NEAR EAST UNIVERSITY

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DISTRIBUTED NETWORK

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ABSTRACT

The distrubuted computers networks is inheritance to use from times that computers was more expencive equipments.

Most important thik of this in heritance ARPANET (INTERNET). Nowdays computer price decreased to resonable level because of the prices of VLSI chips is producing cheapper but still we are using the internet and also in increment rate and speed. Big firm and associations at internet are setting the own special networks with sttructure intranet and extranet mobil equipments with WAP protocol is supplied to this networks to be included. The technology BlueTooth is using, without any physical connection of mobile equipments, the new distrubuted network form is obtained now days.

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INTRODUCTION

At certain times a new technology emerges whichis destined to change the nature of data processing: program control in early 1950's, magnetic tape in the mid-1950's, large on-line storage in the 1960's, and the use of terminals. Today a technology of immense importance is spreading: distributed processing in which intelligent machines in different locations cooperate by means of networks.

This new and vital direction is throwing DP management into one of the worst dilemmas they have faced in the history of computing.

The choices that analysts and managers must make in this new area are complex and have long-lasting implications. Furthermore tha financial implications of making the right choice are great. Some corporations appear to author to be taking the wrong cource. He has attempted to estimate the eventual cost of this. There can be little doubt that it will cost millions of dolars in some corporations, in abandoned approaches, redesign, and program rewriting. And this does not count the lost opportunities and inability to obtain information needed by management because of the incompatibility and nonconnectability of separate systems, minicomputers and intelligent terminals.

Large computers, minicomputers, and microcomputers in intelligent terminals are becoming interconnected into all manner of configurations. The corporation of the near future will be laced with networks which handle not only its data processing but also its word processing, mail and message sending. End users on the shop floor, in the sales offices, in the planning departments- in fact everywhere-are beiginning to perceive what is happening and are demanding a piece of action. They want a minicomputer, or an intelligent terminal, or access to distant data bases.

Unfortunately the tehnology of distributed networks is very complicated. It is easy to perceive the idea of networks, but very difficult to understand the technical subtleties. The subtleties can and must be hidden from the end user. The user perceives merely the dialogue or simple procedure thet is provided for him. But that requires network architectures.

Network architectures specify the protocols or sets of rules which are needed to interconnect computers. These protocols are highly complex because there must be precise cooperation between distant intelligent machines.

Herein lies the dilemma. The various architecture are incompatible. The network architectures of IBM, Univac, DEC, NCR, Hewlett Packard, etc., are entirely different. Machines from different manufacturers cannot in general be hooked together without bypassing the architecture and losing its advantages.

To make matters worse, major common carriers are developed or have developed their architecture for networks. By far the most spectacular of these is AT&T's A.C.S. (Advanced Communications Service), formally called BDN (Bell Data Network). However, different common carriers have different architectures; for example, Teletent, SBS (the comunications satellite subsidiary of IBM, comsat and Aetna), and PTT' s in Europe, Japan and elsewhere (P.T.T. refers to a national telephone administration usually government controlled.)

The networking architectures of the common carriers are fundamentally incompatible with those of some of the computer manufacturers. AT&T's impressive ACS is in head-on collision with IBM's mainstream direction in networking: SNA (Systems Network Architecture). One reason for this is that both perceive networking as their territory. AT&T thinks that data networks, switches, front-ends, intelligent terminals and terminal cluster contollers are considered the dta equivalent of telephone concentrators, PBX's local witching offices, trunk switching offices and telephone instrutrollers, 3705's, network equipment and the many instructions executed in the machines should be interconnected. A great territorial fight is in the making.

Meanwhile DP analyst and executives must make decisions about their corporate networks and how to implement distributed processing.

The end users are clamoring for distributed processing. They have minicomputer salesman beating at the door. DP management knows that the scattered minicomputers must be hooked together- that 60% of data stored in one location will be needed in other locations. Sometimes they ignore the problem and hope that new software will emerge that will tie fragments together. They hear the ARPANET connected incompatible machines. Thay hear that new standards are emerging like HDLC and X.25, X.3, X.28 and X.29.

The new standards will help, but not completely and not quickly. There is no resemblance between the major architectures from manufacturers and X.25, X.3, etc. Even if there were, neither ARPANET nor the current standards would solve the most important of the incompatibility problems- the Layer 4 control mechanisms described in this thesis. The best taht can be hoped for is a clumsy bridge at the transport subsystem level, but many of the worst problems are external to the transport subsystem.

In this thesis explains the technology of computer networks and distributed processing architecture.

Part 1 of this thesis discusses the different types of networks and distributed configurations.

Part 2 explains the concepts of architectures for distributed systems, and what are desirable features of the different layers of the architectures.

Part 3 describes the machanisms that are used in networking, and particularly those in specifications for the new common carrrier (PTT) networks such as the X.25 networks, their X.3/X.28/X.29 interface, and the Bell System ACS network.

Part 4 explains the requirements and mechanisms for dealing wiith errors, failures of different types, recovery, deadlocks, privacy and security.

Part 5 discusses the future directions of network architectures.

CHAPTER ONE

1.THE PROMISE OF COMPUTER NETWORK

In America's pioneering days, each log cabin in the wilderness was an isolated outpost in a disconnected world. The pioneering days of the computer are still with us. But a new technology is envolving that will change the computer world as much as America changed. It is the technology of distributed processing and computer networks. Instead of being isolated outposts, computers will use programs and data stored by computers in other locations.

The growth of communications systems that will make this technology economical is taking place at the same time as the spread of vast numbers of minicomputers and microcomputers. The combination of these developments is fundamentally changing the patterns of data proccessing. Many job which used to be done on large, heavily shared computers can now be done on stand alone minicomputers or microcomputers . Data in central storage units can be shared by large numbers of dispersed users, many having a small computer which can process the data or provide an end-user dialogue which simplifies the access to information. Data of interest to one terminal user may reside in multiple distant computers, accessible via networks. When a computer program says GET, it may be accessing a file unit attached to a computer a thousand miles away.

1.1. PROTOCALS

To enable the increasing variety of computers to communicate with one another, there must be rigorously defined protocols. Sets of rules about how control messages and data messages are exchanged between machines, and how they control the communication process. Along with the procotol definition, the formats of the control messages and the headers and trailers of the data messages are likewise rigorously defined.

These formats and protocols become quite complex. It is desirable that there should be a widely accepted standard so that all manner of machines can communicate. Unfortunately, several different sets of formats and protocols are emerging from different organization, as we discuss later in the book.

Some formats and protocols relate just to the transmission process for transporting data from one machine to another via a complex network. Communications, however, consists of more than merely a data transport mechanism. It may be necessary for one machine to load a program into another, to specify how a remote file will be used, to convert from the procedures or characters of one machine to those of another, to specify security procedures, to specify how compressed data should be expanded or edited before printing, to determine how machine usage will be charged, and so on. In some cases an elaborate contract is drawn up between machines before they begin a session of interaction. These process, which are separate from the transport process, are specified to a greater or lesser extent in the architectures for computer networks and distributed procesing.

1.2. RESOURCE SHARING

The purpose of many computer networks is to permit a far-flung community of users to share computer resources. Many such users now have their own minicomputers and calculators, so the shared resources have to be interesting enough to warrant access via a network. The facilities accessible by networks are in fact becoming more interesting at a rapid rate.

The remote computer may contain software which a user needs to employ. It may be proprietary software kept at one location. The distant computer may provide access to data which is stored and maintained at its location. Sometimes the remote machine compiles programs which are used one smaller peripheral machines.

One of the best known resource-sharing networks is ARPANET, a United States network interconnecting more than fifty university and research computers centers (including a few in Europe). Many universities have inserting, and sometimes unique, computer facilities. These will become more valuable if they can be employed by a larger community of users. The idea behind ARPANET is that a professor or student at one university should be able to employ the facilities at any other university on the network. Usually he does this by means of a terminal, receiving responses from a distant computer almost as fast as if he were at the location of that machine.

A good example of a resource worth sharing is a program at M.I.T. for assisting with mathematics-MACSYMA. It is one of the largest programs written. It can solve simultaneous equation, factor polynomials, diffrentiate, and evaluate the world's worst integrals. A person needing this help can access it via ARPANET.

Public or semipublic networks can also provide access to highly specialized facilities. The New York Times, for example, has automated its archival stores of news stories. Hundreds of millions of abstracts of news items dating back to the early 1960's can be searched with a query language which permits unanticipated queries by linking multiple descriptive words. There are stock market systems which permit users to search for stocks which meet specified criteria of company or financial characteristics price, earnings, performance, and so on. Encyclopedia companies are working at computerizing encyclopedic bodies of information. A network enthusiast's vision is that vast numbers of information systems like these will become accessible, inexpensively, to network users.

Networks can provide access not only to information systems but also to large numbers of problem-solving facilities. Some corporations have a large number of intricate computerized tools for various types of engineering desing or evaluation. These are made available to engineers throughout the corporation via corporate network. There are cash flow models, market forecasting models, budgetary control models, and so on. One hospital has successfully operated a prediagnosis system for several years. A computer program interviews a patient to make a preliminary diagnosis of his ailment to decide whether he should see a nurse, doctor, or specialist. Computerized medical diagnosis will not replace that of a doctor but it could provide worried persons with a quick indication of whether they need to see a doctor or to take some simpler remedial action. Similarly there are systems for job counseling, finding employment, booking theater seats, doing tax calculations, and so on.

In general there is such a rich diversity of computer applications and information banks that it is impossible to predict the way networks would be used if easy network access and a high level of sharing made them economically available.

1.3. CORPORATE NETWORKS

Most computer networks are fundamentally diffrent from ARPANET and the early resource-sharing networks.They are designed for specific applications in business and government data processing. Some of these are for transferring data between separate systems. Some are data entry networks in which computers used for data entry ship their files to distant machines. Some are designed to permit a terminal at one location to have access to data processing systems in different locations.

At a rapidly increasing rate, networks are being built for distributed processing. Intelligent terminals, minicomputers, desktop computers, and programmed devices which control groups of terminals are proliferating. The spread will continue to gain momentum as the power of low-cost microelectronics increases. The small machines in many cases have to be connected to larger machines to exchange data, use centralized data bases, and employ programs stored elsewhere. Computer networks for distributed processing often use quite different protocols from networks like ARPANET.

In some cases a common corporate network has been designed to be shared by a variety of unrelated systems. There are many advantages to this approach, which will become more common as different networking needs develop.

1.4. THE NETWORK RESOURCE

A data network can become a resource in its own right. Once in existence it can completely change the plannig for computer installations. Given the existence of a network like ARPANET, a university confronted with the new demands for computers should ask, "Ought we to provide the resource or could a resource elsewhere on the network be used?"

In some corporations the existence of a corporate network has had a major effect on the planning of data processing facilities. It gives more freedom to plan the balance between centralized and decentralized computers, files, and data bases. Different locations can specialize in diffrent data processing functions. Such is the case with British Steel, for example, which has a network linking many locations in which computers are used. Similarly a trans-Europen network called EIN (European Information Network) linking research centers raises questions about where particular computing resources should be located and whether certain ones should be combined. It is often cheaper to have one expensive facility which is shared among locations than to have separate versions of the facility at each location. Sometimes expensive networks have been justified by a calculation of how much it would cost to provide the same facilities without a network.

1.5. COST REDUCTION

In its early days teleprocessing was very expensive; it was used only on systems with a special need for it, like airline reservation system and military systems. As private networks emerged from their pioneering days, the cost dropped. Public data networks are still in their infancy, and as they grow there is scope for major cost reductions.

There are various aspects of technology which are likely to force the price of terminal usage drastically lower. This is important because almost all aspects of telecommunications are characterized by high price elasticity. In other words, when the price comes down, the usage goes up. This has been true with telephony and telegraphy; it is undoubtedly true with data transmission and computer networks. If the price comes down far enough, the usage will grow by leaps and bounds.

1.6. IMPROVED ACCESSIBILITY

To facilitate widespread use of networks, accessibility to them needs to be improved. It is desirable to have inexpensive machines in offices, shops, restaurants, and the home wherever there is a telephone which can access the data networks as easily and cheaply as making a telephone call.

A major step towards this objective is the creation of a standard interface to shared networks which machines everywhere can use. Such an interface has been defined by the international organization for telecommunications standards, the CCITT (Comite Consultatif International Telegraphique). This standard is the CCITT Recommendation X.25, and the associated recommendations for the attachment of dumb terminals: X.3, X.28, and X.29. These standards are likely to have wide but not exclusive acceptance. It seems likely that there will be directly interconnectable, but large families of machines which employ common protocols will be.

Mass-produced, easy-to-use terminals which plug simply into the telephone jack are needed, and these will eventually have very large sales. One such family of terminals is the AT&T Transaction Telephones and the VuSet terminals . Another will be the pocket terminals with built-in modems and dialing capability.

The telephone is ubiquitous, and so is TV. A television set with an attached microprocessor and keyboard like a pocket calculator can from a color display terminal. The combination of telephone and television technology has the potential of providing society with vast numbers of attractive terminals. This is the idea behind a British Post Office development called Prestel (orginally Viewdata). From the home or office, television set should be minimal no more than the cost of today's TV games. There will be many businesses applications for Prestel and because of the large market for sets, businesses will acquire cheap network terminals.

Cable television can also provide television terminal users with a means of accessing computer networks.

Some countries have a public service for data broadcasting to home television sets. The owner of a set with a suitable attachment can receive frames which he selects from a "magazine" of available frames. The frames contain news reports, weather forecasts, stock prices, sports result, shopping information, information about broadcasts, and so on. The contents of each frame change as they are updated and could be changing constantly like the stock market ticker tape. Given the spectrum space of several television channels, an extremely large number of frames could be broadcast. Interactive dialogues could be created by combining data broadcasting with the use of appropriately programmed microprocessors in the television sets. Programs for such processors could be transmitted through the air like the data they would use.

A standard for broadcasting data to television set exists in Europe.It is called Teletext. The Teletext and Viewdata standards are compatible as far as possible and provide a two-shift character set that includes 64 graphics characters from which diagrams, large lettering and attractive screen formats can be created. Characters inserted into the data stream can also create seven different colors and enable selected portions of the display to flash on and off. This character set makes possible attractive displays on a conventional TV set.

Broadcast data can also be picked up by a hand-held device the size of a pocket calculator or transistor radio. In the future, a pocket calculator could be designed to pick up current stock market .

More interesting, small radio terinals which transmit have been used. Networks using radio terminals have also been used, experimentally. Such networks connect terminals by radio a distance of a few miles to a station from which they may be linked into a computer network. Protocols which work well with radio networks have been demonstrated. Data devices can use radio links much more efficiently than speech devices such as CB radio. In the U.S.A. the FCC (Federal Communications Commission) has made a large block of the UHF spectrum available for new mobile radio applications. It is possible that portable data terminals will come into common use. Some prototypes have been designed for pocket devices a little larger than a calculator, with an extendible antenna. The applications of such devices would be innumerable if their cost dropped like that of pocket calculators. However, unlike pocket calculators, their use is dependent upon whether the common carriers build appropriate facilites.

As computer networks grow and spread, the means for accessing them will drop in cost and become widespread.

1.7. NETWORK APPLICATIONS

As network costs drop, new applicatios become economical.

The combination of price elasticity and economies of scale leads to exponential growth in technology usage. As new applications bring more traffic, economies of scale will lower the transmission cost; as the transmission cost is lowered, new applications will provide more traffic – a positive feedback condition. Some new applications have potential traffic volumes hundreds of times greater than today's applications.

The groups of applications which were a major driving force in the development of the Canadian public data network, DATAPAC, were those relating to the means of making payments- checking a customer's credit, authorizing the acceptance of a customer's check or the use of a magnetic-stripe bank card for making a payment. Some systems transfer funds electronically via networks instead of sending paperwork through the mail.

In the U.S.A. about 30 billion checks are written per year, representing about $20 trillion per year. An electronic fund transfer network could speed up the clearing time for checks by at least one day on average; probably more. One day represents a float of $20 trillion /365 =$54. 8 billion, savable by electronic check trasfer.

The number of credit card transactions is almost double the number of checks, and the payment delay with these is much longer. If all credit and transactions required a message sending over a data network, this information would be about a thousand times as much information transmission as that on the ARPA network.

Much larger in its potential is the prospect of electronic mail. A high proportion of the world's mail could be sent electronically. Only 20.2% of all mail the U.S.A. originates from individuals; the rest is from business and government. Most business and government mail is originated by computer, and much of the rest comes from machines such as typewrites and word processing equipment. Such machines could be connected to networks, on-line or off-line, to avoid the tedious work of manual mail sorting and delivery. Given sufficient volumes, the cost would be much less than conventional mail.

Many communications in business need to be faster than mail. There are far more telephone calls placed than letters sent. Networks offer the prospect of very fast delivery of mail or messages. When mail or messages are sent in seconds, the way they are used becomes quite different from that of conventional mail. Bell's ACS network desing is especially appropriate for office memos and messages.

When a person is not in his office a computer network can put messages in a queue for him.

In cases where letters or messages need to have signatures or drawings, or to be hand-written, transmission by facsimile can be used, rather than by machines which send characters. There are already more facsimile machines in the United States receiving and transmitting documents than telegraph machines.

1.8. HOME USE OF NETWORKS

A futher network application is the reference to information of various types. If terminals were widely available and it were cheap to use them, business and private individuals would be likely to make many references to information such as stock market figures, news, weather forecasts, business data, timetables, educational material, and so on. The British Post Office Prestel service has been heralded as "probably the most significant development in public communications since television"

Who will provide the dta and programs that people will want to use with the Prestel set? The answer to this is perhaps the most important aspect of the Prestel scheme. Anyone can provide it. Computer hobbyists or individual enterpreneurs can put data or programs into the Prestel files, and when any of the viewers use it, the originators will be paid a small royalty. Similarly advertising organizations, large and small, will distribute information via Prestel. But unlike most forms of publishing, the private individual can participate.

One market research study forecast that there could eventually be 10 million Prestel sets in Britian. If this were so the resulting data flow would be hundreds of times that on ARPANET today.

1.9. MERGING TECHNOLOGIES

Much of the potential of networks, then, will arise from having cheap access to distant machines. Low-cost data transmission can be made possible by massive sharing of digital circuits, and the swing from analog to digital telephone trunking. Distributed intelligence can reduce the numbers of bits transmitted in dialogue. Inexpensive terminals can be created by additions to telephone and talevision sets.

Most networks to date have been private and much of what we say will relate to private networks. The first public switched-data networks for computers are now operating. When these have matured and user demand is more certain, there will be massive expansion of the public networks probably using the X.25 and related protocols. Perhaps by the end of the century cheap terminals will be as ubiquitous as the telephone is today.

The computer was initially regarded as a machine for scientific and technical calculations. Later it became a machine for business data processing and this form of computing rapidly overtook scientific computig . Business data processing was originally batch processing with no telecommunications. Terminals access to data processing machines came slowly at first and evetually grew to dominate business data processing. In the future personal uses of computing will grow-to solve problems, to collect data, to obtain information. The terminals will be perceived as a communications medium, like teklevision or newspapers or books, and come to be accepted as part of the information fabric of society. Personal computing will become indispensable for work, for education, for medical care, and for dealing with problems, large and small.

Personel computing whether on pocket machines or network terminals may eventually grow in volume to overtake conventional data processing. The potentials for networks in banking, finance, education, communication between people problem solving, and the running of corporations are endles.

End users of a wide variety of different types will acquire their own machines or gain access to other machines. These machines will vary greatly in their capabilities, ranging from programmable desktop or pocket machines to fast sophisticated minicomputers. Some end users will program, but not most. Most will use prepackaged applications, prepackaged dialogue, report generators, dialogue generators, inquiry facilities, information retrieval systems, data entry systems, word processing packages, and data base interrogation, manipulation and search languages. Often the local intelligent machines will need programs in distant machines. Much of the data entered or used in local enviroments, and often stored in local environments, will also be used else where. It will have to be transmitted.

This endlessly variable collection of machines made possible by today's micro-electronics is growing at a furious rate. Terminals and processors will be scattered everywhere throughout corporations. Most of them will need to communicate. So corporations need networks and network standards that will make this possible.

Distributed processing will eventually spread to every nook and cranny of corporations. It is as inevitable as leaves coming out on a tree in spring. On the other hand, the expansion will be difficult to manage and control. It is difficult now to make the right networking decisions, but the payoff will be huge.

2.THE TREND TO DISTRIBUTED PROCESSING

2.1. MEANING OF DISTRIBUTED PROCESSING

The term distributed processing is used to describe systems with multiple processors. However, the term has different meaning to different persons because processors can be interconnected in many ways for various resons. For some authorities, the term refers to a multiprocessor complex in one location. In its most common usage, however, the word distributed implies that the processors are in geographically separate locations. Occasionally, the term is applied to an operation using multiple minicomputers which are not connected at all.

2.2. LOCAL VS. REMOTE DISTRIBUTED

We can distinguish varying degrees of dispersion of the distributed components;

1. Interconnected by a bus to form a single computer complex.
2. Interconnected by cables in a machine room.
3. Interconnected by in-plant wiring.
4. Interconnected by permanent common carrier telecommunications, e.g., a leased telephone line or permanent virtual circuit.
5. Interconnected by intermittent common carrier telecommunications, e.g., a dialed telephone connection or virtual circuit.
6. Not physically connected.

In case 3, 4, and 5 we may have a computer network. As we will see there are some fundamentally different types of computer networks. If telecomunication lines were fast enough there would be no difference in function between a distributed computer system in one room and a geographically scattered system. Today, however, telecommunication links in normal use for data transmission are much slower-often 1000 times slower-than channels which interconnect the boxes in a computer room. Consequently the functions which we distribute geographically are usually different from those which we distribute in one machine room.

The next generation of communications satellite systems may change the distribution of function on some systems because they will transmit brief bursts of data as fast as the buses or channels in a machine room. However, there will be a propagation delay of about 270 milliseconds-the time it takes light to travel to the satellite and back- and this will inhibit some types of function distribution. It could make sense to put devices such as mass storage (library) subsystems or printer subsystems at the other end of satellite links designed to transmit large bursts of data at high speed.

2.3. MACHINE COSTS

A major driving force towards distributed processing is the cost of small processors. Until the spread of minicomputers in the early 1970's a commonly accepted rule was Grosch's law which said that the cost per machine instruction executed was inversely proportional to the square of the size of the machine. Economies of scale in computing led to centralization. All work became funneled into centralized factory-like data processing shops.

Grosch's law became questioned in 1970's. Some people even suggested that it had bee reserved because the cost per instruction on some minicomputers was lower than on large computers, and on microprocessors was lower than minicomputers.The reason is related to the use of VLSI (very large scale integration) circuits, which can be mass-produced. Their development cycle is much shorter than that of large machines. Therefore they tend to have later technology which is less expensive becausse the cost of technology is dropping so rapidly. Tiny mass-produced processors in the future will give a cost per instruction much lower than that on large machines; they will, however, use a much simpler instruction set. Many applications require a complex instruction set. The sets do not need floating point arithmetic or elaborate MOVE instructions. The price/performance ratio on all computers will drop greatly throughout the next ten years, but it is likely to drop much more rapidly on small mass-produced machines than on machines costing hundreds of dollars.

The application load in large corporations is likely to continue to grow rapidly. The millions of instructions per second (MIPS) required for large on-line data base systems is likely to exceed the capacity of the largest commercial computers. The required capacity can be obtained, however, by distributing system functions and applications to peripheral machines. Functions will be distributed both to machines in the computer center and to many machines in user locations. This trend to distribution of processing will continue because the application program and software usage of machine instructions per second is growing much faster than the development of higher-speed machines.

When small computers are available for $10,000 or less, end users have a high incentive to possess their own machine, regardless of possible economies of scale. There are powerful reasons for tying these computers into corporate systems rather than allowing isolated incompatible development.

2.4. SOFTWARE PATH LENGTH

In comparing the costs of minicomputers and large computers, the software is often a more important factor than hardware. When a transaction enters a system, is processed, and leaves, a large number of software instructions is executed in additions to the instructions in the application programs. The number of software instructions executed for a transaction is referred to as the path length. A typical inexpensive minicomputer handles one transaction at a time,i.e.,single-thread operation-no multiprocessing. It reads and writes file records in a simple direct fashion. The path length is often less than a thousand instructions. On a large computer with a virtual operating system and data base, data communications facilities, the path length is often greater than one or two hundred thousand instructions.

The application programs for most commercial jobs execute a fairly small number of instructions per transaction, often one or two hundred. The total number of instructions executed per transaction in a large computer can therefore be a hundred times greater than in a cheap minicomputer.

The user gains many benefits from the complex software of large computers, but the cost in terms of instructions executed is high.

2.5. THE NATURE OF TELEPROCESSING

The term teleprocessing was used to imply the use of telecommunications facilities for accessing processing power. When calculators and minicomputers become cheap, however, what was originally done by terminals and teleprocessing began to be done on the local machine. The local machine may itself be connected by telecommunications to other machines, and a transaction may then be processed either on the local machine or on a distant machine.

There are two main reasons why a transaction is sent to a distant machine. First the local machine has insufficient power; the transaction may need the number-crunching power of a large machine. Second the transaction needs data which are stored elsewhere. Most commerical transactions-the bread and butter of data processing-do not need large computer power. Small computers or terminal cluster controllers at user locations are sufficient to process them. Therefore the main reason for teleprocessing in commercial data processing is to obtain data, not to obtain processing power. The advent of microprocessors has changed the nature of teleprocessing.

2.6. PROCESSING, DATA, AND CONTROL

In general, there are three aspects of systems that may or may not be distributed: processing, data, and control mechanisms. The arguments relating to the three are different. There may be arguments for centralizing some of the data and distributing others. These are different to the arguments relating to the distribution of processing. A system may have much of its processing geographically scattered, and yet the overall management and control mechanisms reside separately.

In some computer networks the control mechanisms are mostly centralized. In others, they are mostly distributed. Where purely centralized control exists, loss of the center puts the entire network out of action. With distributed control any portion of a network can be destroyed and the rest will continue to function. A centralized system may have its reliability enhanced by having more than one center, or more than one computer capable of control at the center.

Both centralized and distributed control are found in nature, often in combination. A city has largely distributed control. Some functions are centralized in the city hall, but the city would go on working if the city hall were destroyed. Some packet-switching computer networks would go on functioning if any single portion were destroyed even though a few management functions are centralized. A human body has vital centralized functions. It can tolerate much damage, but not the destruction of the brain or heart. Some computer networks are equally dependent upon certain critical components. As networks assume increasingly vital purposes, fault-tolerant control mechanisms will become more important.

2.7. DISTRIBUTED DATA

Where interlinked processors are geographically scattered, the data they use may be scattered also. However, the constraints which apply to locating of data are different from those which apply to locating processors. In many systems it is the structure and usage of the data that determines what is practial in the distribution of processors.

Data can be stored in two types of ways- as straightforward data files or as data bases. A file is data designed to serve a particular application or related group of applications. A programmers's view of file is similar to the file which is physically stored. A data base is in an application-independent collection of data from which multiple different programmer's records can be derived by software. There are major advantages in employing data base software but the software is complex and usually operates, today, on data stored at one location. Distributed data is often organized, therefore, in the of files (usually on-line files) rather than as a data base, although multiple data base ststems may also be interconnected.

Economies of scale in storage systems are different from those in processors. The cost per bit stored on very large storage units is sustantially lower than that on small storage units.

Often, however, it is not the cost per bit that determines whether data should be centralized or decentralized. There may be properties inherent in the data itself which lead naturally to centralization or decentralization. For example, if a file is being constantly updated and geographically scattered, users want the current version (as with the airline reservation file), and therefore the file is usually centralized. If the data as a whole are searched, or secondary key operations are performed on them, they are usually centralized. If they are stored in data base form, they are usually centralized. On the other hand, if the data are used only by the peripheral location where they originate, then they can be decentralized. If the update rate is low, or updates can be performed offline, then multiple copies of the same data are usually stored at different locations.

The question of which configurations make sense in specific distributed processing situations is determined to a major extent by what data are used and whether the data should be distributed.

2.8. CATEGORIES OF DATA DISTRIBUTION

There are a number of types of ways in which data can be distributed and used. Figure 2.1 shows types of data system configurations. The diagrams apply to either file systems or data base systems, or in some cases to combinations of the two.

The top two diagrams show systems in which the data is centralized. Where multiple hosts are used, these might be either local to the data or remote from it.

The next two diagrams show hierarchical data systems. In the first, labeled dependent hierarchical data, the data in the lower-level machines are closely related to those in the higher-level machine. They are often a subset of the higher-level data, used for local application. The master copy of the may be kept by the higher-level machine.

When a change is made to the data in the lower machine, this change must be passed up to higher machine-sometimes immediately, sometimes later in an updating cycle.

In other systems the lower machine may store some of the data that is in the higher machine and also have some which is its own and which is never passed upwards. The lower machine, for example, might keep addresses of and general information about customers. These bulky data are never needed by the higher-level system. The higher-level stystem might, however, store customer numbers, names, credit information, and details of orders-redundantly. These are stored by both machines and any modifications to them by the lower machine must be passed upwards.

In the diagram labeled independent hierarchical data, all of the processors are independent self-sufficient data processing systems. The structure of data in the lower-level machines is probably quite different from that in the higher-level machine. A common example of such a relationship is one in which the lower-level systems are designed for routine repetitive operations; order entry, production control, inventory, and so on. The high-level machine is an information system, possibly at a head office location, product or strategy designers, etc. All of the data in the higher-level machine may be culled from the lower-level machines, but the data are summarized, edited, and reorganized with secondary indices or other means of searching them to answer spontaneous queries.

The next diagram shows a split-data system. Here there are multiple data stystems containing identical data structures. The system in District A keeps District A data. That in B keeps B data, and so on. Most of the transactions processed require the data in the system which handles them, but occasionally a transaction originating in one district needs the data in another district. Either the transaction or the data must be transmitted over the network. Some organizations have installed many minicomputers, each with similar split-data files, and a network interconnecting them.

We distinguish between a split-data and a separate-data system. In the former the application programs and data structures are similar. The multiple machines are planned and programmed by a common group. In the separate-data configuration the interconnected systems contain different data and different programs, and are probably installed by different teams. Nevertheless they serve the same corporation or government body. One of the computers might be able to request data from another. An end-user terminal might be connectable to all systems.

In the configuration shown, one of the systems handles production, another purchasing, and the third general accounting. These systems are in different locations. The production system, which might be in a factory, creates purhasing requisitions,and these are transmitted to the purchasing system. Both the purchasing and the production system generate data which must be passed to the general accounting system.

Figure 2.2 shows a working example of a separate-data system installed with large computers, and Figure 2.3 shows one installed with minicomputers. In the former, the computer systems are 300 miles apart, each system has its own development staff, and both systems are connected to terminals throughout North America. The terminals exist in all locations of large marketing organization. The transaction is relayed to the system it needs by means of the communications concentrators. The minicomputer system is more truly "distributed." Here each store has its own minicomputer and data files. These minicomputers communicate with the central purchasing, marketing, and general accounting systems.

The next diagram of Fig. 2.1 shows replicated data. Identical copies of the data are stored in geographically separate locations, because this duplicate storage avoids the need for high-volume transmission between the systems and thus is cheaper. Such an organization only makes sense if the volume of updates of the data are low.

The last diagram of Fig. 2.1 shows heterogeneous data systems-independent computer systems set up by different authorities for different purposes,and interconnected by a general-purpose computer network like ARPANET. Each computer keeps its own data and there is no commonality or relationship be among the different forms of data organization. A user can access any computer on the network, but he must know the details of how that particular computer's data is organized.

2.9. COMBINATIONS

Figure 2.1 illustrates different forms of data distribution which give different problems. Many configurations contain mixtures of these forms. A typically corporate configuration containing most of them.

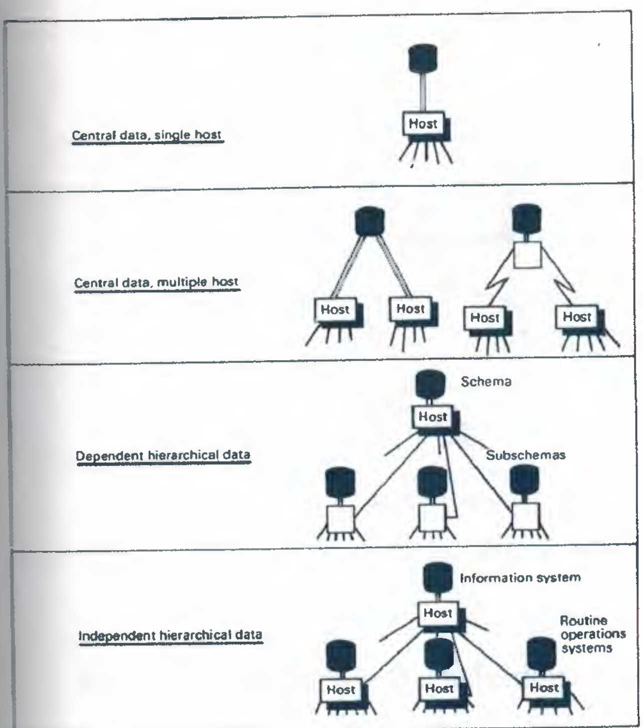


Figure 2.1 Categories of distributed data systems.

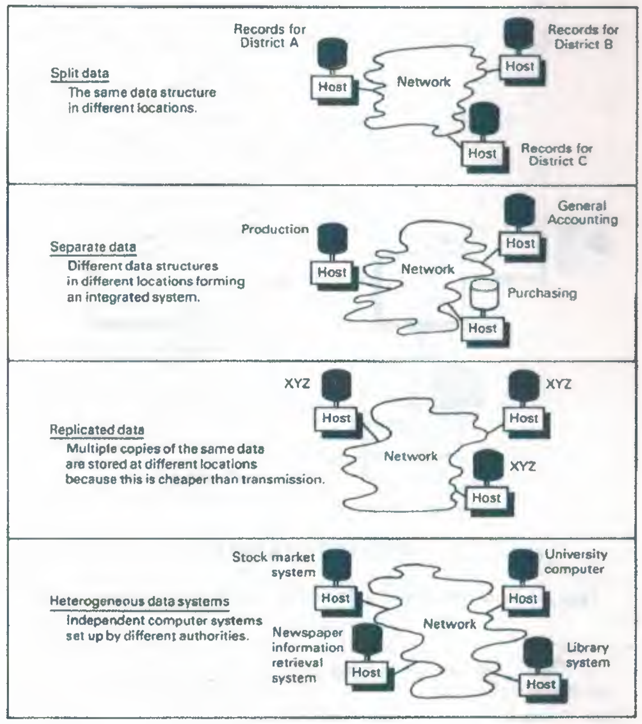


Figure 2.1 Continued

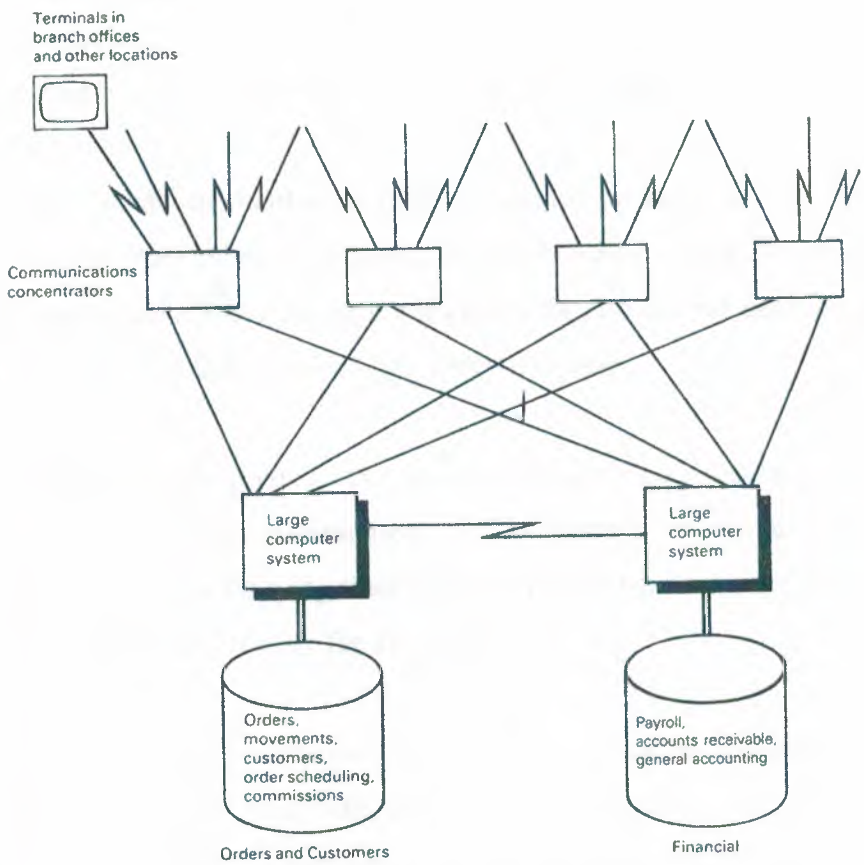


Figure 2.2 An installed example of a large separate-data system.

Data can be dividede within a distributed system according to the following criteria:

1. Geography.
2. Type of data.
3. Type of usage.

2.10. CENTRALIZATION VS. DECENTRALIZATION

The new environment of distributed processing confronts data processing managers with a complex set of choices. What operations should be centralized and what decentralized? Where should the data be kept? What configuration of large computers, minicomputers, and intelligent terminals will best serve the end users?

In addition to the technical aspects of system design-processing, data, and control mechanisms-there are the human aspects. Should the application programming be done centrally or by peripheral groups? Should the overall implementation management be centralized or distributed? What standards should be set centrally?

The costs of hardware militate against a high degree of centralization. Moreover, there are other costs which are often higher than the hardware costs. There are also major human and political arguments for and against centralization. It is often human and political factors which determine the issue.

The important point is that the technology now gives the system designer a choice. The mix of microcomputers, minicomputers and large computers, and the software architectures for tying them together permit whatever mix of centralization and decentralization is appropriate for an organization.

It is no longer adequate for a system vendor to sell only large mainframe computers. A vendor needs to be able to tailor a distributed system to the customer's organization, and the configuration of such systems will differ widely from one situation to another. A computer manufacturer needs a software architecture which ties the distributed components together into an appropriate computer network.

3-PRIVATE NETWORKS

Data networks fall into two broad classes; public networks and private networks.

Public networks are built by common carriers-in many countries the government telecommunications administration. Their transmission and switching facilities are shared by the computers and terminals of many corporations and other organizations. Any one machine using the network many send data to any there (if permitted by security and software constraints.). Many nations are building data networks for this purpose and these will become a vital part of a nation's service infrastructure.

Private networks are built within one corporation or government organization. The implementors lease circuits for private use, usually telephone circuits, and construct a network which may not have its own switching facilities. The majority of corporate networks today use private leased lines rather than public switched data networks. One reason for this is that public data networks are still in their infancy. As they grow the incentive to use them will increase.

The argument has been frequently expressed that public data networks rather than multiple private networks would be better for a nation. Public networks would carry greater traffic volumes and would benefit from economies of scale. Greater traffic volumes would lead to higher line utilization, and to the use of wideband trunks which would give a faster response time. Public networks can afford diversity of routing which enables faulty trunks or equipment to be circumvented. On the other hand, the line utilization of many private networks is higher than the early multiple-user switched networks because they are tightly designed for a given relatively free stable traffic pattern.

Corporations and government departments are generally free to choose whether to build their own private network or use public networks. Their choice willl depend upon the relative cost. The designer uses techniques to adjust the network configuration and choice of circuits so as to achieve a given result at a minimum cost. Today costs still often favor the use of leased circuits, and hence the widespread use of private networks. In future, lower tariffs and greater availability of public switched data networks will increase their use-at least in some countries. To achieve economies of scale in public networks it might pay a telephone administration to adjust its prices so that users are encouraged to desert the private lines and use the public network. This is being done in some countries. Another factor affecting the choise will be whether the software of a chosen manufacturer is compatible with the public network protocols.

For the next few years private networks will probably remain in more common use than public networks.

This chapter describes private networks; the next deals with public networks.

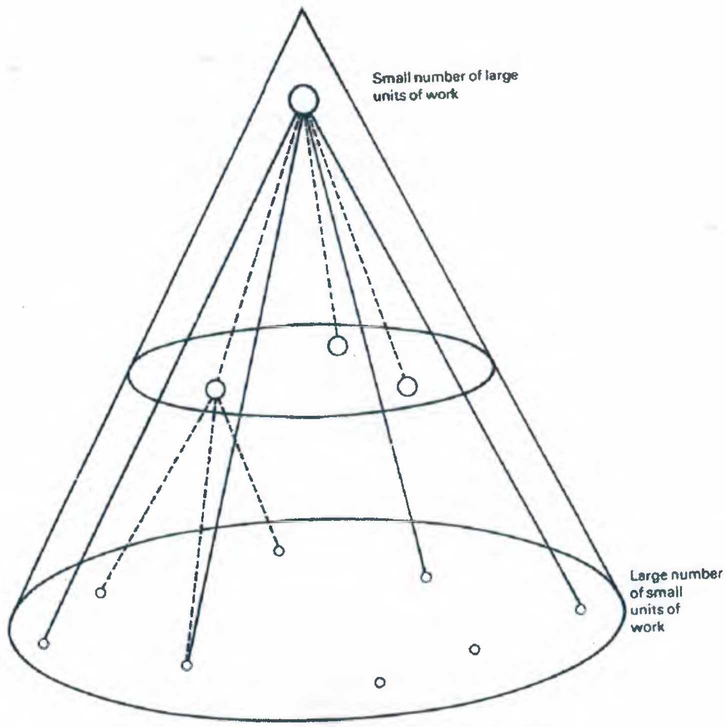


Figure 3.1 Vertical communication.

3.1. PRIVATE NETWORK STRUCTURES

Most private networks are vertical rather than horizontal. This was natural when data processing systems were higly centralized. Even with distributed processing there is usually a hierarchy of work activities. An organization tends to have many relatively simple repetitive jobs at its lower levels. Higher in the organization there tends to be a few complex jobs. The lower levels interchange data with the higher levels as shown in Figure 3.1, but there is often little interchange among the lower-level units themselves. Sometimes the lower work units share common data which is maintained at a higher level.

Because of the vertical patterns of data flow most private networks are star-structured or tree-structured. A growing proportion of private networks interconnect separate self-sufficient computer centers, and these may be horizontally structured networks. Sometimes there are separate vertical networks with horizontal links between their tops as shown in Fig. 3.2.

The network machinisms for hierarchical or star-structured networks are fundamentally simpler in certain respects than those for horizontal or mesh-structured networks. Some types of software have been designed for star-structured networks only, avoiding the complexities which mesh-structured networks have, such as alternate routing, deadlocks, flow control, and distributed network management.

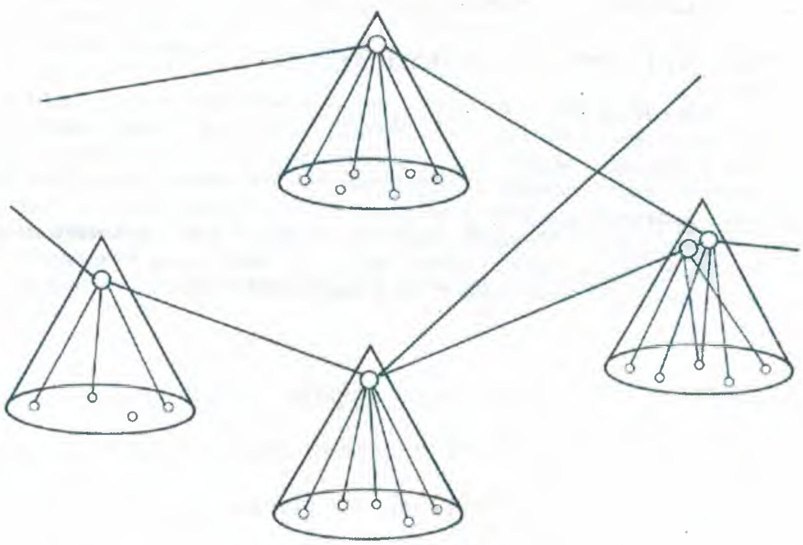


Figure 3.2 Separate vertical networks linked horizontally at their tops.

There are various mechanisms used to implement hierarchical networks:

- Multidrop lines with polling.
- Frequency division multiplexers.
- Time division multiplexers.
- Looped lines.
- Concentrators.
- Multidropped concentrators.

These were all in use prior to the era of computer networks and distributed processing.

Many large corporations have a prolidferation of leased-line networks. Separate networks have been implemented by different teams for different purposes, some for different divisions or subsidiaries of a corporation. Most governments have a much greater proliferation of separate networks.

In this illustration they have all grown up in the same corporation. (The systems described are fictional but are based on the systems of an existing corporation, simplified somewhat for reasons of clarity.)

The systems shown cover the information needs of the corporation from selling the products and maintaining them, to deciding what to manufacture, giving instructions to the plants, and controlling the manufacturing process. They handle accounting operations, provide networks for relaying administrative messages between most corporate locations and data between computer locations and gather together, for management. In addition, they provide terminal services for staff ranging from scientists to secretaries and give remote batch access to large computers.

A system linking leased teletype lines from major corporate locations to a communications center, in which messages are forwarded by a message-switching computer. Several teletype channels are multiplexed onto the leased voice lines, and many terminals may be " multidropped " on each teletype channel.

This network was the first to be installed and remains separate from those installed later. Its purpose is to relay administrative messages from any major location in the corporation to any other, at high speed. Such locations have machines like teleprinters for receiving or transmitting the messages. A message will normally reach its destination in a few minutes. The sending of message is equivalent to the sending of a commercial cable except that it is quicker and more accurate, and the messages are stored for future reference and can be broadcast to many locations. More important, the overall cost per message is substanially lower than that of commerical cables.

Designed to transmit batches of data at high speed between the corporation's major computer centers. Wideband lines from the computer centers are connected to a slow, electromechanical, crossbar switch. Operators can manually dial a wideband circuit from any one computer center served by this netwok to any other. When the connection is established transmission can begin.

Whereas the network for people sending messages to people, this network is for machines sending data to machines. Sometimes tape-to-tape transmission is used; sometimes disk-to-disk. The lines are not physically switched in network; here they are. There is a great difference in line speed.

3.2. AN INTEGRATED NETWORK

The common network may have lower overall cost. It also has better reliability because it can use alternate routes when failures occur. Further, it gives greater flexibility of interconnection. One terminal can reach many computers, and information can be interchanged between the separate computer systems.

As the diversity of information resources grows in a corporation, it becomes less predictable what remote computers are likely to be used at any given location. It there fore becomes more desirable to have a horizontal network spanning the major locations, rather than a collection of disjoint vertical networks. The network in effect, acts as a switch interconnecting the locations.

Conversion from separate networks to an integrated network has in practice proved to be a difficult task. The message formats and protocols of the integrated network are different from those used in the earlier networks. New software is needed and usually terminals have to be changed. This usually requires modification to application programs. Sometimes the use of a new terminal necessitates a new man-terminal dialogue structure which causes major application program rewriting. Because of these difficulties, there are often arguments from groups who want to retain their old network. To make matters worse, sometimes the performance aspects of the new network are worse-longer software path lenghts, more main memory needed, and longer response times.

3.3. MULTICORPORATE NETWORKS

A few private networks link computer centers in multiple corporations. Two leading examples are SITA network which passes messages between airline computers around the world, and the SWIFT electronic fund transfer network which passes financial transactions between banks.

To operate multicorporate networks, a separate service corporation is sometimes set up which creates and operates the network. SWIFT, Society for Worldwide Interbank Financial Transactions, is a nonprofit-making organization set up and wholly owned by banks which are connected to it. SWIFT implemented and currently operates the network. The purpose of which is to send money, messages, and bank statements, at high speed between banks. The participating banks finance the system, and a tariff structure charges for its use on a per-message basis plus a fixed connection charge and an annual charge based upon traffic volumes. The banks range from very small to banks with 2000 branches.

The SWIFT system is message-switching network which originally had two switching centers. Several hundred banks are connected to the system. It can expand without functional redesign to have multiple centers. It uses voice-grade circuits and most traffic is delivered in less than one minute. All traffic is stored at the switching centers for ten days after transmission and during that period can be retrieved if necessary. Transaction can be entered into the system regardless of whether the recipient bank's terminals are busy or not. The oiginator of an urgent message will automatically be informed by the system if there is delay in delivering the message.

4. PUBLIC NETWORKS

During the mid-1970's furious debates ensued among the major common carries of the world abot whether they should build a public data network, what form it should take, and how much they should spend on it.

The common carries (this term includes the telecommunications administrations of counteries with government-controlled telecommunications- the PTT's) desired to provide better service to the computer community. They also perceived that there was a reveneu which would grow to tens of billions of dollars worldwide, which could go either to themselves or to the computer industry. This is the reveneu from the switches, concentrators, multiplexers, poplling equipment, line control equipment, etc. –the various devices used in the interconnection of machines. Common carries operate the equipment for switching and routing telephone calls; it seemed natural that they should operate the new equipment for switching routing data.

One computers were used for switching the desire grew to use them for other functions also. AT&T developed its plans for ACS (Advanced Communications Service) in which the nodes would not only switch data but provide a variety of functions which need processing and storage. The British Post Office created its Viewdata schema (subsequently called Prestel) for operating public data bank accessible with television sets in homes or offices, initially via the telephone network.

4.1. CIRCUIT-SWITCHING AND PACKET- SWITCHING

There are two-main categories of public computer networks: packet-switching and circuit-switching networks.

A packet-switching network divides the data traffic into blocks, called "packets" which have a given maximum lenght (for example, 128 bytes). Each packet of user data travels in a data envelope which gives the destination address of the packet and a variety of control information. Each swithing node in a minicomputer reads the packet into its memory, examines the address, selects the next node to which it shall transmit the packet, and sends it on its way. The packets eventually reach their destination, where their envelopes are stripped off. Then, they may have to be reassembled to form to original user messages. It is rather like a postal service in which letters in envelopes are passed from one post office to another until they reach their destination. The typical delivery time on today's packet networks is about a tenth of a second.

We describe these two forms of network construction in detail later in the book.

A circuit-switching network establishes what is in effect, a physical circuit betweeen the communicating machines. The circuit is set up rapidly under computer control; it remains set up while the data passes, which might take a second or less, and may then be disconnected so that other users can employ the same facilities. The reader might think of a copper path, carrying electricity, which is set up for a second or so between the communicating machines and is then disconnected. In fact the path is not a simple copper circuit because time-division switching is used in which many streams of bits flow through an electronic switch, all interleaved with one another.Circuit switching has been used for decades in telephone exchanges and in the worldwide telex network. The difference with computer networks is that the user circuit is set up and disconnected very quickly. The switched connection is often used only for the time it takes one message to pass, or for one mesage and an interactive response; sometimes it remains connected for the transmission of a batch of data. This rapid computer-controlled switching is sometimes called fast-connect switching.

4.2. PACKET-SWITCHING NETWORS

Many advanced nations now have a public packet-switching network, either working or talked about. These are becoming interconnected into multinational networks so that packets can travel around the world or at least part of it.

The first major public packet-switching network was Telenet. This derived its techniques (and its management) from ARPANET, the first private packet-switching network. Telenet was bought by GT&E, the second largest U.S. telephone company in 1979.

Many subscribers are a long distance from a switch, so concentrators are used to bring the user traffic to and from the network. The concentrators may form small start network linked to a packet switch, like the private networks of the previous chapter, linking many users to the nearest packet switch. Most users are linked to the networks by telephone lines going directly to a switching node or else to a concentrator. This restricts their maximum data rate to that of a telephone line:9600 bits per second. In North America some users can have higher-speed digital links into their premises.

Users machines connected to a packet-switching network need to observe a rigorous set of rules for communicating via the network. It is desirable that networks in different countries should follow the same set of rules so that user machines around the world can employ the same software and control mechanisms, and so that packets can pass easily from one network to another. There has been a high degree of international agreement on the rules- the protocols and message formats- for public packet-switching networks, centering around Recommendation X.25 of CCITT, (Comite Consultatif International Telegraphique et Telephonique) the international standards organization for telecommunications.

4.3. FAST-CONNECT CIRCUIT-SWITCHED NETWORKS

The first public circuit-switched network was built by the Datran Corporation in the United States, and was subsequently taken over by Sourthern Pacific Communications. Sourthern Pasific no longer offers the Datran type of switching publicly.

Whereas Datran built a digital microwave trunk specially for the purpose, other circuit-switched data networks use conventional wideband circuits between the switching nodes. The Nordic data network of Scandinavia. The data switches are interconnected by trunks operating at 64,000 bits per second. Multiplexers and concentrators carry users traffic to the nearest switching node. These also are connected to the network by 64 Kbps trunks. There may be two or more trunks connecting two switches, or connecting a concentrator and a switch. More trunks are allocated to a data network as its traffic builds up.

The network provides switched synchronous data circuits at speeds of 600,2400,4800 and 9600 bits per second. Asynchronous (start-stop) terminals at speeds of 110, 150, 200, 300 and 1200 bits per second may be connected to network.

The call set-up time is normally 100 to 200 milliseconds –very fast compared with the telephone network, and fast enough to make it economical to disconnect after each message and response in man-machine dialoque.

Any circuit-switched network can encounter a “busy” condition, just as there are busy signals from the telephone when all circuits are in use. The designer of a circuit-switched network adds trunks and switching facilities until a sufficiently low proportion of the calls encounters a network busy condition. The probability that an attempted call will be unsuccessful is a basic design parameterof a circuit-switched network. The Nordic network is designed so that less than 0.5% of calls will fail to be connected due to network faults or congestion. The call set up time is fast and most calls are brief, the unit which controls the user connection to the network can retry an unsuccessful call quickly and a high probability of succeeding on that attempt.

4.4. CONNECTIONS BETWEEN NETWORKS

Sometimes it is desirable to employ more than one type of network to achieve a given connection. A dialed telephone call may be made to access the concentrator of a packet-switched network. A multinational call may be set up involving a packet-switched network in one country and a circuit-switched network in another. Not all packet networks have identical formats, and messages may need to pass from one network to another.

To deal with network connections, interface machines are needed. The connection between different data networks is called a gateway. It consists of a minicomputer which appears to each network as though it were a normal node of the network. It takes data in the format of one network and puts it in the format expected by the other.

Euronet could evolve into a "hypernetwork" designed the interconnect other networks. Worldwide hypernetworks will also be needed if efficient public networking is to take place worldwide.

4.5. EIGHT TYPES OF TARIFFS

The switched networks provide two types of connections between machines: first a connection switched through the network so that a machine can request a switched path to any other machine connected to the network: and second, a connection which is permanently established between two machines. On a circuit-switched network it implies a continuous stream of bits or bytes derived by submultiplexing. On a packet switched network it means that when one of the connected machines sends a packet it is routed automatically to the other machine with no preliminary call set-up.

In the future, then, there could be eight main types of basic tariff associated with telephone and telegraph circuits and the two types of data networks:

	Switched	Nonswitched
Telepgraph	Telex , TWX	Leased subvoice-grade circuit
Telephone	Dialed telephone connection	Leased telephone circuit
Packet-switched data network	"Virtual call	"Permanent Virtual Circuit"
Circuit-switched data network	Fast-connect circuit-switched path	Permanent submultiplexed bit stream

In some cases the virtual path through a circuit-switched and packet-switched network can be made to appear identical.

A few countries already have all eight of these types of tariffs. Some countries have a packet network but not yet a circuit-switched data network. Some countries have a fast-connect circuit-switched network but not yet a packet network. Most countries with a circuit-switched data network are saying that they may also acquire public packet-switching facilities.

We could working toward a time when advanced countries will have them all. The designer of corporate systems will then attempt to select that mix of communication facilities which meets his objectives at minimum cost.

In addition to have above forms of tariff there will be tariffs for other services which are not pure communications, such as those associated with processing and storage in the nodes as in AT&T's ACS.

4.6. VALUE-ADDED NETWORKS

The concept of value-added common carries was important in the development of computer networking. A value-added carrier leases communications facilities from conventional common carriers and uses these in conjunction with computers to build a network which offers new types of communications services and tariffs. These are called value-added networks (VANS). Graphnet offered services for delivery of documents, often in facsimile form. Telenet built a network for the interconnection of data processing machines, like the ARPA network although the software and hardware mechanisms eventually became substantially different from ARPANET. Telenet delivers packets of data between computers or terminals in a fraction of a second, and charges by the packet. TYMNET offering similar services evolved from private time-sharing network to a value-added common carrier.

In 1971 the United States Office of Telecommunications Policy recommended a policy of first-tier and second-tier common carriers. The first-tier carriers construct and own telecommunications links, and lease channels to their customers. They typically own 50% to 100% of channel miles in service and lease the remainder from another carrier. The second-trier carriers are the value-added carriers. They add equipment, including multiplexers and computers, to channels leased from first-tier carriers and sell services that they create in this way, including message-delivery services, computer networks, and possibly information retrieval services and computer timesharing devices. It seems likely that second markets will develop in many telecommunications areas. The second-tier carrier may minimize investment in terminals by letting the customer provide these.

Legislation in favor of second-tier carriers has increased to diversity and competitiveness of the telecommunications industry in those countries where it has been passed. In most countries, such legislation does not yet exist.

Telecommunications systems use computers in different ways. Some use them for switching; some for sorting messages which are transmitted; some for processing the data transmitted. At one extreme the computer merely switches the circuits; at the other the circuits are marely links into a data-processing system. The term "computer utility" became used for describing public access to computer networks,and in 1966 the United States Federal Communications Commission (FCC) initiated a lengthy inquiry to determine whether public computing services should be regulated. The inquiry terminated in 1973 and defined the six categories of operation. Local and remote data processing services are not to be regulated, whereas communications systems are. There is hybrid service between these two in which a subscriber sends data, which is processed and transmitted to another subscriber. If the data processing is the primary part of this operation, it is nat regulated. On it is regulated. The former is referred to as hybrid data processing and the latter as will argue. The FCC is now conducting a new inquiry into the subject partly because of the uses of distributed intelligence. It is difficult to say whether certain intelligent functions are "computing " or "comunications "functions.

Hybrid communication services must be completely tariffed and regulated by the FCC. Common carriers may not offer data processing services (hybrid or otherwise) except through a separate corporation with separate facilities, officers and accounting. AT&T has been excluded from offering any such unregulated services under an earlier consent decree.

Most countries do not have these legislative problems because the state telecommunications authority rigorously enforces its absolute monopoly over all telecommunications, no matter how bad its service may be.

4.7. STANDARDS AND CAPABILITY

For computer networks to be useful as possible it is desirable that they should employ standard interfaces so that many different machines can connect to many different networks. Just as telephone devices can connect to telephone networks everywhere, so data devices should be able to connect to data networks everywhere, and the data networks themselves should be linked up worldwide.

The interface to data network is likely to be more complicated than that to a telephone network because it cannot rely on human intelligence as does the making of telephone calls. It must be completely automatic. However, if the interface is rigorously defined it can be built into mass-producible VLSI machines and quantity production will make the cost low. It can reside in in expensive terminals and in computers. One of the distributed logic elements employed by a computer can be standard network interface unit.

Perceiving this, as we mentioned earlier, telephone administrations (common carriers) of the world used their international standards organization, CCITT, to agree upon an internationally recognized set of protocols for making calls on data networks. This is referred to as CCITT Recommendation X.25. X.25 defined the formats of packets of data which will be used both for carrying information and for setting up and disconnecting calls on data networks, and for dealing with the errors and failures. It is likely that many countries of world will build X.25 data networks in addition to those already in use. A wide variety of machines using the X.25 protocols will be manufactured.

Producing a stsndard interface to data network is complex.X.25 does not attempt to define all of the protocols that are desirable for computer communication or distributed processing. It is concerned with the sending of packets across the network interface. Further, it would not be suitable for all types of transmission networks. Other protocols are likely to continue to exist for inexpensive machines like AT&T's transaction terminals, or the British Post Office's Prestel television sets. Other protocols will exist for circuit-switched networks and wideband networks.

Other protocols willl continue to exist in computer manufacturers architectures for distributed processing, and for new or specialized forms of data networks including networks using communications satellities, simple inexpensive networks, networks for facsimile tranmission, networks with radio terminals, networks using cable television, and so on.

Network protocols have been created by the following types of organizations:

- CCITT and standards authorities.

- Common carriers with networks simpler and cheaper than X.25 like AT&T's TNS network, and leased line networks.
- AT&T, with the introduction of its Advanced Communications Service (ACS).
- Common carriers with technology different from that for which X.25 was created, e.g. communications satellite networks.
- Value-added carriers such as Telenet, TYMNET, Graphnet.
- Computer or minicomputer manufacturers with architectures for interconnecting their software and hardware products, e.g. IBM's SNA (Systems Network Architecture), DEC's DECNET, Sperry Univac's DCA(Distributed Communications Architecture),
- Industry groups creating protocols for specific application such as electronic fund transfer or airline reservations.
- Large corporations which develop their own computer network and networking software(sometimes purchased from a software vendor).

4.8. COMMON PRINCIPLES

In spite of the diversity of network types, there are many common principles which can be applied to these networks. The different networks have problems in common such as flow control, transmission errors, users interfaces, congestion, recovery from failures, network management, securitty, etc. Often they use similar mechanisms for solving these problems. The similarities among ARPANET, new common-carrier networks, DECNET, and IBM's SNA are as striking as the differences. We spend much of this book considering the principles and mechanisms.

5.DISTRIBUTED INTELLIGENCE TIME-SHARING

The biggest question mark about ACS is what programs should be placed in the nodes to assist users?

The most innovative and interesting aspect of the Bell design is the capability to have both Bell-provided programs and customer-provided programs in the nodes. These programs could be used for a wide variety of functions. Network users employ a high-level language called FDL for creting features for the nodes. This was originally called "Feature Definition Language" and was called "Form Definition Language" in the FCC filing.

A sentence from an earlier description of the Bell Data Network was, "The functions available to the user are only limited by his ability to program his requirements in FDL."

5.1. REGULATORY UNCERTAINTIES

The risks involved in introducing new telecommunications services in the U.S. are not only the risks of the marketplace, but also the risks of unpredictable decisions from the requlatory authorities. This most innovative aspect of ACS is unfortunately that most likely to cause regulatory or legal problems. If the various government bodies permit, there should be free comprtition between the uses of intelligence in the network, and the uses of similar functions in end-user machines of all sizes.

Freedom for everyone to invent functions that the network will perform appears to be desirable, because a preliminary exemination of what these functions might be indicates that a very rich and useful set is possible. AT&T's ACS filing with FCC omits many of the interesting uses of processing and storage. It is clear that these uses, and many that were mentioned in the filing, are in competition with the data processing industry's marketing of intelligent terminals, network control functions, and distributed processing architectures.

AT&T was constrained in a 1955 concent decree to not market any computing, such as time-sharing services. Since then the technology has changed so that computing and transmission are inextricably mixed in efficient data communications facilities. It is very difficult to define where data processing ends and communications services begin. The reader might ask himself which of the following functions, for example, are data processing, and which are communications?

- Concentrator functions.
- Storage of messages for later delivery.
- Compacting data for more efficient trasmission.
- Programs enabling a user to fill in a format so that only variable data is transmitted.
- Assistance with data entry for transmission.
- Transmission security functions.
- Deriving virtual private networks from a shared networking facility.
- Providing virtual terminal functions.
- Conversion operations which permit incompatible machines to communicate.
- Network auditing controls.
- Network monitoring, billing, and management functions.
- Controls permitting a batch to be entered, validated ,and modified before transmission.
- Dividing long messages into packets for transmission, and reassembly of the messages before delivery to a user machine.
- Dialogue functions to facilitate network sign-on.
- Functions for standard user dialogues such as menu-selection dialogues (e.g. those dialogues which permit a domestic television set to be used for transmission in the British Post Office Prestel (Viewdata) network.)
- Directory functions which permit one subscriber to locate another subscriber.
- Conversion of symbolic, list, abbreviated, or hot-line addresses into real addresses.
- Functions equivalent to those in a computer ized PABX:
- Functions permitting a user to request display or delivery of a message sent time previously.

It makes technical sense to allow telephone companies to put any functions they think useful into network nodes, but to insist that they also provide simple virtual circuit and call facilities. The user then has a choice between buying distributed intelligence functions from the telephone company and using similar functions in intelligent terminals, controllers, or computers. We need regulatory structures which permit the best technologies to win, and that is usually achieved with maximum competition.

Because of the regulatory uncertainties it is not clear at the time of writing how quickly ACS will envolve and exactly what services it will provide. Equally uncertain is how quickly such networks will be adopted by other carriers in North America and PIT's abroad. ACS makes it clear that a new round of international standards are needed to facilitate worldwide networks with similar functions.

5.2. CUSTOMER PROGRAMS

Customer programs will reside in a protected storage area in the nodes where they are used. These programs will be of two types: interactive and noninteractive.

Interactive programs will be used by terminal operators. They can provide message editing functions, data entry assistance, data validation sequences, dialogues to assist in creating transactions or formulating a request to remote machine, assistance in signing on to a remote machine, and so on. They can also be used to establish and receive calls, and to send retrieve messages.

Noninteractive programs are used to assist in the preparation of messages. They can also take totals of certain fields in batches of data entered(to serve as a check on batch integrity). They can add serial numbers to messages, build batches ready for transmission, permit the retrieval and modification of records in batch before transmission, create auditors' journals, automatically distribute message to multiple stations, and assist in message management and network management.

5.3. TERMINAL USER DIALOGUES

A common use of customer programs will be provision of dialogues to assist in data entry or to guide an operator through the steps that are necessary in using the network, using a terminal, or using a remote machine. There are several types of standard dialogues that can be provided to serve multiple different applications. For example:

5.3.1.Form Filling

The network displays a form on the terminal screen, and the user fills in the form. Only the data which is entered is transmitted.

5.3.2.Menu Selection

The node displays a menu and the user selects one item from the menu. On the basis of this choice the node then displays another menu. This continues until a message is built up, which is transmitted.

5.3.3.Command Sequence

The node displays a sequence of commands or questions to the terminal user. The user responds to each and the set of responses is transmitted. Before transmission the node program may apply validity checks or completeness checks to the set of responses and display futher instructions to the operator if necessary.

5.3.4.Text Editing

The user is given the capability to enter text, to inspect it on a screen, and to modify what he has entered. The facilities of advanced word processing machines can be provided, including spelling checks, thesaurus use, right justification, automatic insertion of repetitive phrases or blocks of text, etc.

5.3.5.Batch Build-up

The user is given assistance in building a batch of records. He may insert, delete or modify records as he wishes. The program automatically totals certain fields, applies completeness checks, creates an auditor's journal, etc.

5.3.6.Entry Validation

The programs carry out specified tests on field values. Fields can be tested for range, lenght, character set, field set membership, and structure. A set of field values may be added, for example, a column totaled on an accountants'listing, and tests may be applied to the total. Separate fields may be compared, added or otherwise combined, and tests may be added that are based on multiple fields. Tests may be made contingent on passing other tests.

5.3.7.Data Base Dialogue

A program assists the user in formulating a query for a data base or information retrieval system. The program uses a data base interrogation dialogue which assists the user in knowing how the query should be formulated, what the names of recaord types and field types are, what types of data the user is allowed to inspect, etc. The node may contain some data dictionary or data occurrence information to assist in this. When the query is correctly formulated it is transmitted to a distant data base system.

5.3.8.Sign-on Dialogues

Signing on to use a remote application is remarkably difficult on some networks. Often the sign-on requires three states: sign-on to the network, sign-on to the remote computer, and sign-on to the application or program in that computer. The user has to know a precise procedure which is difficult to memorize in order to sign on. Dialogue techniques can make signing on simple, the operator being instructed how to proceed at each step. Easy-to-use sign-on dialogues should be part of the assistance the nodes give to users.

In addition to interactive programs, may types of noninteractive programs may be customer-written: for example, report generators. A report format or a screen display may be specified. A group of fields is transmitted and a program in the destination node creates the report that contains these fields. Different reports may be created from the same message at different locations.

5.4.FUTURE GROWTH OF NODE SOFTWARE

Some distrtibuted-intelligence facilities are user-independent; the same program can be employed with many different customers. Others are user-dependent, designed by a customer for a specific application. Both types of programs can reside in the ACS nodes.

What likely to happen, if ACS comes into general use, is that all manner of customers will create programs for the nodes. So will software houses. Some of these programs will have wide general applicability. They will be made available either by software vendors or customer associations, or by the telephone company as official ACS features.

ACS, or systems like it, could thus cause a chain reaction in which distriburted-intelligence features become widely available in public networks. It is highly desirable that such networks should harness the immense creativity of computer community in producing user features.

5.5.NETWORK LANGUAGE SUPPORT CENTER

The ACS filing specifies a network language support center which assists customers i their creation of features to reside in the nodes. This enables customers to enter their source programs into the network. It compiles the source program which the customer writes in the high-level FDL language, and provides facilities enabling the customer. It loads the program into the protected storage of those nodes which the customer specifies, and manges all customer programs used in the network.

If the user requires the cuistomer-written programs to operate in different ACS nodes to serve different terminals, he gives appropriate instructions. The programs are then transmitted to the requisite nodes and loaded. Similarly customer-written programs can be deleted from the network.

The programs provided by AT&T will be written in the same language, FDL,as that which customers use. Customers may therefore modify the standard ACS programs. The modified version will be handled by the network language support center like any other customer-written program.

5.6.PARAMETERS

In some cases the program may be used with paremeters which modify its operation. These parameters may be stored in the general storage area rather than locked in protected storage. The parameters can then be changed from a terminal.

Many AT&T-provided programs will be parameterized in this way so that they have the widest general applicability.

The parameters to be used by a terminal can be prespecified and fixed on a per application basis. Alternatively they can be specified for each call when it is set up or for each message before it is sent.

The combined abilities to place costomer programs in the nodes, and to use parameters to select program actions, give great flexibility in using ACS.

5.7.COMPETITION

The distributed-intelligence features we have decribed place networks like ACS in competition with the computer industry. Similar functions can be provided in computer manufacturers architectures for distributed processing and in the software for intelligent terminals and controllers.

Where will be the best place for such functions? In the network, in host computers, or in intelligent terminals and controllers built with microprocessors? Nobody can be sure. It depends on future costs, network deployment, and service. There will be cheap dumb terminals in use for a long time, and these the services of intelligent networks.

It is very desirable that many such features be standardized. Standards, de facto or official, may be likely to emerge from be telecommunications industry than from manufacturers of intelligent terminals, minicomputers, mainframes, and software vendors, who are too busy creating new innovations to have much time to create standards.

The best course in the long run will probably be that some distributed intellegence should come from the compuiter industry and some from common carriers. Different functions are appropriate for each. The reader might glance again , which lists reasons for wanting to use distributed intelligence. Some of these reasons can be satisfied with an intelligent common-crrier network like ACS, but some of them can only be satisfied with intellegent terminals or controllers. The data processing community needs both.

5.8.COMPARISON WITH COMPUTER INDUSTRY ARCHITECTURES

How does ACS compare with the architectures of the computer manufactures like IBM's SNA or DEC's DECNET?

First, it is incompatible with them. It is competitive with them. It does not support IBMS's SDLC terminals. The incompatibility will present difficult management decisions in the future because many of the features of the manufacturers architectures are highly desirable and are not in ACS. The question for big corporations is not whether to use either SNA or ACS, but how to use both. What type of bridge will be built between them?

ACS should provide a ubiquitous transport network with some Layer 4 functions that make it easy to use. It should give great flexibility of interconnections. It appears easy to begin to use and has low start up costs. It provides fast interconnections that should be of high reliability. In addition, it offers an excellent set of machanisms for electronic mail and message switching, with on-demand retrieval of messages.

Any public packet-switching network built on a large enough scale should give a low cost per packet, and this will greatly lower the cost of using terminals for those users who are not connected to a leased-line concentrator network or other private network designed to handle a high traffic volume. Today if you are fairly near a Telenet node and want to use interactively a computer a thousand miles away, the cost is a telephone network. Public packet-switching networks on a large scale will greatly stimulate the use of terminals by individuals, small businessmen, and small offices of large corporations.

A good computer manufacturer's on the other hand, should have many functions which could not easily be put into a common carrier network. They include the following:

- A program in one machine should be able to call functions in remote machine.
- A program in one machine should be able to use files in remote machine.
- A machine should be able to control be pacing of remote operations such as printing and file accessing.
- The operating system of one machine should be linkable to the operating system in a remote machine.
- A data base language operated in one machine should be able to use a remote data base.
- Distributed data base functions will eventually be part of computer networking.
- Tight security needs end-to-end cryptography and management of keys.
- Remote machines can set up sessions which enable them to coorperate in complex ways.

We might use the terms tight cooperation and loose cooperation. Tight cooperation requires precise cooperation between complex machines or complex software. The mechanisms in the cooperating machines are sufficiently complex that they need to be part of the same manufacturer's architecture or an intricate and precise copy of it. Loose cooperation requires machines to interpret each other's messages or packets, provided they follow a protocal for doing so that can be quite differently

6.1.ORGANIZATIONS

Different organizations create networks for different purposes, and we may categorize these as follows:

1. Sıngle Application

Many networks have been built in single corporation for a single application, for example, airline reservations. Such networks are designed and tuned to application in question.

2. Multiple Application

Many corporate networks are designed for multiple applications which can share a common data base or data processing center. These are often vertical networks, constrationed in design for reasons of efficiency, cost, or ease of implementation.

3. Corporatewide Networks

Large corporations have many computer centers and sometimes design networks to interconnect them. A corporate network may be designed as a general-purpose network to serve the corporation and give data-processing designers more freedom to employ remote facilities. Different groups in large corporations have often implemented separate networks, and a corporate network is an attempt to integrate these, provide economies of scale and better services.

4. Multiorganization Networks

Some networks have been constructed to serve groups of similar organizations such as banks, airlines, universities, etc. These are often horizontal networks such as those. Sometimes they are general-purpose like ARPANET; sometimes they are special-purpose like the SWIFT electronic fund transfer network, in which case they can usually be designed more economically.

5. Value-added Carriers

A value-added carrier provides a network constructed with leased lines to serve many customers in selected geographical areas. It may be a general-purpose computer network like Telenet or TYMNET. Special-purpose value-added networks are also feasible.

architected and from different mnaufacturers. There is no sharp distinction between "tight" and "loose" cooperation, but rather a scale of varying complexity.

In general, common-carrier architectures of the future can facilitate loose cooperation. Computer manufacturer architectures like SNA, DCA, and DECNET can facilitate tight cooperation.

It is likely that future transport networks will be more flexible and more reliable if they are major implementations of common carriers. Functions requiring tight cooperation will be the province of computer manufacturers. Functions requiring loose cooperation may be up for grabs.

The telecommunications industry should be encouraged to go ahead as fast as possible with networks like ACS. They will make a major difference to the uses of computing. At the same time the computer industry should be free to compete, putting distributed intelligence into its machines, and using simple virtual circuits or leased lines where this appears best.

6.TYPES OF COMPUTER NETWORKS

There are many different types of computer networks. The diversity is caused by the different types of distributed processing, the different neeeds of users, the different types of organizations owning or operating the networks, and the emerging new requirements of the office-of-the future.

There are major differences in the machanisms of a horizontal network and a vertical network, or between an amorphous network serving incompatible computers like ARPANET and tightly designed network serving the machines and software of computer manufacturer or one corporation.

6. Common Carriers

Common carriers such as telephone companies provide nationwide data networks of several different types. Some of them are essentially the same as networks provided by value-added carriers, usually designed to move packets of data between subscribers in a fraction of a second. A telephone company has advantages that a value-added company does not if it chooses to use them. It can employ is high-speed digital path-ways and switches directly rather than having to lease the tariffed subchannels. Digital PCM trunks operate at speeds of millions of bits per second.

Telephone companies also operate leased digital facilities or circuit switched networks.

7. Multiple Common Carriers

Multiple comon carriers agree on network protocols with which to interconnect their data networks, just as telephone networks are interconnected. The common protocols permit the buildings of multinational, and eventually worldwide, computer networks.

8. Wideband Networks

Networks capable of carrying high bandwith traffic are coming into existence for use such as copying machines, transmitting to copying machines, remote slide presentations, and teleconferencing.

6.2. SPECIALIZED NETWORKS

It would be appealing to have a vast general-purpose network that could serve all types of distributed processing needs. These needs, however, are diverse and conflicting. One system demands very fast response times; another can tolerate message delivery taking hours, but needs it cheap. One system needs brief interactive transmission; another requires batch transmission of lengthy records and files. The needs of type-writer-like terminals are different from those of visiual-display terminals with large screens. Some machines can afford massive software overhead; others are very limited. On some networks the main thrust of design must be to minimize cost.

Particularly diverse are those software requirements external to message transport mechanism. There are many important functions of this software, as we discuss later, and they differ widely from one type of system to another.

There is great number of computers, minicomputers, microcomputers, terminals and peripherals which need to be connected into distributed systems. The variety is too great for any general-purpose network to serve the needs of all these devices. Therefore, we find many forms of specialized computer networks, often operating more economically than a general-purpose network. Networks may be specialized in the following ways.

6.3.WIDEBAND NETWORKS

Most office machines have required transmission facilities of voice-grade speed or lower. That is not surprising because nothing else was generally available. Now wider bandwith facilities are emerging, at least in North America. These includes AT&T's DDS network offering data rates up to 56 kbps, Xerox's XTEN network taking channels of 256 kbps into users'premises, SBS(Satellite Business Systems) offeering user channels up to 6.3 mbps, and American Satellite.

Along with the higher bandwith capability, office machines using high data rates are reaching the market place and are in the development laboratories. These include intelligent copying machines which transmit to one another, displays for giving remote still-video presentations, teleconferencing facilities using freeze-frame or full-frame video, and high-speed computer printers and graphics displays. It also makes sense to have computer-to-computer transmission or computer-to-storage transmission at high speeds for some applications.

CHAPTER TWO

1.COMPUTER NETWORKS

1.1 DEFINATON

Distribution techniques within holistic systems establish the foreground for architectural implementation in heterogeneous environments for computational, contextual, and cooperative design sets. Intelligence in each of these settings provides the point and multipoint decision-making capabilities for operational evaluation and, quite likely, intelligent modification of the distribution techniques. Combined, the two methods afford today's and tomorrow's telecommunication networks the ability to operate in legacy, heterogeneous, and federated systems proactively.

1.2 OVERWIEV

Prepared as a tutorial on the capabilities and techniques of distributing intelligence in today's telecommunications systems, this tutorial provides the reader with foundations and principles for advancing the advanced intelligent network (AIN) toward the next level of execution and interoperability.

1.3 BACKGROUND

Offered here is an overview of basic techniques and standards important to understanding some of the more theoretical elements of distributed intelligence techniques, focusing on the following three basic topics:

- **Fundamentals of the open standards interconnection (OSI) model**—breaks down the seven-layer stack of the OSI model; the OSI structure forms a common mindset for understanding the specifics of the operations applicable to distribution activities
- **Primer on intelligent networking**—provides the principles of intelligent networking activities, configuration, and interoperability
- **Primer on distributed processing techniques**—provides a summary of existing approaches to process distribution models

Additional material exists for each of these topics, and these summaries are not intended to provide a full discourse on the concepts and practices of these components. The reader should consider the following as reference points to the remainder of the tutorial.

1.4 FUNDAMENTALS OF THE OSI MODEL

Distributed network intelligence is grounded in the OSI model. It is within this model that the necessary relationships between multiple hosts of the distributed network will be established. The OSI reference model defines a partitioning of network operability into seven layers where one or more protocols implement the functionality assigned to a given layer. Working from the bottom of the stack upward, the following layers are defined:

- **Physical layer**—handles the transmission of raw bits
- **Data link layer**—aggregates a stream of bits into a larger data unit called a frame
- **Network layer**—performs routing among nodes within a packet-switched network
- **Transport layer**—establishes a process-to-process channel
- **Session layer**—creates and manages a name space used to link different transports considered part of a single application
- **Presentation layer**—provides a common format of data exchange between different types of peers
- **Application layer**—implements the functionality of the application

Each layer provides services to the layer above in the protocol stack and uses the service from the layer below. For messaging, each layer adds its own header to the message being passed on by the layer above it on the sender side. At the receiver side, each layer takes off the header from the message and passes the unbundled message to the layer above it.

Figure 1 gives the graphical representation for the OSI stack. Note that the model is replicated between disparate hosts. It is this replication that provides the framework for interoperability between compatible members hosts to execute in a distributed setting.

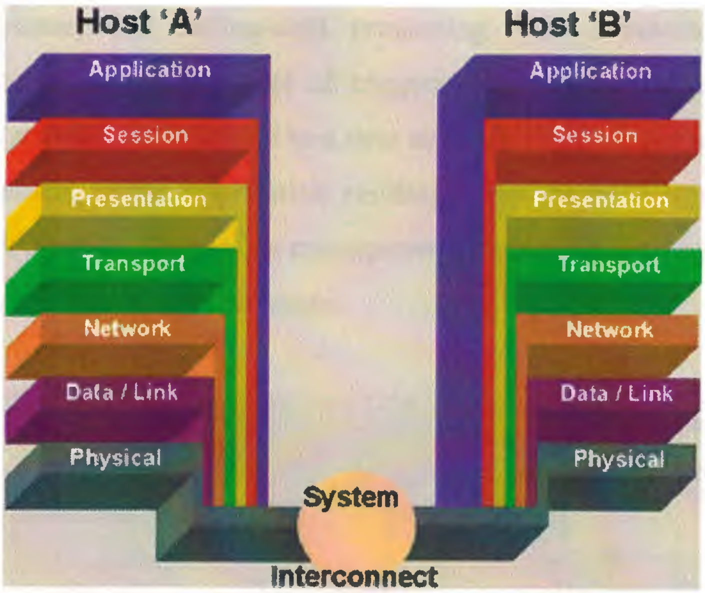


Figure 1. Diagram of the OSI Stack

The OSI model provides a framework from which to begin to define the basic capabilities of an interconnection solution and strategy. The layers of the OSI model establish a simple method of rationalizing communication theories between disparate computing elements. For distributed processing techniques, the OSI stack broadens the scope of basic interconnection and opens up the discussion to include how the interconnected elements may actually use and benefit from the connection mechanism at hand. Successful protocol agreements are achieved between distributed network elements through the use of the OSI model.

1.5 PRIMER ON INTELLIGENT NETWORKING

The intelligent network (IN) relieves the telephone switching system's burden of higher-level service introduction, management, and execution, allowing the switch to concentrate on the routing and management of calls. Introduced in the mid 1980s as a response to the demands of the regional Bell operating companies (RBOCs) for more rapid introduction of services and for relief of in-path call processing, the IN was initially defined as IN/1.

1.5.1.IN/1 Architecture

The initial services offered in the IN/1 architecture were 800-number translation (free phone) and calling-card processing. The architecture of IN/1 focused on implementing a standard set of triggers within a switch that, when invoked, would initiate an off-switch request to a new network element: the service control point (SCP). Management of the application residing upon the SCP was defined by another new network element, the service management system (SMS). Figure 2 shows the high-level topology of the IN/1 architecture.

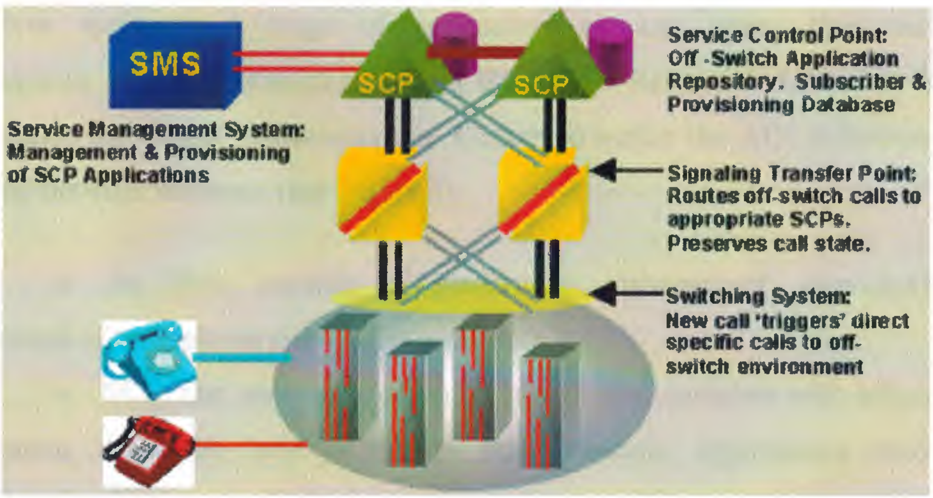


Figure 2. Basic IN/1 Architecture Topology

With IN/1, service logic was removed from the switches themselves to be placed in application database servers or SCPs. The introduction of the SCP to the network fabric brought about the need to create supporting systems for creation, provisioning, deployment, and management of new services. Overall, the necessities of service manageability and maintenance combined with emerging computing capabilities brought about the need for distribution techniques. The limitation of the IN/1 architecture was seen in the diversity of service capabilities. Like the movement away from singular management environments, service as a whole moved toward more distributed settings.

1.5.2 AIN Architecture

Immediately following the IN/1 architecture came the need to abstract service development, deployment, and management even further. The construction of the AIN ensued. With the release of the AIN 0.1 architecture came the ability for multiple service providers to create and enable new services within the IN. The largest advantage to AIN over IN/1 is the ability to provide service independence.

Service independence was achieved through the creation of an entirely new set of triggers considered more generic than those implemented through IN/1. The triggers themselves apply to a range of application services rather than the limited 800/freephone services established within IN/1. AIN Release 1 defined a full set of requirements for trigger implementation. Contained within the AIN definitions are the following network elements (see Figure 3):

- An SMS capable of performing management, provisioning, and maintenance of multiple services at the same time
- SCPs that serve as application repositories complete with subscriber and provisioning databases; one SCP can host multiple applications through the establishment of a generic platform environment
- Signaling transport points that route off-switch calls to the appropriate SCP
- Service switching points with added intelligence that are capable of detecting AIN triggers for off-switch routing

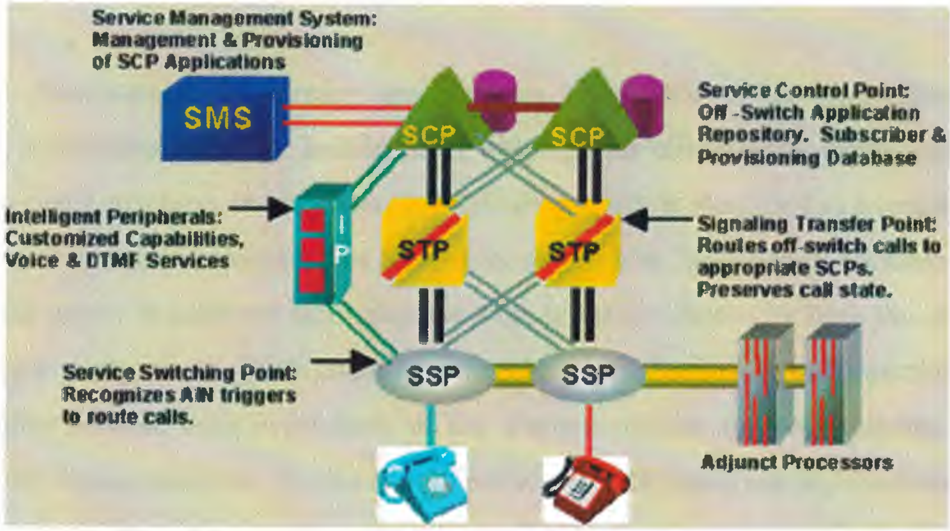


Figure 3. IN/1 Network Elements

The emerged capabilities and requirements of the AIN model for an SCP are natural for distributed environments. Generic platform environments, which host a range of services and are combined with multiple entry points for management and provisioning, form the groundwork that distributed systems provide. Distribution of intelligence in the IN network targets the keeper of the system's value-added purposes. The SCP holds the keys to the services of the IN, and it is here that distribution realizes the maximum value.

1.6 PRIMER ON DISTRIBUTED PROCESSING TECNIQUES

Distributed processing is more of a computer science concept than it is a telecommunications technique. Nevertheless, the broadening of intelligence in the telecommunications environment encompasses the theories and principles of distributed processing. An information management and control activity, distributed processing involves the separation of work between computers that are linked through a common communications network. Methods of implementing distributed processing run the gamut between simple segmentation of workload between member computer elements to cooperative tasking of computer elements to achieve a singular goal. Common practices for implementing distributed processing take the form of client/server and distributed object architectures.

1.6.1 Client/Server Model

The client/server architecture arose during the 1980s as an alternative to centralized, mainframe computer architectures, although the client/server model can be applied to a single machine. In client/server methods, a client is identified as a requester of services and a server is identified as a provider of services. Negotiation between the client and the server is achieved through a message interface chosen by both the client and the server components. With client/server techniques, flexibility, interoperability, and scalability become both byproducts of the implementation and requirements for improving the implementation. To this end, client/server techniques are implemented in two-tier and three-tier settings with variations applied to the three-tier methods for the inclusion of message-servers (also called transport protocol [TP] monitors), application servers, and object request brokers (ORBs). Each of the transitional configurations for client/server methods brings about capabilities that build upon the previous method (see Figure 4).

- Basic two-tier client/server implements simple request-reply actions in which the requester typically takes the form of an established graphical interface while the more powerful server actually implements the request and fashions a reply to the client/requester.
- Three-tier expands upon the limitations of two-tier architectures (typically sizing, processing overhead, and reliability) by implementing a logical middle tier that enacts message queuing. Maintained logically in both the applications of the client and the server, message queues are established to allow asynchronous operation on the client's part during the processing of the transaction by the server.
- Transaction monitoring enhances the three-tier architecture by implementing higher orders of logic within the transactions themselves. This logic implements larger queuing methods that allow further abstraction of the asynchronous operations of the clients while at the same time performing redundancy operations that guarantee the safety of the in-flight transaction.

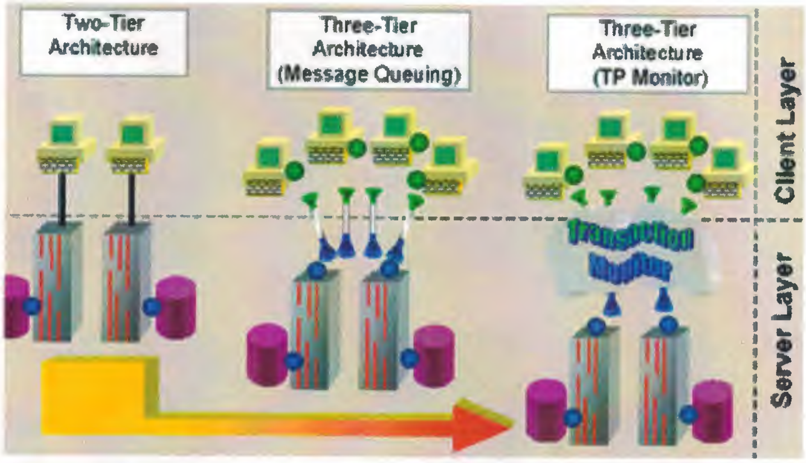


Figure 4. Two- and Three-Tier Client/Server Models

In ORBs, client/server architectures take on the evolving role of distributed objects.

1.6.2 Distributed Objects

Distributed objects are the application of object technology to client/server systems (see Figure 5). The architecture makes two distinctive presumptions: one, that the participating machinery in the architecture is capable of assuming and encapsulating the functions of an agreed set of common primitives known as common object services and, two, that the capabilities of object-oriented principles are available to the requesters of those services. The latter of these presumptions places the newly created services on equal footing with the basic primitives, which allows for larger and larger classes of services to be developed and integrated into the overall architecture's topology.

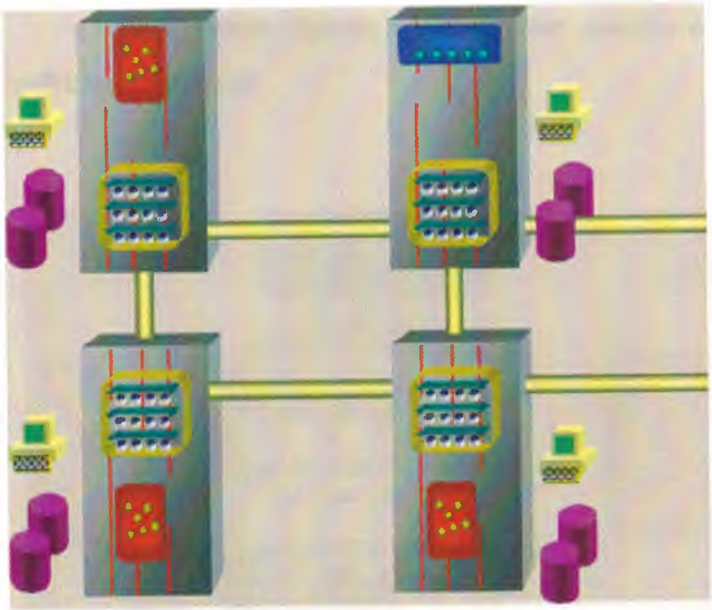


Figure 5. Distributed Objects

The application of distributed objects depends on the existence of a common set of services that is readily available to all participants in the system. These services are defined to be available through an interface known as an object request broker (ORB). The ORB allows other objects to make local or remote requests to other objects in the system. Primitive services available within the confines of the ORB are similarly available to local or remote requests at the same time as they cooperatively interact to provide the request/reply service. The Object Management Group (OMG) has been instrumental in defining the components contained within an ORB. These components are the founding elements of the common object request broker architecture (CORBA).

1.6.3 Basic CORBA Architecture

In this topology, the following elements may be found (see Figure 7):

- An ORB that CORBA defines as the object bus, which allows objects in the overall system to perform request/reply actions to other objects in the system
- The common object services, which provide system-level objects that allow the bus to interact with the system upon which it resides
- Management facilities, which refer to applications that are used by the application objects; the objects within this facility are generic to the overall system

- Application objects, which are the specific elements that provide value-added work to the system

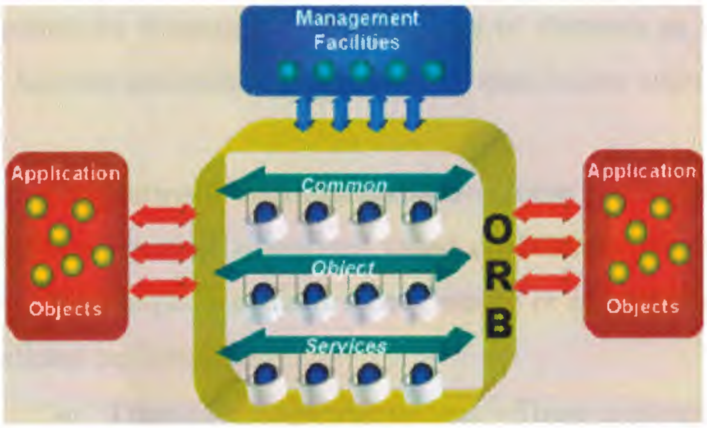


Figure 6. CORBA ORB Architecture

One can find client/server techniques embedded within the distributed object topology. The important distinction made between client/server and distributed objects are established with the commonality that exists between member systems of a distributed object framework. While client/server relies upon either an agreed message interface or a mediation element such as a TP monitor, distributed objects rely on the existence of a common architecture from which an established mediation device may be constructed. Distributed objects is an open architecture providing participation, development, and rapid deployment of solutions

1.6.4 Possibilities of Distributed Network Intelligence

Distribution in the IN affords improvement at all levels of execution, operation, administration, maintenance, and provisioning. The main benefit found with distribution of intelligence is the ability to define systems that meet fluctuating demands logically. A distributed system is one proactively designed for reactive behavior. In the IN, traffic loading is the principle reagent that influences the transitions between system states. Distributing the detection and reaction to state transitions between differing computing systems is an effective means of performing system modification while injecting the least amount of intrusive actions. In a distributed system, intelligent actions perform cures that are not worse than the disease.

At various layers of telecommunication systems, intelligent distribution occurs in several logic points:

- **Data/link (switching systems) implementations**—These implementations dynamically allocate links or channels as nodes encapsulating those entities become available. Conversely, they deal locate when the nodes are removed or altered.
- **Network implementations**—These implementations perform dynamic routing and congestion algorithms based on behavior characteristics of participating elements. Such implementations route through or around nodes based on their current and predicted performance.
- **Transport implementations**—These implementations mediate call flow between the objectives of the nodes to receive the calls and distinguish between node typing so that the appropriate call is enacted on the node that can best facilitate the objectives of the call.
- **Session implementations**—These implementations correlate service provisioning to nodes capable of performing the service in question. Again, such implementations use the behavior patterns of the nodes in question combined with their ability to perform the service tasking to establish route paths to service nodes considered to be capable of performing the deployed service.

2.NETWORK MANAGEMENT

The general theme so far is to allocate to heterogeneous members of one's distributed IN those tasks considered relevant to the capabilities of those members. Configuration in this instance is an intelligent activity that dynamically changes as the nature of both the service requirements and system specifics change. This is intelligent behavior based on intelligent distribution. Perhaps the most commonly addressed distributed intelligent activity, however, runs a course through all of these activities. This is the action of performing network management.

Using the standard means of action/reaction to events within the system, network management works proactively to perform the traditional actions: configuration, event (fault), performance, provisioning, and security management. Each of these actions is triggered by behavior events in each of the participating systems. The network manager in this instance can either be an independent or participatory member of the system. As a result of the distributed nature of the system, the network manager becomes the vehicle for the overall coordination of state between the member elements to be able to define a single system state.

2.1.HETEROGENEOUS ENVIRONMEMTS

A core competency of distributed systems and therefore distributed intelligence is the ability to relate tasking to the capabilities of the member nodes in the system. To this end, heterogeneous environments establish the best possible methods for applying intelligence toward a distributed system. In heterogeneous environments, tasking methods applied to the most appropriate container for the actions to be performed in the overall system are found. Distributed intelligence in heterogeneous models allows the system designer to accomplish the following tasks:

- Retain use of legacy elements and systems
- Isolate usage of member computing elements
- Brand computing elements to perform best-fitting tasks
- Establish rules for functionality creep beyond designated computing elements
- Coordinate system behavior rules to overload escalation and abatement actions

Using the client/server model for interaction, combined with the OSI stack as a requirement template for determining interactive behavior, one may begin to define the interoperability model between heterogeneous platforms, which accomplish the following:

- Provide identification of the makeup of the member nodes or sets of nodes
- Establish a matrix of attributes to be applied to each member node
- Abstract the attributes to collections of nodes
- Identify the principal connectivity method between nodes
- Establish a common set of interactive primitives or messaging components between nodes

- Broadcast the attribute matrix to member nodes (note: The system is alive.)
- Establish an agreed manager of the system; voting ensues

Now that the system is operable as a singularity, rules for reacting to changes in the system may be implemented either at the voted manager or within the confines of the member nodes. One has essentially established heterogeneous attributes as the common environment between the members of the system. Once the attributes are received and the method of system management (voting or otherwise) is established, each system can act independently to detect state changes and can then react corporately based on the rules for behavior dictated by the management scheme.

2.2.GROWTH MODELS

Change determines the behavior in distributed intelligent systems. One of the most predominant elements of change appears in system growth. For systems in which retention and preservation of assets is a key factor, growth most certainly brings about heterogeneous computing environments. Applying the principles of establishing best behavior for the appropriate elements in a heterogeneous setting, system designers become unburdened by the inclusion of legacy components in an evolving architecture. All that is needed is a redefinition and redeployment of the attribute and behavior matrix to the system. One must remove some of the functionality applied to the legacy node and distribute it to newly added members of the total system. The legacy environment is retained and continues to contribute to the activity of the overall solution.

3.TYING SOLUTIONS TO ARCHITECTURE

Several well-established solutions exist for enabling heterogeneous architectures. Those covered here are distributed computing environment (DCE), CORBA, and component object module (COM).

3.1.DCE

DCE performs fundamental request/reply interaction between systems containing DCE components. This interaction is made possible through a remote procedure call vehicle that is considered a fundamental middleware piece of the DCE. DCE source code is available from the Open Group, and vendors wishing to implement DCE on their systems incorporate this source code into their platforms. DCE itself contains several middleware services, which, once converted, reside atop a specific operating system. Once available, the services interact to provide transportability of service to other computing systems that have adopted the DCE standard. These services include the following (see Figure 7):

- Remote procedure calls, which enable client/server-like interaction with procedures on other systems as if they were local to the calling system
- Directory naming capabilities, which provide a simple naming convention for file structures applied across the member nodes
- Time synchronization services, which establish a single clock value across the member nodes
- Distributed file access
- Authentication and security methods for resource accessibility

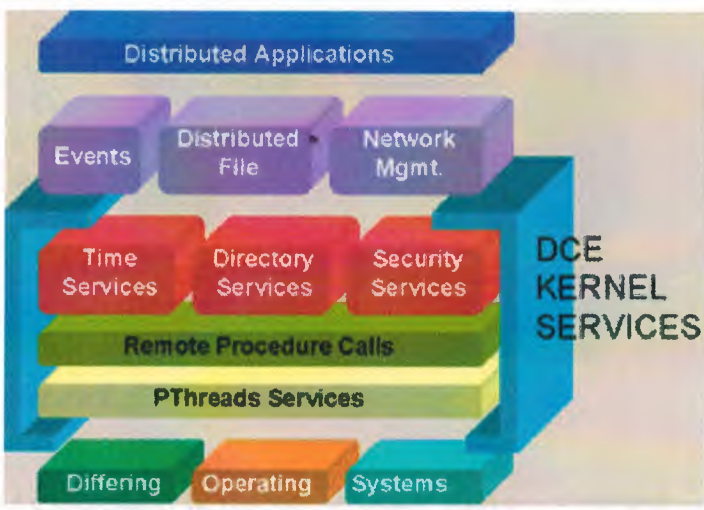


Figure 7. OSF DCE Layers

DCE also provides multithreading services and relative platform independence for application developers.

3.2.CORBA

The OMG offers CORBA as an infrastructure for establishing distributed components. CORBA comes in the form of interface specifications written in an independent interface definition language (IDL), which imposes no implementation mandates for operating systems or programming languages. As a result of this neutrality, components coded to the CORBA IDL must perform discovery of other components at run-time. As a benefit of this discovery operation, a CORBA system (as a totality) is both dynamic and self-defining. Through extending the capabilities of the components in the system, the rediscovery of the system results in a dynamic redefinition of the attributes of the system. This redefinition can then become the impetus for enabled behavior modification of the node elements in the system (see Figure 8).

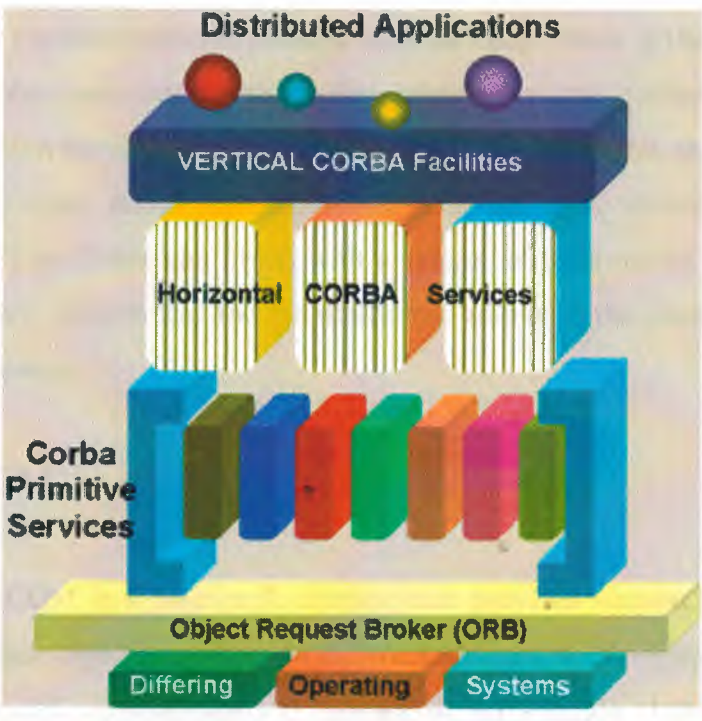


Figure 8. OMG CORBA Topology

As discussed in the introductory sections, CORBA requires the presence of the ORB. The ORB provides the vehicle for performing invocations of local and remote CORBA objects. Unlike an RPC, an ORB invocation is not a simple function call. Rather, it is a more granular invocation of an object method associated with a specific instant of data. RPCs do not bring the capability of object-oriented technology to the distributed medium. Contained within the specifics of the ORB are the following 11 object services of CORBA:

- Concurrency
- Events
- Externalization
- License
- Life cycle
- Naming
- Persistency
- Properties
- Query
- Relationships
- Transactions

The environments possible with the cooperation of these services combined with basic object-oriented methods for inheritance and container manipulation provide application developers and system designers with the tools necessary to create behavior-specific open middleware solutions. Through IDL, definitions of a heterogeneous system's attributes can begin with a nugget of information and be expanded through discovery, inheritance, and redefinition to adhere to the changing characteristics of the living system.

3.3.COM

COM is a Microsoft offering that provides support to objects communicating with other objects residing on different computing elements in the same manner that they would communicate and interact within a single element. Like a CORBA IDL, COM enables interaction through the specification of an interface to acting objects. Through COM, object interfaces are instantiated and uniquely identified through an element known as a global unique identifier (GUID). The element is a generated 128-bit value, which essentially guarantees uniqueness amongst other interface GUIDs on the local system or connected remote systems.

3.3.1.Distributed COM

Distributed COM (DCOM) is simply an extension of the COM model (see Figure 9). In essence, DCOM enables the distribution of COM capabilities to other computing elements. With COM, it is easier to think of component interaction in terms of interprocess communication. Where the destination component resides upon a separate machine, DCOM acts to augment the interprocess communication with a network protocol. The result is an abstraction of the interaction to the end-user where remote objects are referenced in the same manner as local objects. This abstraction is particularly useful in growth scenarios where current coding schemes are protected from the addition of computing elements and the distribution of COM objects to those new elements.

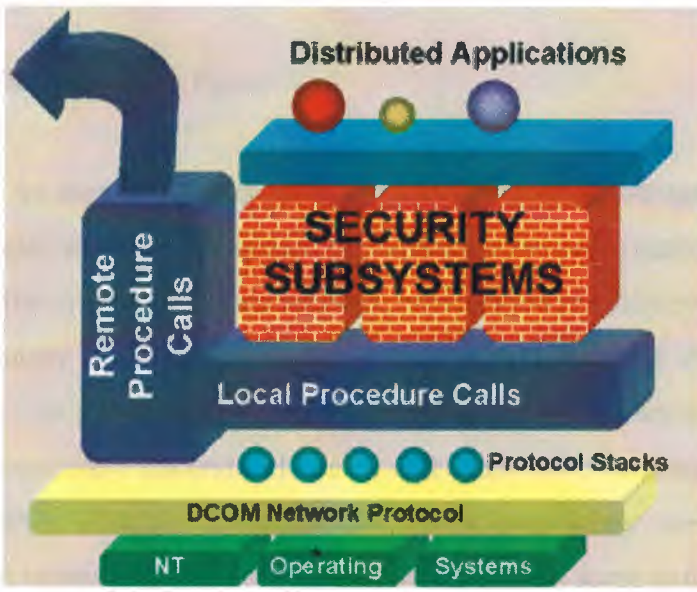


Figure 9. DCOM Interaction Topology

Interaction between components on different machines is managed through a midlevel DCOM network protocol that uses any of the following low-level transport protocols:

- Transmission control protocol (TCP)/Internet protocol (IP)
- User datagram protocol (UDP)
- Internet packet exchange (IPX)/sequenced packet exchange (SPX)
- Network basic input/output system (Net BIOS)

Whether connection-oriented or connectionless, DCOM implements a security framework for the low-level protocol. Connection management is maintained through collaborated reference counts against objects in use combined with a pinging scenario between computing elements. The DCOM protocol is based on DCE's RPC model, particularly in the area of converting data structures used in the communication path to data packets across the network.

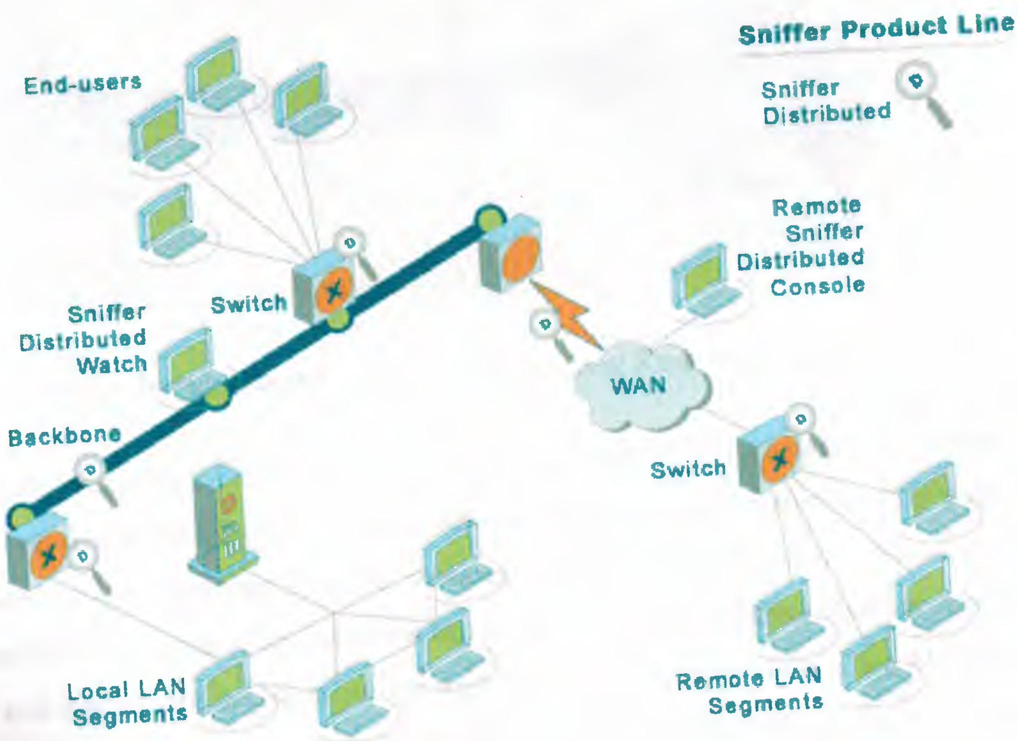
Certainly, DCOM is an environment available to Microsoft Windows products (Windows 95, Windows 98, and Windows NT). Various UNIX platforms are capable of implementing DCOM as a result of cooperative development activities between Microsoft and UNIX software vendors. In addition, several packages exist that integrate the elements of DCOM and CORBA through the use of an established bridge that performs conversion and mediation between the two.

3.3.2.The Sum of the Parts

As seen in the examples of growth models, heterogeneous environments serve the greater whole of the system by exploiting the best capabilities of the member nodes within the system. In legacy settings, exploitation is complemented through the reuse of contributory computing elements through refinement of their responsibilities in the system. The penalty paid for the heterogeneous collaboration of these elements is found in the necessary common elements that must exist between these elements. Whether DCE/RPC, CORBA, COM/DCOM, or a proprietary message-oriented-middleware (MOM) technique, processing power is reduced to some extent on member elements in the system to accommodate object and resource location transparency. Refining the needs of the system so that the most efficient method for object independence can be achieved dulls the loss of processing power for the computing elements but may eventually detract from the overall health and growth pattern of the system.

So which system is best? For the field of intelligent networking, one must look at the specifications and requirements. Intelligent networking is far different from on-line transaction processing (OLTP), but many of the methods in intelligent networking find their roots in OLTP systems. In the same vein, intelligent networking also finds basis in relational database management systems (RDBMS). The specifications of intelligent networking are too abstract to be a subject for this tutorial, but for determining heterogeneous topologies, a simple statement would be that the speedy processing of the in-flight transaction must be verified, augmented, and returned by the system while under the continued oversight of independent collaborating management processes. An object model serves these needs.

4. INTERCONNECTED INTELLIGENT NETWORKING



4.1. INTRODUCTION

The distribution of intelligence in a telecommunications network begins as nothing more than segmentation of responsibility (see Figure 11). The foundations of that segmentation are established according to the trend of moving telecommunications solutions toward more diverse computing platforms and away from monolithic settings. With movement and diversity comes the ability to integrate new solutions into the overall base system with greater speed and efficiency. Ultimately, the base system transforms to become part of a larger set of integrated components—each with differing levels of responsibility and contribution to the intentions of that evolved solution.

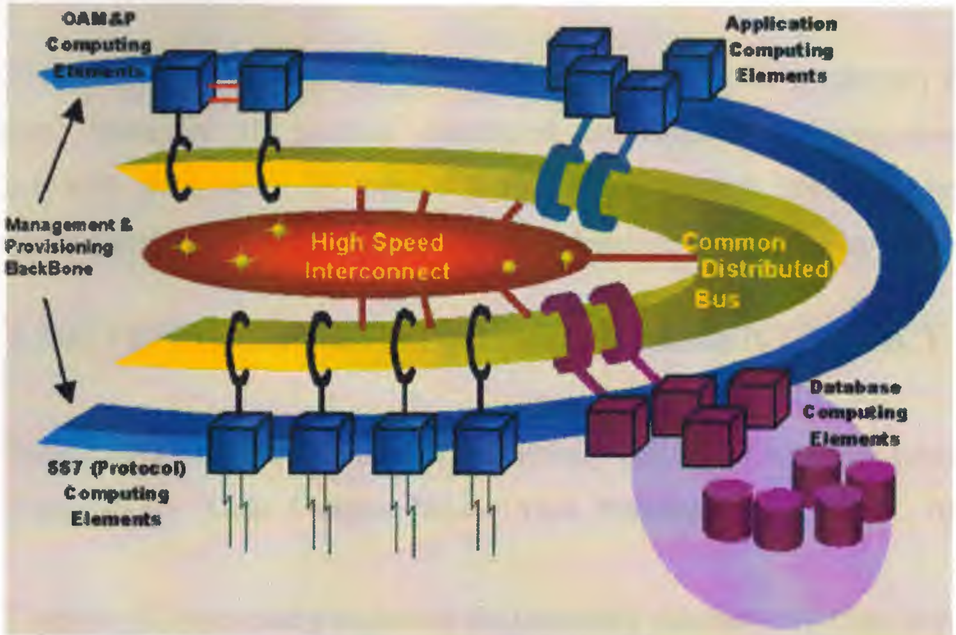


Figure 11. Interconnected Intelligent Networking Responsibilities

Implementing the distribution technique requires several fundamental elements: a high-speed communication interface between participating computing platforms, a negotiated protocol between member services, and a delegation authority for assigning responsibilities to computing platforms based on the makeup of their member services. These and many more decision-making activities continually occur in a capable system that dynamically acts and reacts to both the changing environment and changing needs of the networked solution.

Intelligence in the distributed environment finds its roots in the management of the solution. Cooperative behavior between member sets of the distributed environment lends data to the intelligent patterns. Most of all, the intelligent system grows. It exploits the diversity of the system topology to delegate responsibility to the outer reaches of the system informatively

This tutorial begins with an introduction to the principles of intelligent networking and traditional distributed processing techniques. Before introducing the implementation methods, the emerging capabilities of a distributed intelligent networking system and how they may be engaged to legacy situations through both homogeneous and heterogeneous

Platforms are discussed. The tutorial then moves to the mechanics and the architecture necessary to perform distributed intelligence implementations and concludes with discussions of today's tools, standards, and implementation sets considered applicable to constructing the ultimate objectives of distribution in the AIN.

5.DISTRIBUTED NETWORK MANAGEMENT POLICY

Final approval by the Information Technology Advisory Committee (university-wide): Approval by Main Campus Senior Vice President and Provost: 10/10/95.

Purpose: It is necessary to protect the university data network from disruptions originating from any network attached device and to ensure the reliability, availability and stability of the university data network. This policy requires distributed network management participation from all academic and administrative units who have devices attached to the university data network.

Source: Communications Advisory Committee.

Scope: This policy applies to all campuses of Arizona State University and to all academic and administrative units who have devices attached to the university data network.

Background: As computer networking proliferates, the university data network becomes more and more vulnerable to disruptions, affecting not only the source of the disruption but many other innocent computer users throughout the university. To protect the university data network from these types of disruptions requires participation directly from the academic and administrative units with devices attached to the university data network. These units must be responsible for performing certain network management tasks that require intimate knowledge about the unit's networking activities, administrative structure and future growth plans. Proactive distributed network management will minimize network problems and maximize utilization of the university data network.

Keywords: University data network, Distributed Network Manager, network attached device, computer, workstation.

Policy: Each academic and administrative unit must designate at least one employee who will perform the duties of a certified distributed network manager. This individual must have responsibility and authority for network coordination in their units. This individual should either be certified by IT or have arranged for the services of a certified network manager. This individual will regularly interact with IT and other certified distributed network managers on issues relating to the management of university data network.

5.1.CONSEQUENCES OF NON COMPLIANCE

Units that do not meet this requirement will have their equipment disconnected from the university data network if it is found that they are causing a problem that is negatively affecting the overall operation of the network.

CONCLUSION

Distributed computer networks from beginning until today were studied in this thesis.

Nowadays we have not change to think of that the computer is not included any network. Most of the people connecting to Internet, this is the network in global level; here. Information share from the different users.

Computers are connecting to each other and distributed network and handworks is making for code break operations that seen sometimes internet, so this operation is being produced with more cheap computers instead of expensive super computers. At last with distributed networks. It has not change to think of together with distributed database. That cannot be mentioned. The companies and government associations at global dimensions, have not another way that using these techniques, over the. Internet we can give example. Internet and extranet applications to this. When the developments and communication speeds increments at electronics circuit design is taken into consideration we can estimate events that will happen in future.

I cannot think of that in near future equipments that is using and the people will become a peace of global distributed networks.

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4. The words in italics are taken from the description of the Layer 1 interface in the CCITT Recommendation X.25.
5. The change from analog to digital operation is discussed in the Telecommunications and Computer, 2nd ed. 1976, and Future Developments in Telecommunications, 2nd ed., 1977, both from Prentice-Hall, Englewood Cliffs, NJ.
6. 274 million bits per second is the speed of the Bell T4 carrier, of which there are several implementations using different transmission systems. These are described in the Future Developments in Telecommunications, 2nd ed.