "user friendly;" thus, they were normally operated by experienced computer personnel. Computer prices dropped dramatically in the mid 1980s, thereby enticing business and government agencies to purchase computers systems for each employee in an organization. A shift in emphasis from centralized and consolidated computer resources to networked desktop personal computers was born. Networking provides organizations with the ability to connect desktop computers users, giving them the capability to communicate with other users and to share computer hardware and software resources. Today's technology allows the use of faster, less expensive computers (workstations) and mid-range server platforms to replace the traditional mainframe.

The ability to share and communicate information is vital to the accomplishment of the security assistance mission. This article will discuss the phases involved in the life cycle of a network, which include planning, designing, budgeting, implementing, operating and maintaining a Local Area Network (LAN). Issues involving training, policy, and "lessons learned" will also be examined in this article.

LIFE CYCLE OF A NETWORK

The network planning phase requires careful requirements analysis since it will be the cornerstone for ensuring that an office's computing hardware and software requirements are identified; this requires consideration of information needs, existing resources, and plans for future growth. The requirements analysis is the first and most important step in the network design process.

Requirements Analysis

The first thing that should be done in a requirements analysis is to identify and list the benefits to be derived and the problems to be solved with the implementation of a LAN. No single aspect of network design is more important than fully understanding the needs of the user. The network design is the product, and the user is the customer. The network is built for the users, and it must conform to their needs in meeting security assistance mission and organizational goals. In designing a LAN, one should first list the detailed functional requirements that the LAN users must have. The following examples of such needs are provided:

- External communications to access the external Security Assistance Network, as well as numerous other programs accessed through DDN MILNET.
- Internal communications (e-mail).
- File sharing capability between offices or persons A and B, etc.
- Organizational scheduling program for personnel.

Listing these requirements will assist in determining the technical specifications of the computer hardware and software needed in the design process.

The next step is to perform an inventory of all presently available hardware and software. One of the purposes of this inventory is to determine the feasibility of upgrading current hardware to be used with the new LAN. A detailed article by Ernest McCallister in the Spring 1996 issue of *The DISAM Journal*, entitled "Personal Computer in the Security Assistance Office" covered many of the aspects to be considered when reviewing computer hardware requirements. A good example of the issue might involve an existing 486 computer with four megabytes of Random Access Memory (RAM). Although this computer may be slow in accessing database and word processing applications interactively, it could be upgraded with additional RAM and used as print server or mail server on the new LAN. This is more cost feasible than purchasing a new computer to perform the batch processing functions of printing or mail serving. Some of the newer 486 and Pentium computers are also capable of being upgraded by removing and replacing the microprocessor with a faster, more technically advanced chip.

Printers should also be considered when determining hardware requirements. Most of the printers shipped from a factory are configured with only 2 megabytes of memory. A network interface device is needed to connect the printer to the network if the printer is not physically attached to a client computer on the network. Additional memory will be required to print any type of extensive graphic presentations. I have upgraded the RAM on several of the DISAM network printers from 2 MB to 32 MB of RAM and occasionally still experience problems with users not having enough memory to print complex vector or raster graphics.

Section 1504, Table 1504-2, "Minimum Specifications for New ADP Equipment" in the Security Assistance Management Manual provides additional information concerning computer hardware and software used in performing security assistance mission functions. Again, the decision to upgrade computer hardware/software versus purchasing new hardware/software should include consideration of the following:

- Are sufficient funds available to purchase new computer hardware/software?
- Is it more feasible to upgrade or to purchase?
- Will upgrading the hardware/software enhance the capabilities of the system enough to fully meet the automation requirements of the present and near future?
- Purchases should be made in accordance with policy guidance provided in Section 1504 of the SAMM when using FMS administrative funds for the acquisition.

Types of Network Implementations:

There are several types of network implementation solutions. Choosing the right solution is essential in terms of cost savings, training users and system managers, and the expense of maintaining a network. Three solutions are possible: resource sharing, peer to peer solutions, and local area networks.

Resource sharing permits the sharing of files and printers and is designed for a small number of users in an office of not more than 5 or 6 workers. Resource sharing solutions do not require extensive wiring or communications equipment. Two computers may be connected, using Windows 95, with a parallel or serial cable. No file server is required.

Peer to peer resource sharing allows systems to share resources such as printers, disks, and applications without the need for a dedicated server. Peer-to-peer solutions are the

intermediate step between resource sharing and implementing a dedicated server with a Network Operating System (NOS) installed. Windows NT Server and Novell are examples of Network Operating systems. Peer-to-peer solutions offer the following capabilities:

- They do not require a dedicated server.
- Their cost is less than a NOS.
- They are upgradeable to a NOS when needed.
- They can be integrated into the enterprise LAN.

The point here is that a file server or an operating system designed specifically for networks (NOVELL or Windows NT) is not necessary to have a network. A good example of a peer-to-peer solution is a small SAO office of four workers where each has a computer and shares files and printers: in this example, all four computers would be running Windows 95, and no file server would be required. Windows 95 has a built-in networking capability but is usually used as the client operating system on a LAN that has a dedicated server running the WINDOWS NT Network Operating System.

TECHNICAL DESIGN SPECIFICATIONS

We are now at the point of defining the technical hardware/software requirements of the LAN, based on the functional requirements previously identified. Let's take a look at the following network issues: identifying server requirements, types of server's, selecting an operating system for the server, client workstation software, and network cabling and adapters.

Identifying Server Requirements:

One server size does not fit all needs.[1] The need for specific server features is driven by the application in which the server will be used. Many vendors now design different families of server products to meet a broad range of data processing and communications needs. Servers now have single, multiple, and quad processors to meet the requirements of an organization's data and communication processing load and data integrity or redundancy needs.

I was presented with the following scenario five years ago when I assisted in the design of the DISAM local area network. Should a single server perform all application functions (e-mail, print server, file server, and communication server), or should separate servers be acquired for some of the application functions. The chosen network design employed two servers, one for file and print sharing, and one for communications. A dedicated communications circuit was installed from DISAM to the IDSS (Interoperability Decision Support System) server at IDA (Institute for Defense Analysis). This circuit experienced several problems in it's infancy. For example, it was inadvertently disconnected on several occasions by communications personnel. The servers on each end of the circuit needed to be rebooted to re-synchronize them. We were fortunate that only the users of the communications server were affected. Most of the individuals who were using the other network server (file and print sharing server) were not even aware the communications server was not operating. The point here is that in order to determine server requirements, it is necessary to carefully analyze an organization's data requirements, to include: amount of e-mail to be sent and received: number of network users; and number of simultaneous connections needing internet access.

[1] *Server Planning Guide* published by DELL Computing, dated January, 1996.

Most computer suppliers now categorize their server products in three groups which are designed to meet the distinct needs of three different types of users. Thus, suppliers will furnish entry-level, mid-range, and high-end servers. Entry-level servers are generally used in small businesses or offices with 15 or less users, and consist of a single processor. These servers generally are not designed to be upgraded. Mid-range servers are high performance servers which usually have dual processors and can support from 15 to 100 users. They are designed to be scalable, meaning they can be cost-effectively upgraded to meet the future needs of a growing network. High-end servers are required to run large networks with over 100 users who require extensive database processing and where optimal disk throughput is also required.

Here are some questions to assist in determining which server group is best fitted for a specific organization's needs:

- How many users must the server support?
- How much disk storage capacity does the server need?
- How large and how many database applications will be running on the file server?
- How long can the server be expected to last before the organization's growing requirements exceed its capacity?

A tape backup unit and an uninterruptible power source (UPS) should also be added to a server's list of hardware requirements. The tape backup unit should have the capacity to back up the largest disk drive on the server.

Now it's time to take a look at selecting an operating system for the server. Most networks with more than ten computers have at least one computer that acts as a file, print, and/or application server. Key factors in choosing a server operating system include the following: ease of client workstation connectivity to the network; available server applications; built-in security to protect data and files; easy installation and configuration of shared resources (printers, modems, etc.); built-in networking protocols (e.g., TCP/IP); and performance.

The following server operating systems are available from Microsoft:

- Windows NT Server
- Windows NT Workstation
- Windows 95
- Windows for Workgroups.

Windows NT Server is the only Microsoft operating system that can support the requirements listed below in items one through three and is the best choice for also satisfying the requirements in items four and five if they are needed:

1. Dial-up Networking that supports multiple clients at the same time.
2. File and Print sharing for Macintosh computers.
3. File and print sharing over a router.
4. A high performance file, print, or application server.
5. File and print sharing for Unix computers.

Client Workstation Software

The Security Assistance database programs (TMS and SAARMS) were developed to operate only on IBM compatible systems with Microsoft Disk Operating System (MS-DOS) version 5.0 or higher which is the specified operating system for the SAO client computers[2].

Microsoft offers four network client operating systems: MS-DOS with the Network Client 3.0, MS-DOS with Windows for Workgroups, Windows 95, and Windows NT Workstation. Windows 95 now comes pre-installed on 90 percent of all new computers that are purchased unless a different operating system is specified. Windows 95 is generally the best suited operating system for client workstations connecting to a network for the following reasons: its ease in connecting computers to a network (plug and play technology and hardware detection integrated in the software); it provides a platform for a new generation of 32 bit software that provides enhanced features, multitasking, and improved performance; and it provides remote computing capability imbedded in the operating system software.

Windows NT Workstation is a good choice if a need exists for a higher level of security and performance, or if RISC (UNIX or DIGITAL) computers are part of the network. In a peer-to-peer-network, both the Windows 95 and Windows NT Workstation operating systems perform client and server roles. What this means is that no server is needed in this configuration and each workstation serves dual roles: as a "client" when it accesses another computer on the network and as a "server" when the workstation itself is accessed by another computer on the network. MS-DOS with Network client 3.0 and Windows for Workgroups are also peer-to-peer candidates; however, they do not deliver high performance and should only be used if adding older computers to the network.

Let us next look at the application software running on the client workstation computers. The most important aspects in determining the application software requirements for the client workstations are ease of use, user training, whether a command policy exists which dictates what software will be used and/or supported by the command, policy guidance contained in Section 1504 of the SAMM, and whether the ability exists to easily imbed or import files, text, spreadsheets, graphics, etc. from one software application to another. Two of the Security Assistance database programs (TMS and SAARMS) require Microsoft's Access program to be installed in order to execute the modules. This requirement, along with the fact that Microsoft Office software allows for object linking and embedding (OLE) of the various Microsoft application software (database, word processing, presentation, and spreadsheet) were the reasons DSAA selected this software as the standard suite of application software for the SAO community. Object linking and embedding allows the importation of text, files, etc., from one application into another.

NETWORK ADAPTER CARDS AND CABLING:

A network adapter is a hardware card placed into an empty slot in the back of a computer or server. This card physically connects to the cable that links the network together. In addition to providing the physical connection to the network, these network adapters:

- Transmit data bits back and forth and translate this data.
- Control data flow by regulating a standard pattern (byte stream) for transmitting data to and from the computer.

[2] Department of Defense Manual 5105.38-M, SAMM, Table 1504-2

- Address the data to a particular computer; each card has its own unique address.

When purchasing a network adapter it is important to ensure that it is compatible with the installed computer operating system and that it supports "plug and play" technology.

There are primarily two cable plant design alternatives for the SAO offices which are worth considering. These are twisted pair and coaxial cable. Twisted pair is the most commonly used cable for small offices and is made from insulated strands of wire. Unshielded Twisted Pair (UTP) is the most commonly used cable for small LANS. It comes in different categories and data communication rates which vary from 4 to 100 megabits per second and can carry an unboosted signal about 300 feet. The UTP cable requires a connector that looks like a standard phone cord. UTP cable is less expensive than coaxial cable; however, a network hub is needed is this configuration.

Coaxial cable looks likes television cable and is usually used in very small offices where all employees are in the same general area (one or two rooms). One advantage of using coaxial cable is that a network hub is not needed. A disadvantage is that the cable is installed in a "daisy-chain" loop, so if it breaks anywhere the entire network is down. The safest alternative, if budgeting funds exist, is to use twisted pair cabling.

A final reminder when installing cabling in a ceiling: check with local fire officials as to the type of cable to be used and how it is shielded for compliance with fire code specifications. This step is often overlooked.

IDENTIFYING COMMUNICATIONS REQUIREMENTS:

A local area network, which by definition is limited to a small area, needs a way to connect to the "outside" world. This is done by establishing telecommunications.

The term telecommunications is derived from *tele*, meaning at a distance, and *communications*, meaning exchange of information. A circuit or a dedicated phone line and a hardware device (computer, data send unit (DSU), or modem) is needed in order to facilitate connections between the LAN and the outside world. Larger networks usually have circuit lines which allow direct connectivity to the Internet. How can smaller networks (5-15) users do this and not have to buy or lease circuit lines (which are relatively expensive) or share a single computer with a modem attached?

Modem sharing makes this possible over a local area network[3]. Modem sharing lets everyone on a network share a single modem/fax and phone line to access online services and the Internet, to fax from desktops, and more—without extra phone lines and expensive hardware. We are currently evaluating modem sharing software at DISAM and will advise security assistance offices of our findings upon completion of testing.

Modems come in different speeds, and faster is better. Speed and compatibility with other computer hardware are the main factors when choosing a modem. The speed of most new modems is 33 kilobits per second (kbps) or higher. One limiting factor pertaining to modem speed is the quality of the phone line circuit. You may only be able to connect to a server at 19.2 kbps even though you have a 28.8 modem. One reason may be the modem attached to the server is only a 19.2 kbps speed modem; the other reason could be the phone line quality. Most new modems support "plug and play" technology which automatically detects the modem's model and manufacturer type and installs the appropriate software.

[3] INSYNC ModemSHARE User's Manual

OPERATING AND MAINTAINING THE NETWORK

An individual in the organization should be appointed as the LAN Manager. This person should be somewhat computer literate, with good problem solving and training skills, and should be responsible for network administration, which includes:

- Performing software and hardware installation.
- Adding and deleting user accounts.
- Backing up the files.
- Writing network policy and operation guides.
- Network troubleshooting.
- Performance analysis and optimization.
- Disaster recovery planning and implementation.
- Managing application, system, and network security.

TRAINING

Keep in mind that managing and using the new local area network is going to require training. Most of the software applications today have improved help functions embedded in the software. Some programs will actually take you to the specific screens needing modification in order to correct a problem or configure the software. Several years ago it was not uncommon for individuals to share computers. Today it is an exception to the rule if a worker does not have a personal computer. Personal computers users today are more computer literate than several years ago; however, the author believes the software applications are becoming more difficult to use because of their so called "added enhancements." The added enhancements lead to increased maintenance troubleshooting time as well as increased training for users on the use of the software. The system manager will also need training in order to maintain the network system software and provide troubleshooting support to the network users. The product *Microsoft Technet* provides a useful source of information for network managers on solving networking problems.

LESSONS LEARNED

The following memorandum describes some of the problems that I encountered when installing our LAN here at DISAM. The "lessons learned" checklist was prepared to assist others so that they will not make the same mistakes we did during this installation.

[Beginning of memorandum]

18 Nov 1991

FROM: Tim Reardon

SUBJ: DISAM LAN Problems

This memorandum is provided for the purpose of documenting some of the problems we have encountered concerning the installation and maintenance of the Defense Institute of Security Assistance Management (DISAM) Local Area Network.

The installation of the network was initially scheduled to begin on 15 May 1991 but this date slipped to June 24. The Statement of Work specified that the cable installation be completed by July 8, 1991. The wiring subcontractor was asked to bid on 60 cabling drops. It became apparent that the number of drops that were actually needed was underestimated and approximately 20 more drops were required. Two of the areas requiring cable installation could only be accessed when they were not in use by students. There were also several changes concerning the specific locations where these drops were to be installed, and this added to the delay. The cabling installation was finally completed during the first week of August.

We also experienced some problems with the file server. Several of the interface card hardware switch settings and software settings were incorrect, thereby causing hardware conflicts within the file server. We also had several banks of memory chips in the server that were defective and they had to be replaced.

After the server problems were corrected, we started experiencing hardware problems with the concentrator cards, printers, and several of the workstations. A concentrator card that had been working for approximately two months went bad during the week of 16 September. This unit had been operating in a closed wiring closet with no ventilation and unfortunately the building's air conditioning was also out during this period. The temperature in the closet was observed to be over 130° F at times. There also had been a thunder storm the night prior to the discovery that the concentrator card was out, and a surge protector had not been purchased for the concentrator.

An abnormal number of hardware failures also began occurring. To date, I have placed service orders or returned to the dealer seven machines to be repaired under warranty. Given the fact that we only purchased 37 machines, this number represents a failure rate of approximately 19 percent. After another concentrator card and supervisor module card went out in early November, we started to suspect that there could be problems with the power in the building. I also learned that the building had experienced a "brownout" on 7 November. On 13 November, I powered down the file server and the UPS system. While I was talking on the telephone and powering up the UPS at the same time, as the UPS powered up, the phone I was talking on lost power.

It is also important to note that during the LAN installation several major electrical renovations were occurring. A new phone system was installed in which the new instruments now needed a power source. The floor below DISAM was totally renovated during this period and new wiring and air conditioning units were added. As I was leaving the facility one night, I inadvertently hit the dim button instead of the off button to turn off the lights in one of the offices and I noticed that the whole bank of lights in the hallway dimmed also. I asked our customer to contact Base Civil Engineering and request that a power survey be performed. Additionally, the air conditioning unit fails frequently.

We have also experienced some problems caused by users who have not been trained to use the system. The customer also wanted to run several applications under WINDOWS that they had been using prior to procuring the network, and we have spent time in setting up these applications to run under WINDOWS.

I have been asked to devote more time to assist in the training of users, correcting minor problems, and providing system software enhancements since we have been placed on contract for follow-on support. This has helped tremendously in alleviating minor problems with the equipment and complaints from the customer. [End of memorandum]

LESSONS LEARNED CHECKLIST

- Perform a site survey of the area where the LAN is to be located.
- Have the power monitored prior to installing the network hardware.
- Obtain and review building diagrams prior to cable installation. Check for proper heating/cooling, and ventilation. Ensure that the cable is not placed near air conditioning and heating units. Ensure that the cable meets specifications and fire codes (if run in the ceiling).
- Ensure that there are uninterruptable power supplies on the file servers and all Concentrators/Multiple Access Units (MAU), with surge protectors on the remaining hardware.
- Ensure that adequate power outlets exist throughout the areas where the network is to be installed.
- Present proposed network configuration to customer prior to contract award.
- During the bidding process for hardware and software, check the maintenance policies and all warranty stipulations prior to purchase. If local acquisition regulations permit, purchase file server (and all cards in the file server) and all major network hardware from a local dealer.
- If the customer has existing applications and software running on stand alone workstations, check to make sure these applications can be rehosted to the network, and also check if any file conversions or format changes need to be made.
- Ensure that training is included in the contract proposal, or that the organization is going to provide training. There is nothing more frustrating than putting 50 to 60 untrained users on the network.
- Prototype the network prior to delivering it to the customer. This should not be accomplished at the customer site.

CONCLUSION

This article was written to assist in designing a Local Area Network specifically tailored to users' needs, and to address some of the key issues facing network designers. It is crucial that the network design plan take into consideration things such as changes in technology, budget constraints, use of existing equipment, and use of in-house organizational personnel as system administrators to plan and implement a computer network. Then and only then can there be assurance that a network is specifically designed to meet a particular organization's Security Assistance needs.

ABOUT THE AUTHOR

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