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INTERNATIONAL VALUE ADDED NETWORKS

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INTERNATIONAL VALUE ADDED NETWORKS

INTRODUCTION

This paper discusses the development of value added networks. Emphasis is on the international operations for the next five years. Since these networks have a three to seven year development cycle, those of us who are planning networks can accurately predict their development for the next few years. Since international operations are just about to become significant, it is now possible to predict how such services will evolve.

This paper is not concerned with the technical details of how networks operate internally, but with their role in computer oriented communications. It should be emphasised that these networks are made with computers to serve computers and computer terminals, and are therefore part of the computer industry, not the telephone, or 'real' communications industry. The actual transmission of data from point A to point B is quite another matter, and is beyond the scope of this paper.

SOME DEFINITIONS

Every specialty has its jargon, and the specialty of value added networks is no exception. Unfortunately, the jargon is not well defined, and new words are often thrown about with such disregard to language and logic that precise communication is impossible. The following definitions are by no means mathematically rigorous, nor are they universally acceptable, but they will do for the purposes of this paper.

To begin with, what is an 'international value added network'? The word 'international' seems clear enough, but 'value added network' needs to be spelled out. Let us say that it consists of geographically dispersed nodes. Each node is a computer with special peripheral equipment connecting it to the telephone network. Each node sends and receives digital data to all the other nodes. If the actual transmission facilities are analogue, modems are used to convert to and from digital. As far as the nodes are concerned, all communication is digital. Except for some network supervisory overhead, the sources and sinks for this data are terminals and host computers, which are connected to the nodes either directly or through the telephone network.

Of the many values added by such a network, the most important are the following four:

1 Speed and code conversion
2 Protocol and interface
3 Error recovery
4 Economics.

1 Speed and code conversion
Through a variety of flow control mechanisms, the network prevents a 10 000 character per second host from overrunning a much slower terminal. Speeds are constantly adjusted to allow maximum data flow without loss of data. Data is also converted from one character set to another if required.

2 Protocol and interface
Every host and terminal has a limited number of ways with which to communicate with other devices. A host designed to handle one type of terminal may not be able to talk to 15 other types (or other hosts). However, any device connected to a mature network can potentially talk to any other device on that network.

3 Error recovery
Data sent over the telephone network can be garbled. Sometimes the communication path is disrupted entirely. The value added network protects the user from these problems. Path selection is automatic and data is routed around damaged areas of the net.

4 Economics
Terminals tend to use telephone facilities inefficiently. By multiplexing data from many users onto a relatively small number of telephone lines, the cost to the user can sometimes be greatly reduced. This is especially true for slow terminals going long distances.

Hosts and terminals

It may seem unnecessary to define hosts and terminals, since everyone knows that hosts are computers which can terminate many independent data streams from the network and terminals are used to initiate data streams and access hosts. The trouble with that is that a host can access terminals, too, as well as other hosts. As terminals get more sophisticated, they can initiate and terminate many data streams. The point is that there is no real distinction between a host and a terminal from the network's point of view, merely differences between devices which source and sink data and initiate and terminate data streams. However, for the purposes of this paper, let us say that a terminal is a device which initiates calls to access a host.

Intelligent terminals

The intelligence referred to in this context means the ability to recover from errors in the local communication link by retransmission; also, flow control mechanisms to regulate the flow of data so that the network is not concerned about mechanical timing considerations. Remote job entry terminals using bisynchronous communication satisfy this definition. Note that intelligent terminals use more complex protocols than simple terminals. Also, there is more hope of standardization of interface and protocol with intelligent terminals.

Packet switching

Packet switching and value added networks are often confused. Packet switching is a commonly used technique whereby data on a single data stream is sent through the net as packets. Users are charged by the packet, which makes it expensive to send one character at a time, since each character would require its own packet. Other techniques, for instance virtual circuit switching, handle the data character by character. Between any two nodes, data is still broken up into blocks, but data from several users can share the same block. This requires more processing in the nodes, but makes more efficient use of the telephone lines.

Gateway

A gateway is a special type of node that interfaces one network to another, or to other gateways. They are an extension of the concept of a value added network functioning as a protocol converter. In addition, they can be accounting and access control points.

HISTORICAL PERSPECTIVE

In the late 1960s, two networks were developed which laid the groundwork for all networks to follow. They were the ARPAnet, and TYMNET. The ARPAnet was sponsored by the United States Department of Defense as an experiment in computer communications. Its purpose was to tie together many different kinds of large computers on many different university campuses. A variety of simultaneous experiments could then be carried out to test the feasibility of sharing data base, hardware, and software among the universities.

50 kilobit lines and packet switching were used to move the data. Since low speed terminal support was not a consideration and since the lines were lightly loaded, the inefficiencies of packet switching did not matter. Network control was distributed among the nodes, with each node having global knowledge of the net. Some standard host interfaces were developed and many independent teams of graduate students successfully modified their machines to attach them to the net. The ARPAnet was quite successful in achieving its original goals. It became the most widely studied and publicized network.

TYMNET developed quite differently. Its primary purpose was to interface large numbers of low speed terminals to a relatively small number of timeshared computers operated by Tymshare, Inc. Most of these terminals were full duplex and interacted with the computers character by character. Each character was echoed from either the network or the computer according to what the user was doing. Echo control had to pass back and forth between network and computer very smoothly to retain the flexible typing characteristics of the full duplex terminal. Finally, since this was to operate in a commercial environment, it had to be efficient and low cost. That ruled out packet switching and 50 kilobit lines.

A scheme called virtual circuit switching was invented in which the path that the user's data was to follow was determined when the user logged on. This path was called the virtual circuit because of its analogy with a telephone circuit. Data following that circuit does not have to carry routeing information with it. Furthermore, data from many users can share the same physical record. The overhead of checksums and record headers can be spread over many small users. Finally, since flow control operates node to node rather than circuit end to circuit end, there is no need for the recipient of data to send back a message to the sender that it is all right to send more data. This scheme proved to be so efficient that it is possible to serve up to 40 low speed (10 to 30 character per second) interactive terminals on one 2400 bit per second line.

Control was centralized at a single point called the supervisor. The supervisor generated accounting, checked user names and passwords, provided network diagnostics, and decided how to route the virtual circuits. This scheme reduced overhead and provided quick response to network trauma. It also allowed the nodes to have smaller memories since they did not have to have global knowledge. TYMNET normally has four supervisors, one in control and three for backup.

In November, 1971, TYMNET was fully deployed and operational, a 50-node net serving 5 host computers for Tymshare, Inc. In February, 1972, the National Library of Medicine put the first non-Tymshare host on the net, an IBM 370/155 with a medical data base. Since then, TYMNET has evolved far beyond its original design goals to become the largest value added network, serving about 25 000 users a day. It is the only international value added network currently operating.

THE INTERNATIONAL SCENE

TYMNET is already established and growing rapidly. It first went abroad as a private network, serving the needs of Tymshare, Inc. Now parts of it are also functioning as a public network. Since TYMNET is not an internationally recognized carrier, that part of it which is public and international is usually owned by a record carrier such as ITT, RCA, or WUI. The record carrier negotiates agreements with the PTT of a particular country, which may result in the PTT owning some of the equipment.

The rules governing which user can access which host from which nodes over which lines are quite complex. They are enforced on a user-by-user basis by the network supervisor. For instance, RCA, ITT, and WUI each have a line between Italy and the United States. The agreement is that each successive call is placed on a different line so that traffic is divided equally among them. If one line is out, it loses its turn.

Telenet

Telenet was formed in 1972 using ARPAnet technology. The plan was to 'commercialize' it, i e, put in the features needed to make it sell, and go into the network business. Telenet currently serves most of its territory with time division multiplexors, but there are ambitious plans to extend the coverage of true network nodes. They provide European access by interfacing to TYMNET. They have been approved by the United States as an international record carrier, and they are marketing in Europe. They intend to provide services similar to those of TYMNET.

Euronet

Euronet is a joint venture of several European countries. It is scheduled to go into operation early in 1979. There will be one node each in England, France, Germany and Italy. It is a packet switched network using the same hardware as the French Transpac network. If successful, it is likely to spread to other European countries. It is expected that Euronet will interface to the other major networks with an X.7X type connection.

Datapac and Transpac

Strictly speaking, the Canadian Datapac and French Transpac are national networks, but are mentioned here because of their international implications. To begin with, these countries feel strongly that international traffic that originates or terminates in their country must use their network. For instance, if a user in Canada accesses a host in France, both Datapac and Transpac must be involved. In fact, no other network may be used. A connection involving TYMNET would be disallowed, unless, perhaps, a Tymshare customer is accessing a Tymshare host. In this special case, TYMNET would be functioning as a private network.

Datapac and Transpac are very similar in their service offerings and in the manner in which they intend to interface to other networks. They are looked upon as models of what a national network should be, and many other countries may have similar policies. The policies and services are still not at all firm, and may be changing in the next few months. However, the following list summarizes the current situation.

First, host interfaces will be X.25 only. This means that new software and front ends will have to be developed before any hosts can use these networks.

Second, only two types of terminals will be supported, intelligent terminals which speak X.25, and simple asynchronous devices. The asynchronous support will be quite limited, and the pricing structure will favour intelligent terminals operating at high bit rates.

Third, the host, rather than the terminal, will be billed. Note that this is the reverse of normal telephone procedure. There is much disagreement on this point. It is quite complicated when several networks are involved. For instance, suppose a user in France wishes to access a host in the United States. He may first call TYMNET, because only TYMNET can handle his particular type of terminal. He then goes to Transpac, because this is an international call. From Transpac he goes to an American international record carrier (actually part of TYMNET again), then to Telenet, because only Telenet serves this particular host, and finally to his host. Currently, such a call would not be allowed, because the tariff arrangements have not been worked out. If and when they are worked out, they might work something like this: the customer would get two bills, one from the host for its timesharing or data base service, and one from Transpac for communication. Transpac would be billed by TYMNET and the IRC, and the host would be billed by Telenet. Note that in this case, Transpac would have to bill the customer, not the host, since there is no convenient way for Transpac to identify the host. This billing problem is a messy one, and likely to delay international operations. Note that if the customer wanted to access a Tymshare host, the entire communication would be handled by TYMNET, since TYMNET would be considered a private network in this case. The customer would get only one bill from Tymshare.

What Canada and some European countries would like to see is each country served by one network in that country. If a call is international, then the call would involve only the two networks of the source and destination countries. These two networks would each have a gateway node, and the two gateways would talk directly to each other with an X.7X type protocol. If each country has a gateway node, and if each gateway talks to every other gateway, then the gateways form a fully interconnected metanetwork of their own. Presumably, no alternate routeing would be allowed, so if the line between two gateways is down, the two corresponding countries could not communicate. This approach simplifies the billing problem, but raises questions of reliability and cost effectiveness. The X.25 protocol and related technical matters have received a lot of publicity lately, but the twin problems of customer billing and international policy are the real barriers at this point. Until they are overcome to everyone's satisfaction, a healthy international service is unlikely to occur.

X.25

X.25 is one of the remarkable achievements of recent years. In an industry long known for its resistance to standardization of any kind (the computer industry, not the telephone industry), X.25 stands out as an exception. To be sure, the mainframe manufacturers have given only token acceptance of the new standards so far, but on the other hand, they have not offered any convincing alternative. All public value added networks, without exception, enthusiastically endorse the new standards.

Strictly speaking, X.25 refers only to a high level protocol designed primarily for interfacing hosts to networks. There are many other standards associated with X.25 for other levels of interfacing. For instance, there is a standard for the shape and other physical properties of the connectors, another standard for the voltage levels and other electrical properties, another standard for the logical meaning of each pin in the connector, and so on. However, there is a consistent set of these standards which is commonly referred to as X.25.

At each level, substitutions can be made without much impact on the rest of the interface. For instance, in a 'pure' X.25 interface, the rules for the format of the serial bit stream (framing, record headers, checksumming, etc) are described by HDLC. However, both Datapac and Transpac allow the user to substitute a bisynchronous type format to take advantage of existing hardware and software. The rest of the interface remains the same.

Each level of standards addresses a different problem. For instance, the standard for connectors considers how cables are connected; the electrical standard dictates the cable driver and receiver circuitry, etc. These low level standards, originating in the telephone industry, have existed for years. What are new are the higher level standards dictating the software for flow control, interleaving multiple data streams, call initiation, and other problems relating to network interfacing.

The experience of both TYMNET and Telenet indicates that the typical network customer is very reluctant to modify his host to interface to a network. As a result, both networks employ a number of programmers whose sole function is to develop and implement custom interfaces adapted to what each particular host can handle. This approach is impractical for Datapac, Transpac, and Euronet, and those networks are dependent on the acceptance of the new standards. Obviously, only a few large customers will be willing to undertake the task of converting their equipment to the new standards. These new standards are complex, and the conversion cost will be high. The two other possibilities are special consulting firms who specialize in the computer communications business and the computer manufacturers. The special consulting firms are too few and too small to do the job by themselves, and the manufacturers will be reluctant to make the investment if this is just a passing fad. On the other hand, if the new standards really catch on, any manufacturer who does not conform to the new standards will miss part of the market. It should also be noted that there is plenty of ambiguity in the highest levels of the new standards. This will make it possible for several parties to claim that they speak the same language, yet be unable to speak to each other. Also, for any particular application, there are still higher levels of 'protocol' which can not be defined in general. The new standards go far toward allowing different computers to talk to each other, but it will never be as simple as plugging a lamp cord into a wall socket. There will always be some customizing required for any network application.

TERMINAL SUPPORT

The number of different kinds of terminals is very large, and increasing rapidly. Each seems to require its own type of support. Simple terminals differ in baud rate, character set, carriage return times, parity requirements, and so on. Intelligent terminals differ in protocol requirements and capabilities. It is impossible for anyone to describe a simple set of rules which covers all cases.

Since TYMNET was designed from the beginning to handle large numbers of terminals, flexible terminal support was designed into the network. There is an elaborate language with which the host can talk to the network about terminals, as well as direct user control. ARPAnet and Telenet have also developed a terminal server to increase the variety of terminals which those networks can serve. The new networks under development, however, intend to provide rather limited support for the variety of terminals. This means that many terminals, those currently offered by IBM, for instance, will not be able to use these networks. There is a definite trend toward standardization of terminal types.

In the past, the simple terminal has been by far the most common and important in interactive applications. However, the cost of adding intelligence to a terminal is dropping rapidly with the microprocessor technology. It seems clear that the cost of the electronics of intelligent terminals will soon be much less than the cost of the mechanics and packaging. If this is true, then the simple terminal may soon disappear.

One barrier to this evolution is the lack of a suitable protocol for interactive intelligent terminals. Rather than wait for one to develop, TYMNET has developed its own and has also developed a terminal, or terminal cluster, to use it. When functioning as a terminal cluster, it can initiate and terminate several independent data streams over one telephone connection. All of TYMNET's echo control and terminal control can pass through this protocol to influence the operation of individual keyboards and display devices. Many microprocessor controlled terminals can be adapted to this protocol by modifying their mocrocode. Unfortunately, this protocol is not a widely recognized standard, nor is there any convenient way of passing it from one network to another. It is therefore useful only to users of TYMNET.

There is some discussion in this area, and some manufacturers have even made misleading claims about product lines which satisfy the requirements, but the problem of standardized protocol for intelligent interactive terminals is probably too new and unknown to be successfully attacked at this time. It is bound to become a pressing problem in the near future, however, as intelligent terminals and value added networks proliferate. The old bisynchronous protocol seems to have no long term future, although it is going strong now. IBM's SDLC and associated offerings were announced years ago, and never really arrived. Other manufacturers have made even emptier announcements. Even if the promises were made good, none of these protocols really serves the needs of value added networks.

MESSAGE SWITCHING AND ELECTRONIC MAIL

The established form of message switching is the ancient and well known TWX service in which very slow terminals can dial each other on a network similar to the telephone network. More recently, minicomputer based message switches have been developed which provide an alternative to TWX. They use the telephone network and can use faster terminals. An obvious enhancement is to interface such a switch to a value added network. Now any user can use any type of terminal. Sender and receiver can use totally different terminals. Also, the network should be less expensive for long distances. TYMNET has been experimenting with such a service for some time. However, the really exciting possibilities arise when a full fledged timesharing system is used for the message switch.

ONTYM, a message switch service based on large DEC PDP10s, has just become available on TYMNET. It runs under a timesharing monitor developed by Tymshare which was designed to provide fast response to large numbers of interactive users. It has all the features one expects of a mature timesharing system, such as text editing and file archives. In addition, messages are passed from one system to another, so that once a user has entered a message on one system, that message will be delivered even if that system goes down.

The method of message delivery is determined by the recipient, not the sender. If one sends a message to John Doe, the system will do what is appropriate to get the message to Mr Doe. If Mr Doe is travelling, the system may hold all messages until Mr Doe checks in, and then deliver all accumulated messages, regardless of where he may be or what kind of terminal he is using. When Mr Doe returns to his home office, he may specify that messages are to be sent to a particular type of terminal at a particular telephone number during certain hours. When he goes on vacation, he may ask that his messages be forwarded to Mr Smith.

The system has a variety of recovery mechanisms to cover all foreseeable types of failure. For instance, suppose a message was sent to a terminal which was out of paper. When the recipient realizes that he may have lost some messages, he asks the system to list all messages sent in the last few hours, then retransmit any messages he wants.

Since this service is new, it is possible that some valuable features have been overlooked. However, since the system was written in a high level language on a large timesharing system, it should be relatively easy to add these features as they are discovered. It should also be easy to add special features for any particular customers who are willing to pay for the software development.

A number of other applications can be developed on this message switch, for instance, network conferencing. Conferences among geographically dispersed participants could go on for years, if required. A special type of conferencing is auctioning, in which some users describe items to be sold and other users bid on them. A particular item could be auctioned in minutes, as in a conventional auction, or months.

The cost of the basic service is expected to be much less than TWX. In fact, it is nearly competitive with first class mail, which makes ONTYM the first electronic mail service. There appears to be no technical justification for maintaining the TWX service.

This gives rise to a severe problem. TWX is very well entrenched. Much capital is invested in it. Complex tariff structures are built around it, and some PTTs derive a substantial amount of revenue from it. For these reasons, ONTYM is currently offered only in the United States. The network supervisor prevents access to it from any other country. Its distribution to other countries will be slow and uncertain.

THE DISTANT FUTURE

It is difficult to predict with any accuracy what will happen in this field ten or twenty years from now, but considering the great investment required to develop and use these networks, it is worth a try. The telephone industry is clearly in for a difficult time. Technology is changing at an unprecedented rate, rendering obsolete equipment which was intended to last for decades. Fibre optic connections between homes and local telephone exchanges may soon cost no more than copper wire, and give many megahertz of bandwidth with very little noise. All electronic digital telephone exchanges will offer many services not currently available at very low cost. Since the conversion from old technology to new cannot be made overnight, there will be severe compatibility problems when users from one area communicate with another area served by a different technology. Those unfortunate people who decide tariff structures will have to cope with extreme disparities of cost and quality of service seen by different users.

Against this background, consider the reasons for the existence of value added networks. They are speed and code conversion, protocol and interface, error recovery, and economics. The first three can be handled by intelligent terminals and front ends for the hosts. If a good set of standards can be developed, these problems can be simplified. Also, it should then be possible for any device to call up any other device on the telephone network and talk to it. The cost of the microprocessor based electronics required to do this should be very low. That still leaves the last justification, economics.

Suppose that in the future, fibre optic, satellite, or wave guide technology allows the bandwidth between telephone exchanges to be immense by present standards, and still be low in cost. Also suppose that the cost of installing an electronic digital telephone exchange based on mass produced integrated circuits becomes very low. Then most of the cost of the telephone network will be in the connections between the exchange and the individual user. This cost is difficult to reduce beyond a certain point because of the labour required to install the wires (or fibre optics). If this is the case, it will not matter very much whether a particular telephone is idle or tied up in a long distance call. The cost will be nearly the same. Furthermore, it will not make economic sense to give a discount to the user who requires only a small amount of bandwidth. If this comes to pass, and if the tariffs are changed to reflect the technology, then the economic justification for value added networks will also disappear. On this speculation, I suggest that we are creating a race of dinosaurs. Value added networks will continue to evolve for another decade or two, and then die.

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