## INTRODUCTION BY EDITOR

*This article, the fifth in a series on the history of packet switching, provides an account of the early days of commercial packet switching services in the United States. It is remarkable and refreshing — and possibly controversial — in stressing the business of technology more than the technology itself. The previous articles covered the early history of packet switching in the UK (by Peter Kirstein, February 2009) and in Canada (by Tony Rybczynski, December 2009), the early history of the Internet (by Len Kleinrock, August, 2010), and the development of X.25 virtual circuit networking in France (by Remi Deprés, November 2010).*

*Commercial packet switching networks were launched in most countries by the Postal Telephone & Telegraph administrations (PTTs), but the situation in the U.S. was different. AT&T was the dominant communications service provider, but initially showed little interest in packet communications. Entrepreneurial companies, particularly Telenet and Tymnet, became leaders in commercializing packet switching services.*

*The earlier articles in this series described the technical history of packet switching and the development of the international X.25 standards. This article focuses on commercial, competitive and regulatory developments in the U.S. and is written by key figures in these developments. Larry Roberts is generally considered one of the pioneering architects of packet technology and, in particular, the ARPANET, and was co-founder and President of Telenet, the first regulated commercial packet carrier in the world. Stu Mathison was VP of Planning at Telenet from its creation until it became a part of Sprint in the 1980's. Phil Walker, an attorney, was also a co-founder and managed Telenet's regulatory and legal affairs.*

*—Steve Weinstein*

# THE HISTORY OF TELENET AND THE COMMERCIALIZATION OF PACKET SWITCHING IN THE U.S.

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## COMPUTER COMMUNICATIONS IN THE 1960'S

### THE MAJOR CARRIERS

In the 1960's, the telecom industry in the United States (and Canada) was organized differently from telecoms outside of North America. In the rest of the world government-owned PTTs were the exclusive telecom operators. In the U.S., regulated private companies provided all public telecom services. Public communication services were deemed to be "common carrier" services, according to the Communications Act of 1934, and were therefore subject to regulation by the Federal Communications Commission (FCC).

AT&T (also known as the Bell System), a private company, was the dominant provider of domestic and international telephone services, while hundreds of smaller independent telcos served rural areas.[1] Western Union, also a private company, but much smaller than AT&T, provided domestic telegraph and telex record communication services, message switching services, and private line data services.[2] AT&T and Western Union both offered leased line services, and AT&T offered circuit switched services for voice and data communications applications. International record (message/data) services were provided by International Record Carriers (IRCs).[3] All of these carriers would later influence the commercialization of packet communications in the U.S.

Large corporations in the 1960's and 70's typically operated centralized data centers, initially mainframe-based and later minicomputer-based, and needed to connect many remote terminals — for applications such airline reservation systems, banking systems and retail point-of-sale systems. Corporations typically implemented leased line "star networks" using multiplexers/concentrators, or polling techniques over multidrop lines, or a combination of these techniques. Lines were leased from AT&T and the other carriers.

Companies offering time sharing services (the 1960's and 1970's version of "cloud computing") typically deployed "star" data communication networks by installing time division multiplexers or statistical concentrators in major cities, and used leased voice-grade lines to connect these devices to central computers. End users in major cities made "local" phone calls to these multiplexers to access central time-sharing computers. End users in other cities made long distance or WATS (Wide Area Telephone Service) calls directly to the central computers.

Some time-sharing companies built more sophisticated "mesh networks" using leased voice-grade lines to connect remote concentrators to one or more computer centers. A few corporations implemented mesh networks. Each such network was custom-designed and used for accessing one company's computers.

AT&T's tariffs did not generally allow a corporate customer to use a private line network for any purpose other than accessing that company's computers. In a few cases, where public interest and safety considerations applied, such as the domestic ARINC and the international SITA data communications networks serving multiple airlines, and the SWIFT network serving multiple banks, the sharing of data communication networks was permitted.[4]

*[1] As of 1970, AT&T and its subsidiaries (the Bell Local Operating Companies; Western Electric, the manufacturing arm; and Bell Labs) had more than one million employees and $16 billion in revenues, accounting for 86 percent of telephone revenues in the US. The independent telcos accounted for $2.6 billion in revenues.*

*[2] Western Union, with revenues of $400 million in 1970, was approximately 1/40 the size of AT&T.*

*[3] The International Record Carriers were RCA Global Communications, ITT World Communications Western Union International and Tropical Radio and Telegraph Company (TRT).*

*[4] ARINC was appointed in the 1920's as the exclusive inter-airline communications provider by the Federal Radio Commission (later known as the FCC). SITA — founded as Société Internationale de Télécommunications Aéronautiques in 1949 — provides international telecommunications for the air transport industry. SITA deployed one of the first private packet networks in the early 1970's. SWIFT — founded in 1973, the Society for Worldwide Interbank Financial Telecommunication — operates a worldwide financial messaging network which exchanges messages between banks and other financial institutions.*

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### FROM MONOPOLY TO REGULATED COMPETITIVE CARRIERS

One of the first companies to challenge AT&T was Microwave Communications Inc. (MCI), which applied to the FCC in 1963 for a license to provide "specialized communications services" over a microwave radio system between St. Louis and Chicago. In 1969 the FCC authorized MCI as a "Special Service Common Carrier." This decision was the beginning of a "slippery slope" and the scope of MCI's service offerings expanded over time.[5]

Shortly thereafter, in 1969, Datran (a subsidiary of University Computing Corp.) applied to the FCC for authorization to build a $375 million nationwide, all digital, microwave-based, fast circuit switching network, specifically for data communications. The network would consist of 244 long haul microwave stations operating in the 6 GHz band, and local distribution using both short haul 11 GHz microwave radios plus leased lines from local telcos [1].

In 1971, the FCC authorized the construction of Datran's network. AT&T strongly opposed the authorization of MCI and Datran, arguing that they constituted "unnecessary duplication" of AT&T's nationwide network. These FCC decisions, authorizing competition in the U.S. telecom industry, soon resulted in the entry of various new types of carriers, some of which were based on packet communications techniques.

Against this background, several organizations would propose various technical and commercial network architectures to address the expanding communication requirements of computer users. While this article will focus on the commercialization of packet communications services, it is useful to understand the range of competing network architectures for public computer communications which were proposed, and in some cases, deployed during the 1970's and 1980's. The most important such data networks are briefly described in Table 1.

## THE ARPANET

The history of the ARPANET is well known and widely reported [3]. We will not repeat this history here but we will focus on how the ARPANET contributed to the development of commercial packet networks in the U.S.

In 1968, the U.S. Department of Defense's Advanced Research Projects Agency (ARPA) issued an RFQ for the implementation of packet routers for ARPA's initial four-node packet network. The RFQ and the specifications for the network were drafted by Larry Roberts and Barry Wessler,[6] based on research and analysis from many contributors as described in Len Kleinrock's article in this series [4].

ARPA awarded the contract in December 1968 to Bolt Beranek and Newman, Inc. (BBN), a small research and development organization located in Cambridge, MA, and specializing in acoustics and computer science. BBN developed the packet routers, or as they were then called Interface Message Processors (IMPs), in nine months and installed them at four sites in the Western U.S. during the latter part of 1969 to form the initial four-node ARPANET.

In early 1968, as part of research for a joint MIT master's thesis, Stu Mathison and Phil Walker met with Larry Roberts and discussed his vision for the ARPANET as a "resource sharing network" to link together the various computer research centers funded by ARPA. They were impressed with the vision and investigated the commercial potential and the regulatory status of packet switching in the course of their thesis work and subsequently.

The ARPANET continually expanded, growing from four nodes to 38 nodes by 1973, each node connecting a university or defense-related data center to the network.

In the summer of 1970, Stu Mathison, Phil Walker and Barry Wessler met in Washington, DC to discuss the feasibility of building a commercial version of the ARPANET. Prior to entering graduate school at MIT, Mathison had spent a year working as a teleprocessing systems engineer at IBM and understood the costs and limitations of the available telephone communication facilities and services for computer communications. The group concluded that the ARPANET technology was not yet ready for commercial application because the network provided only host computer interfaces, and not terminal interfaces.

In 1971 BBN deployed the Terminal Interface Processor (TIP), which enabled multiple types of asynchronous terminals to access the ARPANET and *all* its host computers *over a common network*. The TIPs significantly enhanced the commercial potential of packet technology.

As the number of IMPs and TIPs in the ARPANET expanded and the number of hosts and users increased, the ARPANET user community (i.e., researchers mainly funded by ARPA) increasingly began relying on the network for day-to-day communications and to support their research projects.

As the ARPANET became more of a communications service for the ARPA research community, and as others outside the ARPANET community sought to utilize the network,[7] Larry Roberts wanted to transfer the ownership and operation of the network to a communications common carrier, such as AT&T or Western Union. As carriers, either AT&T or Western Union could have furnished the ARPANET service to both the ARPANET community and the general public as well.

Roberts met with executives from both companies and neither company was interested in taking over the operation of the ARPANET or operating a commercial version of the network. His offer to AT&T was for ARPA to turn over the current ARPANET to AT&T and purchase back service from AT&T as part of their public service. AT&T and Bell Labs executives studied this offer for months but finally decided that packet switching service was not compatible with their strategy. AT&T would not begin to offer packet switching network services until roughly a decade later (i.e., 1982). Western Union never developed a commercial public packet network service.[8] After finding

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*[5] The term "slippery slope" was the title of a book describing the emergence of competition in U.S. telecoms. The author was Bernard Strassburg, the Chief of the FCC's Common Carrier Bureau from 1963 until 1973.*

*[6] Larry Roberts was the Director of the Information Processing Techniques Office (IPTO) in ARPA from 1966 until 1973. Barry Wessler was the IPTO Program Manager for the ARPANET project until 1970.*

*[7] Officially, only ARPA contractors could utilize the ARPANET, but this was extended whereby "authorized users" were permitted to use the network. Other parties were not permitted to use the network because the AT&T tariffs for the underlying leased communications lines did not permit shared usage.*

*[8] WU was awarded a contract in 1976 to build the Autodin II network, a private packet and message switching network for the military. WU's Autodin II network was long delayed and failed to meet DOD requirements. DOD cancelled the $30 million contract with WU in 1982 and contracted instead with BBN.*

| Type of Network | Company | Description |
|---|---|---|
| All-Digital Fast Circuit Switching Network | Datran | 1969 — Datran filed an application with the FCC for a $375 million all-digital circuit switched microwave network, with Datran-furnished local distribution facilities. (Many experts believed that fast circuit switching was superior to packet switching for data communications.) The Datran network was partially deployed beginning in 1971. AT&T opposed Datran before the FCC, by introducing aggressively priced digital transmission services, and by supporting value-added packet carriers. Datran was unable to raise sufficient capital and went bankrupt in 1976, shortly after Telenet launched its public packet network service. The FCC belatedly concluded that AT&T digital services were priced below cost. Datran filed an antitrust suit against AT&T and negotiated a $50 million settlement which approximated Datran's investment-to-date. |
| Domestic Satellite Systems | Satellite Business Systems | 1975 — IBM acquired a controlling interest in the CML (Comsat-MCI-Lockheed) domestic satellite venture, and after FCC approval, created Satellite Business Systems, with Comsat and Aetna participation. In 1980 SBS launched an all-digital satellite system to provide private switched enterprise communication networks for integrated voice, data and image applications. The Ku band satellite system used time division multiple access (TDMA) satellite channels, and demand assignment of satellite capacity, with 5 and 7-meter earth stations, and special facilities to enable customers to manage their networks. SBS successfully deployed many enterprise networks, but the large size and high costs for the earth stations limited the number of companies and branches which could be served. SBS data services attracted a limited customer base and SBS entered the long distance voice market in order to build traffic for the satellites. The voice business never reached breakeven and IBM bought out Comsat and Aetna and sold SBS to MCI in 1985 in exchange for 16 percent of MCI stock. The satellites were subsequently sold and re-purposed, with most transponders leased for a variety of applications. Other domestic satellite systems using very small aperture ground terminals (VSATs) provided data networking services successfully in the U.S. and other countries beginning in 1980's. |
| Packet Network Carriers | Telenet Communications Corp. | 1972 — Bolt Beranek and Newman, the company that built and operated the ARPANET packet switches, formed a separate subsidiary called Telenet Communications Corp. for the purpose of commercializing packet switching technology. Telenet deployed a commercial packet network in 1975 and played a significant role in creating the international X.25 standard for commercial packet networks. Over the next several decades Telenet expanded its network globally and also become a major supplier of turnkey packet networks for industry, US carriers, and international carriers such as British Telecom. Eventually Telenet become the data network division of Sprint Corporation and Sprint International. |
| | Tymshare/Tymnet | Tymshare, founded as a time sharing company in 1966, developed an extensive packet switching type network to connect its end users to its time sharing computers. Tymshare became a leading time-sharing vendor and recognized the opportunity afforded by network services. In 1972, the National Library of Medicine asked Tymshare if NLM could purchase Tymshare network services to enable users to access the Medline database. Tymshare agreed and began selling network services to other companies. The network service was initially provided under the "joint use" provisions of AT&T private line tariffs. After some controversy regarding the regulatory status of the Tymshare network, this network was spun off in 1976 into a wholly owned subsidiary called Tymnet. Tymnet filed an application with the FCC in 1976 to operate as a public communications carrier and approval was granted in December 1976. Tymnet first offered service under tariff in April 1977. Tymnet became one of the leading packet network carriers in the US, and in the world. Tymnet's technology was similar to Telenet's packet switching, but there were important differences as shown in Table 2. Tymshare and Tymnet were acquired by McDonnell Douglas in 1984, and Tymnet was acquired from McDonnell Douglas by British Telecom in 1989. |
| | AT&T Transaction Network Service (TNS) | 1976 — AT&T introduced the Transaction Network Service in several cities. TNS was the first packet type service offered by AT&T. TNS was designed to carry short transactions between point-of-sale terminals and remote host computers. TNS was offered in a few cities with limited success and was terminated shortly thereafter. |
| | AT&T Net 1000 Service | 1982 — AT&T subsidiary American Bell announced the introduction of the Net 1000 service, which consisted of distributed processing centers linked together by the AT&T Long Lines X.25 Basic Packet Switching Service. The Net 1000 service supported a wide range of terminal types, and provided both virtual call service and message transfer service. The service was "programmable" by customers who could store and process their customized software on the Net 1000 computers. The service failed to attract many customers and was terminated in 1984. |
| | Regional Bell Operating Companies (RBOCs) | After divestiture of the Bell Operating Companies from AT&T, the RBOCs deployed packet networks within their franchised local exchange areas. Initially they operated as islands, not interconnected to the major intercity packet networks, and failed to attract significant traffic. By the time the RBOCs had X.25 packet networks widely deployed, the industry moved away from X.25 packet network standards towards an open TCP/IP architecture. Eventually, the RBOCs became leading providers of Internet access services utilizing ADSL technology. |

**Table 1.** *Commercial data network service providers in the 1970's and 1980's.*

| Type of Network | Company | Description |
|---|---|---|
| Specialized Packet Carriers | Xerox XTEN Service | 1978 — Xerox announced a plan to build and operate the XTEN network — a nationwide, satellite-based digital network, with in-city terrestrial microwave and omni-directional digital radio transceivers for network access. Xerox proposed the allocation of a 130 MHz band (10.55-10.68 GHz) and the use of cellular radio techniques for connecting local network nodes to user premises. Data rates provided to users would be multiples of 256 Kbps. The service, to be launched in 1982, would interconnect a company's office automation systems and would provide message and document transfer services, protocol conversion and teleconferencing. In 1979 Xerox acquired WU International, an international record carrier, and placed the XTEN team under the operational control of WUI. In 1981 Xerox terminated the XTEN effort, and sold WUI to MCI [2]. XTEN never got off the ground. |
| | Federal Express ZapMail Document Delivery Service | 1984 — Federal Express (FedEx) was the leader in overnight physical document delivery service in the United States. Concerned that emerging facsimile systems and services would undermine FedEx's document delivery business FedEx designed and deployed its own facsimile service, called ZapMail, based on a dedicated nationwide packet network. (If ZapMail was successful, FedEx intended to deploy a Ku band satellite and tens of thousands of VSATs.) The network utilized high-capacity "non-stop" Tandem computers as packet switches and X.25 packet-oriented "ZapMailer" facsimile systems located on high-volume customer premises and in FedEx offices. FedEx offered customers guaranteed two-hour delivery via ZapMail. FedEx expected customers would pay a premium to have their documents delivered in hours instead of overnight; and by migrating document traffic from trucks and aircraft, FedEx reduced the cost of its transportation network. The ZapMailer did not conform to the "Group 3" specifications for fax transmission over public telephone networks and could not communicate with the growing number of Group 3 fax machines. Businesses were able to buy their own Group 3 fax machines and transmit documents themselves more cost effectively over the phone network. Quality problems with both the ZapMail fax equipment and the packet network, and limited customer interest, led the company to stop taking orders in March 1986. The service was a commercial failure, discontinued in October 1986 with a $320 million write-off. |
| | DHL and NetExpress | In the 1980's, DHL was the leading international overnight document delivery service. Like FedEx, DHL was concerned about growing competition from facsimile systems and services. In 1983 DHL recruited Larry Roberts, Barry Wessler and others from GTE Telenet to build a global packet network for electronic document transmission. DHL formed the NetExpress subsidiary which designed new X.75 packet switching equipment and then operated a global packet network oriented toward facsimile store and forward in the 1990's. NetExpress sold the X.75 facsimile switches to other countries to support the international facsimile network. The network operated successfully for many years but was eventually discontinued. |
| Computer Service Companies | IBM Information Network | In 1974 IBM announced its Systems Network Architecture (SNA), a proprietary packet-like network architecture for IBM computers and terminal systems. Subsequently IBM established the IBM Information Network as an independent business unit to provide both information processing services and SNA network services to IBM customers. IBM also helped thousands of companies deploy private SNA networks. Other computer manufacturers offered their own proprietary network architectures, such as Digital Equipment Corporation's DECNET. |
| | GE Information Services Company | GE Information Services Company (GEISCO) began providing time sharing services in the mid 1960's and grew to become an industry leader operating multiple data centers in the US, Europe and Asia. GEISCO developed and operated an extensive proprietary network to enable customers to access the GE data centers. But GEISCO was reluctant to offer any regulated services, and to make its network available to competitors, so it did not initially offer public network services. Eventually GEISCO did offer network services but was late to the market. |
| | CompuServe | Founded as a provider of time sharing services in 1969, the company developed a packet switching network based on DEC PDP 11 minicomputers and in 1982 formed CompuServe Network Services as a separate subsidiary. In the 1980's CompuServe added an X.25 interface to its network. CompuServe's business expanded globally and operated successfully for many years. In 1998, WorldCom acquired both CompuServe's network services division and also AOL's network services division and created WorldCom Advanced Networks. WorldCom later acquired UUNet, a leading Internet service provider, and MCI, and renamed itself MCI. In 2006, MCI was acquired by Verizon. |

**Table 1.** *Continued...*

that current carriers would not take over the ARPANET and offer public service, Roberts discussed the issue with Bernie Strassburg, Chief of the Common Carrier Bureau of the FCC. Strassburg advised that the best approach would be to form a new company and apply for an operating license from the FCC.

## TELENET COMMUNICATIONS CORPORATION

While Roberts was exploring options for converting the ARPANET into a commercial public packet communications service, BBN was exploring ways to commercialize the technology. Steve Levy, the Executive VP of BBN, was a proponent of developing new technology under government R&D contracts and then transferring the technology into commercial products and services [5]. Levy considered several alternatives:

- Convert the ARPANET into a public network operated by BBN if suitable approvals could be obtained from the U.S. government.
- Build and operate a new public packet switching network.
- Sell "turnkey" packet switching network systems to corporations, government agencies and telecom administrations (PTTs, telcos, etc.).
- License packet switching technology to other firms.

In early 1972 BBN hired Lee Talbert, who had previously worked as a Special Assistant to the Secretary of Defense, to determine how to commercially exploit packet network technology. Talbert considered the above options and presented a proposal to the BBN Board of Directors to invest $25 million to build and operate a public packet network. At this time BBN's total annual revenues were approximately $13 million, the market potential and regulatory status of packet switching carriers was uncertain, and AT&T's plans to provide packet network services were unclear.[9] The proposal was rejected by the Board. Talbert left BBN shortly thereafter, along with two senior BBN staff (Ralph Alter and Steve Russell), and formed Packet Communications Inc. (PCI), intending to raise venture capital and build and operate a public packet network.[10]

Concerned that PCI would recruit other key staff from BBN and exploit the technology, which BBN had spent tens of man-years developing, Steve Levy sought advice from Bob Kahn and Frank Heart regarding possible actions. Kahn worked at BBN on the basic design of the ARPANET and prepared the proposal to ARPA for the implementation contract.[11] Heart managed the Systems Division of BBN, which developed the IMPs and TIPs and operated the network control center. Heart and Kahn had previously talked with Stu Mathison — then a management consultant at Arthur D Little Inc. — about the commercial viability and the regulatory status of a public packet network. Levy subsequently invited Mathison to prepare a proposal for a market and feasibility study to be done by ADL. Mathison prepared the proposal and included Phil Walker, then a third year law student specializing in communications law, as part of the team to address the regulatory issues.

In October 1972, Sam Labate, President of BBN, wrote to Mathison and Walker proposing that:

- Mathison and Walker join the BBN corporate staff.
- Additional management be assembled.
- A new BBN subsidiary be formed with $250,000 of seed capital furnished by BBN.
- A portion of the ARPANET contract be transferred to the new subsidiary[12].
- A feasibility study be undertaken with assistance by Arthur D. Little, Inc.
- A business plan and investment memorandum be prepared.
- Additional capital and staffing to execute the business plan be obtained [6].

Later that month, the BBN Board adopted a resolution to form a new subsidiary to offer public telecommunications services and/or products with specific orientation to the need for better data communications. The Chairman, Acting President and Chief Financial Officer of the new company would be Steve Levy.[13] BBN offered Stu Mathison and Phil Walker positions as VPs for business planning and legal/regulatory affairs respectively in the new company. Frank Heart, the head of BBN's Systems Division, would be a member on the Board of Directors. Levy had also offered Kahn the position of CTO, but Kahn decided to accept an offer from Roberts to join him at ARPA.

Mathison and Walker[14] joined BBN in Oct 1972, initially as members of the corporate staff, and both joined the new company, Telenet Communications Corporation, when it was incorporated in Dec 1972. The company was located in the BBN building in Cambridge, MA. In early 1973 Telenet hired Richard Hovey and Christopher Newport to join the planning team. Hovey had a background in computer science and would later help define the Telenet Host Interface Specification. Newport was previously the Chief Engineer, Advanced Products Line, at Honeywell Information Systems, responsible for design of the minicomputers (Honeywell 316s and 516s) used in the ARPANET and the special-purpose communication interfaces required by the ARPANET. Newport became Telenet's VP of Engineering. In May 1973 Barry Wessler, who had been the ARPANET Program Manager in the Information Processing Techniques Office (IPTO) at ARPA, joined Telenet after finishing his doctorate.[15]

*[9] Telephone companies in the UK, Canada, France and other countries indicated an interest in providing public packet switching services. Although AT&T was not receptive to Larry Robert's proposal to take over the ARPANET, it was likely that AT&T would eventually offer a public packet network service.*

*[10] In January 1973, PCI filed an application with the FCC to build and operate a public packet network in the US. Although PCI had not yet obtained financing, the company proposed building a 20-city packet network with a capital investment of approximately $30 million. In November 1973, the FCC approved PCI's application. Despite its FCC authorization, PCI was never able to raise sufficient venture capital, possibly in part because of BBN's formation of Telenet, and evolved into a consulting company.*

*[11] Bob Kahn and Vint Cerf would later co-design the TCP/IP protocol which became the basis for the Internet.*

*[12] Transferring a portion of the ARPANET contract to the new subsidiary was not practical and all ARPANET contract work remained at BBN.*

*[13] From the outset, Steve Levy recognized that his primary role was to organize Telenet and assist in the financing of the company. Levy intended to search for a permanent president of Telenet.*

*[14] Walker joined BBN and Telenet on a part-time basis, converting to full-time when he graduated from law school in June 1973.*

*[15] Barry Wessler would later drive Telenet into the private network systems business and lead the company in its international expansion.*

In early 1973, Telenet was actively looking for a permanent president. Larry Roberts was also trying to convert the ARPANET to a more permanent operational status which could serve a wider community. The ARPA mission called for funding research programs but not for operating commercial networks. Roberts was also seeking to finish his term as Director of the IPTO in ARPA. In May 1973, Barry Wessler began discussions with Roberts regarding Telenet's plans to build a new public packet network. In June 1973, BBN announced that Roberts would join Telenet as President and that Telenet would be re-located to Washington, DC.[16] In the summer of 1973, the Telenet team relocated to the DC area, and met periodically with Roberts and Donald E. Ward, a communications attorney in DC.

Roberts joined Telenet officially in September 1973, and in October the company filed a Section 214 application with the FCC to construct and operate a nationwide public packet network.[17]

## REGULATORY ISSUES

The growth of computing and data communications during this period raised several regulatory questions. The Communications Act of 1934 states that the provision of interstate communications services for hire is common carriage and subject to FCC regulation. Did that mean that public packet carriers are subject to regulation, and if so, what rules and regulations should apply?

While new companies were seeking to supply communications services, established communications companies were seeking to offer computer services. Specifically, common carriers such as GTE and Western Union were planning to become "computer utilities" (cloud computing in today's terminology) and to provide combined data processing and communications services in competition with established, unregulated computer service companies. Could these carriers subsidize their unregulated computer services from their regulated communications service offerings? Should they be required to set up separate subsidiaries to provide unregulated computer services?

Further complicating matters, the tariffs of the existing carriers in the 1960's prohibited sharing (or reselling) leased communication lines. Such tariff provisions would prevent companies from leasing lines and providing public packet network services. Should these provisions be revised [7]?

To address these and several other related issues, the FCC initiated its First Computer Inquiry in 1966 to define which computer communication services were to be regulated and which were not.[18] The FCC concluded that operators of public communication networks were subject to regulation and must file applications under Section 214 of the Communications Act for approval to construct their networks, and must file public tariffs containing their rates and regulations.[19]

The FCC also found that AT&T's tariffs, which barred sharing leased lines, were overly restrictive. In mid-1974, AT&T filed tariff revisions permitting value-added carriers, which AT&T called "Composite Data Carriers," to use leased lines and WATS lines "to perform data switching for others."[20]

In the First Computer Inquiry, the FCC also ordered that common carriers such as Western Union and GTE must set up separate subsidiaries for the provision of data processing services.

## TELENET OPERATIONS AND GROWTH

### TELENET BUSINESS PLANS

In its FCC application in 1973, Telenet proposed building a hybrid terrestrial/satellite network, initially with packet switching nodes in 18 cities. Within four years thereafter, Telenet intended to expand the network to 62 cities. The initial nodes would be interconnected via leased 50 Kbps lines and a 1.5 Mbps multi-access "broadcast" satellite channel serving four earth stations managed by one of the domestic satellite operators.

The architecture and service offerings in Telenet's application were modeled after the ARPANET but there were important differences [8]. The network would consist of newly designed data switches for host computer and terminal access. However, unlike the ARPANET, the network switches (called Telenet Interface Processors or TIPs) would be located in Telenet Central Offices (as opposed to customer premises) and multiple customer hosts would be connected to each TIP over leased communication lines. Telenet would define a new Host-to-TIP communications protocol and customers would install a "network control program" (NCP) in their hosts to implement the protocol. Terminals would access the network over local dial-up phones or leased lines.[21]

The network would support terminal-to-host and host-to-host communications, although virtually all customer applications were expected to be terminal-to-host. The host interface protocol and the service offering were based on

*[16] Roberts believed that Telenet should be located in DC in order to separate it from BBN, to facilitate interactions with the FCC, and to better serve the government user community. The DC area was also Robert's home.*

*[17] Telenet took the position that regulation of a public packet network was necessary because (1) that appeared to be required under the Communications Act of 1934; and (2) obtaining FCC authorization would enhance Telenet's credibility with prospective investors and discourage entry into the packet network business by larger corporations reluctant at that time to enter regulated businesses (e.g., GE, IBM, and Xerox). Telenet also believed that tariffs filed with the FCC would give Telenet leverage with large customer organizations when setting prices, as well as offer the ability to modify or increase prices to all customers merely by filing tariff changes.*

*[18] Regulatory and Policy Problems Presented by the Interdependence of Computer and Communications Services and Facilities, First Computer Inquiry, Notice of Inquiry, 7 FCC 2d 11 (1966); Tentative Decision, 28 F.C.C. 2d 291 (1970); Final Decision, 28 FCC 2d 267 (1971). The FCC would subsequently modify its computer-communication regulations in Computer Inquiry II and Computer Inquiry III proceedings.*

*[19] Although the FCC initially determined, in Computer Inquiry I, that packet network carriers were to be regulated, in 1980 in the Computer Inquiry II decision it concluded that only "basic" communications services should be regulated and that "enhanced" communication services need not be regulated. Services involving protocol conversions were deemed enhanced services. Second Computer Inquiry, Final Decision, 77 F.C.C. 2d 384, modified on reconsideration, 84 F.C.C. 2d 50 (1980).*

*[20] Composite Data Carriers were more popularly called Value Added Networks, or VANs.*

*[21] Initially, Telenet offered terminal interfaces only for asynchronous terminals, similar to the ARPANET. Telenet (and Tymnet) later developed bisynchronous interfaces for IBM remote batch terminals, and a synchronous data link control interface for IBM 3270 display terminals.*

virtual circuits (VCs), which were easily understandable to customers since VCs emulated telephone calls (with some terminal handling enhancements). Initially, the *internal* network protocols and routing algorithms were based on packets, like the ARPANET.[22]

In planning the Telenet service the company had to define the pricing of these services. Monetizing the service was a critical break with the ARPANET. Should a user be charged only for a network connection of a certain speed, or for both the connection and usage?

With a virtual call construct at the network level (vs. a host-to-host logical connection), Telenet would be able to charge for usage on a per-call basis. Both switched and permanent VCs could be offered. The caller or called party could be charged, in a fashion similar to telephone calls.

Telenet concluded that it was also necessary to charge for traffic to ensure fairness in pricing and to prevent abuse. (In much of today's Internet, the absence of usage charges fails to discourage spam and heavy usage by peer-to-peer applications and video streaming, but usage charges remain controversial.) By utilizing a virtual call concept, Telenet would be able to charge either the caller or the called party for all the traffic in the call. In the case of users accessing remote time sharing or data base services, the called party (host computer operator) typically paid all network usage charges as a cost of providing the overall time sharing service.

Financing the proposed Telenet network was also a challenge. Although BBN provided the initial financing for organizing and planning the business, it did not have sufficient capital to fund developing and deploying the network.

In April 1974, the FCC approved Telenet's application [9]. Over the next six months, Telenet firmed up additional investors and received a $2 million investment in January 1975.[23] In a subsequent series of private placements, Telenet raised an additional $11 million and in December 1977 went public and raised $12 million more. Telenet's network plans and rate of expansion reflected the investment funds, which were available.

### THE TELENET NETWORK ARCHITECTURE AND DEVELOPMENT STRATEGY

Larry Roberts and Chris Newport began active recruiting in mid-1974, and by year end, Marie and Allen Rousseau were hired as directors of software development and operations, respectively. Perry Gann, John Holmblad, Howard Seid and Marc Seriff were hired as system designers/programmers.

The strategy for designing and developing the Telenet network reflected its small staff. The architecture envisioned Telenet Central Offices or TCOs in major cities with multiple packet switches and special line switching and recovery hardware for access lines to customers. Minor cities would be served by multiplexers referred to as Telenet Access Controllers or TACs for terminal access. The TACs were simple and inexpensive time division multiplexers and were later replaced with more powerful and versatile multi-microprocessor systems of Telenet design.

In terms of hardware, Chris Newport determined that the most cost-effective minicomputers to use for TIPs were Prime minicomputers, which were software compatible with the Honeywell 516 computers used in the ARPANET. Telenet would then be able to use portions of the ARPANET software (developed by BBN but funded by the U.S. government and therefore in the public domain) in its network. (It is of note that the entire RAM memory in the TIPs was 64Kbytes — for all software and buffering. In such an environment, rewriting code to make space for new features was a continual necessity.) Telenet designed and developed new host and terminal interface software, as well as new network management software, and initially used the routing algorithms of the ARPANET.

Roberts, Wessler, Newport and Hovey spent several months designing Telenet's service offering concept, and the corresponding Telenet Host Interface Protocol. As noted, the service offering was based on virtual calls. Marc Seriff designed the Terminal Interface Protocol.

The Telenet Host Interface Protocol was designed to provide error-free transmission, provide for virtual end-to-end connections, and support various pricing structures. IBM had recently introduced the synchronous data link control protocol (SDLC) and Telenet adopted SDLC as the physical layer and the layer two link level protocols. Telenet designed level three of its host interface protocol to set up end-to-end virtual circuits, provide end-to-end flow control mechanisms, and support caller paid and called party paid virtual calls and other features. This became the model for the future CCITT X.25 host interface protocol [10].

Telenet recognized that many customers would not be able or willing to develop the necessary network control program in their host computers to implement the Telenet Host Interface Protocol. Two approaches were used for such customers.

- Telenet contracted with Cambridge Telecommunications, a small company specializing in IBM communications software, to develop software implementing the Telenet Host Interface Protocol which would be installed in the customer's communications front end processor.[24] This software was called the Telenet Modified Emulator Program or TMEP.[25]
- Tymshare offered a network service, discussed in a subsequent section, which employed an asynchronous modem emulation interface to connect host computers to its network. This type of interface does not require any special software in the customer host. The network "looks like" a group of asynchronous terminals. Telenet adopted the Tymshare approach and offered to install TACs at customer premises. The TACs provided up to 96 asynchronous ports for host and terminal access to the Telenet network.

Telenet adopted and augmented the ARPANET Telnet protocol for asynchronous terminals. It supported

[22] *A packet is a self-contained, independent block of data carrying sufficient addressing information to be routed from source to destination without reliance on earlier exchanges between this source and destination computer and the transporting network. In the ARPANET packets were dynamically routed from node to node."*

[23] *In 1974, Joe Gal at Lehman Bros. contacted BBN to assist in the financing. Neill Brownstein of Bessemer Ventures agreed to become the lead investor provided several other investors could be found. In addition to BBN, the other investors were the Palmer Group, Time Ventures (a subsidiary of Time Life Inc.), and Bowne and Co. (a financial publishing company)."*

[24] *In the 1970's, most IBM host computers had communications-oriented front end processors for managing multiple communications lines.*

[25] *Telenet would subsequently acquire Cambridge Telecommunications and this group would later develop standards and software for interfacing IBM terminal equipment, such as the IBM 3270 display terminals, to the Telenet network.*

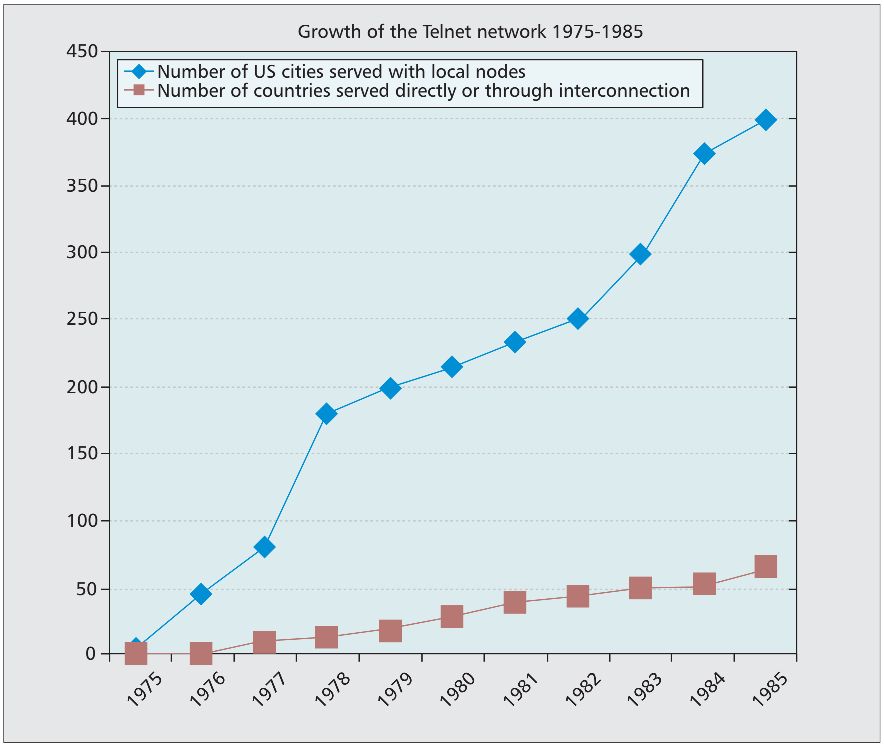


**Figure 1.** *Growth of the Telenet Network 1975–1985.*

different terminal types, translating differences into a canonical form, as was done with the ARPANET Telnet protocol. Telenet's terminal protocol was the basis for the CCITT's X.3, X.28 and X.29 terminal interface standards [11].

In early 1975, Telenet was actively setting up Telenet Central Offices (TCOs) in seven cities, installing computer equipment, testing circuits and trying to get the whole network and network management system working together. By the summer of 1975, Telenet was beta testing its service with its first third-party customer — Scientific Time Sharing — in Bethesda, MD [12].

## THE FIRST PUBLIC PACKET NETWORK TARIFF

As an authorized common carrier, Telenet was required to file a tariff with the FCC describing its service offering and the terms and charges for the service. Telenet filed the world's first tariff for packet network services on August 15, 1975, and it became effective the next day officially launching the service.

In developing the service and pricing, a wide range of pricing approaches were considered. Under one pricing model usage charges would be based on the amount of information transmitted (number of packets), and the sender would pay for all packets that he sent. The alternative pricing concept was the "telephone pricing model" where either the caller or the called party pays for the entire call and all usage charges, irrespective of the amount of traffic transmitted in each direction.

The telephone pricing model prevailed and virtually all commercial packet networks followed this model with the deployment of X.25 networks in the 1980's and until the migration of public packet networks from X.25 to TCP/IP in the 1990's.

Telenet traffic charges were $0.60 per kilopacket, independent of distance. There was also a time-based charge of $0.90–2.40 per hour for terminals dialing into the local Telenet node. Dedicated leased access ports were priced at $75–150/month for 50–1200 bps, and $200/month for 2.4–56 kb/s. Access lines, leased from AT&T, were provided at AT&T rates. Telenet customers paid, on the average, less than $5/hr for terminal access to hosts. In comparison, long distance phone calls at the time were approximately $25/hr.[26]

## NETWORK GROWTH

Telenet's network grew rapidly over the next several years, as shown in Fig. 1. From the initial seven cities in Aug 1975, the network grew to 16 cities by yearend 1975, 47 cities by yearend 1976, and 81 cities by yearend-1977 [13].

## THE TELENET MULTI-MICROPROCESSOR PACKET SWITCHES

In 1976, Telenet began the design of a new line of "third generation" packet switching equipment under the leadership of Chris Newport, VP of Engineering, and Holger Opderbeck, Director of Software Development. The new systems, called Telenet Processors (TPs), were phased into the public network over several years, and were incorporated in packet networks furnished to PTTs and other large organizations. The first TPs were installed in Telenet's public network in August 1977.

Chris Newport worked with Pradeep Kaul of Digital Communications Corp. (now Hughes Network Systems) to design the TP hardware platform and they jointly obtained a patent on its multi-microprocessor technology [14]. Initially, DCC started manufacturing the TPs, but after five years, Telenet also started manufacturing the equipment.

The TPs were designed to provide a wide range of line configurations and traffic handling capacity, high processing power, large memory capacity, high reliability and low cost for that period of time. These goals were achieved through a multi-microprocessor architecture where each line card had its own microprocessor and memory, as

[26] *To put Telenet's usage charges into perspective, today's average household sends and receives over the Internet approximately ten gigabytes per month at a cost of $40-60 per month. At Telenet's usage charge of $0.60 per kilopacket (ignoring inflation since 1975), each household today would have to pay approximately $50,000 per month (assuming each packet contains the maximum 128 bytes) to send ten gigabytes. Obviously today's networks reflect an enormous reduction in the cost of transmission and processing over the past 35 years.*

[27] *Initially, each line card could handle 4 or 8 lines using asynchronous, bisynchronous, SDLC and X.25 protocols. TPs could be configured with up to 60 line cards of any type, installed in any order. Multiple line cards could be backed up with a single spare line card of the same type. TP memory capacity was initially two 256KB common memory modules, 64KB on each CPU card and 16KB on each line card. The CPU and line cards each had its own microprocessor.*

| | Telenet | Tymnet |
|---|---|---|
| Packet size | Variable length up to 128 bytes of user data | Variable length up to 66 bytes of user data; Tymnet II introduced 1000 byte packets |
| Packet composition | Single user's data per packet | Multiple users' data per packet |
| Routing | Hybrid centralized and local routing | Centralized routing management via supervisory computer |
| Service offering | Virtual circuit | Virtual circuit |
| Date of initial operation | August 1975 | 1971 (internal Tymshare use only) |
| Date of initial service to third parties | September 1975 (Scientific Time Sharing) | 1972 (National Library of Medicine) |
| Date of initial common carrier service offering | August 1975 | April 1977 |
| Terminal support | Asynchronous initially; later added IBM 3270, IBM 2780 | Asynchronous initially; later added IBM 3270, IBM 2780, Burroughs Polled Terminals |
| Host interface options | • Telenet Host Interface Protocol or TMEP (proprietary) initially;<br>• Asynchronous modem emulation;<br>• X.25 (1976) | • Asynchronous modem emulation initially;<br>• Tymnet Synchronous Host Protocol (proprietary);<br>• X.25 |
| Enhanced network features | Virtual private networks | Virtual private networks |
| | Turnkey private networks | Turnkey private networks |
| | Email (Telemail) | Email (OnTyme) |

**Table 2.** *Comparison of Telenet and Tymnet technology.*

well as access to common main memory via dual bus architecture. Dual main memory banks, arbitrators, buses and central processing units were used to ensure that a subsystem failure would not cause the TP to fail.[27]

All TP software, including system software, was designed and built by Holger Opderbeck's development group [15].

In moving from the TIPs to TPs, the architectural change from the ARPANET became more pronounced in that now even internal trunk routing was done over X.25-like virtual circuits instead of simple packet transfers. Routing was globally static and locally dynamic. Routing tables associating X.25 addresses with a TP's trunk and host lines were created in the NCC and downloaded with overnight software and table updates. The TPs used these tables in conjunction with current queue lengths to select the next hop for a virtual circuit setup.

In the late 1970's and early 1980's, under the leadership of Roy Rosner, Senior VP of Product Operations, the TPs were deployed throughout the public network, replacing the Prime minicomputers and TDM equipment. The new equipment and software also became the foundation for Telenet's turnkey systems business. Telenet and Northern Telecom would soon become the leading providers of packet network systems in the 1980's.

## TYMSHARE AND TYMNET

While Telenet was seeking and obtaining FCC approval to furnish a public packet network service, raising venture capital, and building its network, Tymshare, a time sharing service company, began to sell "excess capacity" on its private data communications network to data base firms offering services which did not compete with Tymshare's time sharing business. (However, this position broke down and Tymshare eventually did market network service to its time sharing competitors.)

The National Library of Medicine's Medline data base service was Tymshare's first network customer and Tymshare argued that it was providing such services under the "joint use" provisions of AT&T's tariffs. Despite the fact that Tymshare was providing a network service very similar to Telenet's, and the FCC found that Telenet's service was a regulated common carrier service, Tymshare continued to provide network service on an unregulated basis for several years.

In 1975, Telenet filed a complaint with the FCC and in 1976 the FCC ordered Tymshare to file a Section 214 application [16]. Tymshare then set up its network services division as a separate, wholly owned subsidiary called Tymnet, and Tymnet filed an application with the FCC which was approved in 1976.

Like Telenet, Tymnet also migrated from using conventional minicomputers (Varian and Interdata) as network processors, to Tymnet-designed systems called Tymnet Engines. The Tymnet Engines and their operating system software, called "Internally Switched Interface System" (ISIS), were the foundation for the Tymnet II network [17].

A detailed description of the Tymnet network and history can be found in the references [18]. A brief comparison of Telenet and Tymnet is shown in Table 2.

Telenet and Tymnet would subsequently grow very rapidly, in parallel, sometimes even serving the same customers. Both companies benefited from this competition. If either company failed or provided poor service, the other company was available as "back-up."

In hindsight, a major strategic failure of both companies was their unwillingness to fully interconnect with one another, and with smaller domestic public packet networks, and to create a fully interconnected public data network whereby any terminal or computer could obtain economic access to any other computer on the interconnected networks. But even if the X.25 networks were fully interconnected, it would have been by means of virtual circuit interconnection. With the advent of the TCP/IP based Internet, it is unclear if this virtual circuit strategy would have had much long term success.[28]

In 1984 Tymshare and Tymnet were acquired by McDonnell Douglas. In 1989 the Tymnet Networks Division of McDonnell Douglas was acquired by British Telecom for $355 million. Tymnet's annual revenues were estimated at the time to be $250 million [19]. In 1993 BT and MCI negotiated an arrangement where MCI took ownership of the U.S.-based portions of Tymnet and they would share in a 50/50 international joint venture called "Concert." At that time, Tymnet had approximately 5,000 nodes in 30 countries. A variety of protocols were handled over a single packet-switching-network, and Tymnet's most-used protocols were X.25, asynchronous, and SNA/SDLC. In 1997, BT was in talks to acquire MCI, but the talks failed. MCI was acquired by WorldCom in 1998 and the Concert joint venture was gradually dismantled. MCI WorldCom gradually phased out the domestic Tymnet in favor of an IP-based network in the early 2000's. The international portion of Tymnet, under BT, was shut down in the early 2000's for similar reasons.

MCI was well positioned to provide TCP/IP services. The company was involved in NSFNET, the TCP/IP-based research and education successor to the ARPANET, and WorldCom had acquired UUNet in 1996, one of the leading TCP/IP service providers. MCI WorldCom was acquired by Verizon in 2005.

## THE PUBLIC NETWORK CUSTOMERS

### COMPUTER AND DATABASE SERVICE PROVIDERS

During the first six months of Telenet's operation, 33 customer host computers were connected to the Telenet network. Most customers were computer service companies and companies providing business users access to data base services [20]. Each computer service had a unique interactive, text-based command/response interface. A unified user interface with graphics would not emerge until the World Wide Web was developed in the 1990's. By the mid 1980's several hundred customers and host computers were using the Telenet network, including many corporations using the network for internal applications, as well as government agencies and educational institutions.[29] Similarly, Tymnet was serving several hundred customers and host computers by the mid-1980's.

### FEDERAL AGENCIES

Telenet and Tymnet also sought to enlist government agencies as customers. Telenet's headquarters location in DC increased its focus on government customers.

In the early 1970's, many federal agencies wished to build and operate a single shared packet network, called FedNet, to replace the multiplicity of private networks operated by each federal agency and to eliminate the need for duplicate data bases. The U.S. Department of Agriculture (USDA), with offices in every county of the U.S., was to be the lead agency for FedNet. Telenet lobbied against FedNet, on the theory that the government should not enter into businesses which could be better handled by private enterprise. While the FedNet issue was pending, Vice President Gerald Ford was invited to speak at the National Computer Conference in Chicago, and he took this opportunity to question the wisdom of creating a "big brother state" run by computers all linked together. VP Ford's comments turned the tide against FedNet, and the proposal for a single government computer network was dropped.

In 1979 USDA issued an RFP for public packet network services and awarded Telenet the largest packet network contract to date — $250 million over eight years — to provide data communication services to USDA's six data centers and more than 10,000 terminals throughout the U.S.[30]

Over time, many other federal civilian agencies would become customers of Telenet, Tymnet and other packet carriers.

[28] *The TCP/IP protocol became the dominant protocol due to many factors beyond just an open architecture and philosophy. It was adopted by the U.S. Dept. of Defense as one of the acceptable DOD standards, but since there was no other protocol that had the same properties/capabilities, it became widely used in DOD. ARPA also paid to have TCP/IP incorporated in UNIX and other systems, and the TCP/IP software stack became free to user organizations. Also, X.25 suffered from a much smaller number of allowable flows per host ($2^{12}$ vs. $2^{48}$) which would today be a serious problem for servers and network gateways. X.25 was also burdened by the extra complexity of retransmission at each network node rather than end-to-end retransmission. Internode retransmission became unnecessary with low-error-rate fiber transmission trunks. As the millennium passed the X.25 networks declined in importance and the "open" TCP/IP networks prevailed."*

[29] *One notable Telenet customer in the early 1980's was "The Source." The founder and president of The Source, Bill von Meister, negotiated an arrangement with Larry Roberts whereby The Source could utilize Telenet network at night, when there was no business traffic, for only $0.50 per hour (vs. approximately $5 per hour during the day). The Source was then able to offer an attractively priced information service for consumers with PCs at home. Bill von Meister went on to found Control Video (which evolved into America Online). AOL's consumer service was based on the same very low off-peak network pricing. Eventually, this network pricing allowed AOL to offer unlimited service for a nominal flat monthly price. AOL grew into one of the largest consumer-oriented online services and one of Telenet's largest customers. Marc Seriff — a member of the original Telenet design team, and principal architect of the Telenet interactive terminal interface (1974) and Telenet's Telemail email service (1979) — later became the primary architect of the AOL service infrastructure.*

[30] *The USDA contract award to Telenet occurred after Telenet went public and after the announcement that Telenet was to acquired by General Telephone and Electronics. Without the backing of GTE, it is unlikely that USDA would have awarded Telenet such a large contract.*

## PACKET SWITCHING IN OTHER COUNTRIES

While Telenet and Tymnet were expanding their packet network services in the U.S., PTTs and carriers in other countries were simultaneously announcing plans to offer similar packet network services based upon extensions of the ARPANET technology and similar research networks in the UK, France, and elsewhere [21]. For example, in 1973 the French PTT announced plans to build the Transpac network, and in 1974 Bell Canada's Computer Communications Group (CCG) announced plans to introduce Datapac.[31]

### PACKET NETWORK STANDARDS

While Telenet and Tymnet developed and deployed their networks before any standards existed for public packet networks, the carriers in Canada, France, the UK and Japan all wanted to deploy public packet networks but preferred to wait until international network interface standards for packet networks were established. This placed great urgency on developing these standards. Such standards would:

- Provide a single, global standard host interface protocol for computer manufacturers to implement which would work in all countries.
- Ensure that all national packet networks could be interconnected and provide a common, unified international service.
- Provide users worldwide with common interfaces and services.
- Legitimize public packet networks service among manufacturers and users.

As described in the previous article in this series by Tony Rybczynski, the standardization effort was led by Bell/CCG in Canada, the French PTT, the British Post Office, Nippon Telephone and Telegraph, and Telenet and resulted in the rapid adoption in 1976 of the CCITT X.25 host interface standard, the interactive terminal interface standards (X.3, X.28, and X.29), and the X.75 network interconnection standard [22].

In 1976 Telenet became the first carrier to implement and offer the X.25 host interface protocol. X.25 was very similar to Telenet's Host Interface Protocol.

Following upon the adoption of CCITT packet network standards, public packet networks based on X.25 were built in:

- Canada — Datapac — operational in 1977.
- France — Transpac — operational in 1978.
- Japan — NTT's packet net — operational in 1979.
- The UK — International Packet Switching Service (IPSS) and the British Packet Switching Service (PSS) — operational in 1980.

To promote the adoption of X.25, Telenet launched the *X.25 Documentation and Certification Service* in 1976 under the leadership of Peggy Karp. Computer manufacturers could get technical assistance and have their products tested and certified by Telenet prior to connection to the Telenet network. Computer manufacturers and software suppliers began to provide X.25 support in the late 1970's. Among the first X.25-certified software products were those for IBM 360/370 mainframe systems, Burroughs 6700/7700 mainframe systems, DEC PDP-11 minicomputers, Prime Computer minicomputers, Univac 1100 series systems, Data General minicomputers and Tandem Non-Stop computers. X.25 support by computer manufacturers and others accelerated after adoption of the 1980 version of X.25, which enhanced the 1976 version. By the end 0f 1984, Telenet had certified X.25 interfaces for more than 200 computer systems.

### TURNKEY PACKET SYSTEMS

By 1978 Telenet had developed a new line of packet switching systems, as described earlier, called Telenet Processors (TPs). The TP product line software conformed to the international X.25 standards. PTTs around the world were keenly interested in deploying public packet networks, and a demand for X.25-compliant packet network systems emerged. Except for Northern Telecom, no major telecom or computer equipment manufacturer had yet developed a line of X.25-compliant network computers.

Early on, BBN and Telenet had considered selling packet network systems, but did not believe there was a sufficient market among corporations for such systems. Also, furnishing private packet networks would compete with Telenet's public network in the U.S. By 1978 the Telenet public network had demonstrated the viability of public packet networks, and large corporations — particularly banks, financial institutions and aerospace companies — expressed interest in acquiring private packet networks to consolidate their disparate private line teleprocessing networks.[32] PTTs were also potential customers for packet network systems.

Telenet decided to enter the packet network systems business and its first major system sale was in 1980 — for an international packet gateway system in London for the British Post Office (the UK PTT).

Early adoption of CCITT X.25 standards and the success of Telenet's public network enabled Telenet to compete with much larger telecom and computer equipment manufacturers. Over the next several years, Telenet would furnish packet network systems to carriers in Mexico, Chile, Venezuela, Norway, Turkey, Australia, the Philippines, Hawaii and other countries.

Large corporations and government agencies also became major customers. Hughes Aircraft was Telenet's first corporate packet network system customer, followed by Citicorp, Manufacturers Hanover, Bankers Trust, the Union Bank of Switzerland, Dun and Bradstreet, the Federal Reserve Bank of Chicago, GM, NASA, the U.S. Secret Service and others. Many turnkey packet networks were global in scope. Some were hybrid satellite/packet networks, such as K-Mart's, which linked 2,000 K-Mart stores across the U.S. to headquarters via Very Small Aperture Satellite Terminals (VSATs) and packet switching equipment at each store.[33]

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[31] *Packet networks in the early to mid-1970's included the Experimental Packet Switching Service (EPSS) built by the British Post Office (UK PTT, now British Telecom) which became operational in 1976; the Cigale network built by a French government agency; the RCP network built by the French PTT (now France Telecom) as a testbed; the CTNE network built by the Spanish PTT (now Telefónica); JIPNET, a research network in Japan; the European Information Network, built jointly by the UK, Switzerland, France and Italy; Euronet, a network planned by the European Economic Community; Transpac, the public packet network built by the French PTT; and the Canadian Datapac network built by the Bell Canada Computer Communication Group (CCG) and the Trans-Canada Telephone System.*

[32] *IBM attempted to address the need for private multi-computer networks with its Systems Network Architecture; however, SNA was mainly for linking IBM computers and terminal systems together and did not really address the need to link the computers of different manufacturers. A comprehensive set of articles describing the SNA architecture and its evolution are contained in the IBM Systems Journal vol. 15, no. 1, 1976 and in vol. 22, no. 4, 1983.*

## INTERNATIONAL PACKET NETWORK SERVICES

With operational packet networks in the U.S. and several foreign countries, Telenet sought to interconnect with the foreign networks. Interconnection between Telenet in the U.S. and Datapac in Canada was straightforward. Traditionally, U.S. and Canadian carriers interconnected directly. Telenet and Bell Canada had worked closely together in obtaining CCITT approval of the X.25 standard and each company implemented X.25 in 1976 and 1977, respectively. Telenet and Datapac were interconnected in 1979 [23]. In 1977, Telenet furnished a turnkey packet network to Teleinformatica de Mexico S.A. (TIMSA), an entrepreneurial start-up company in Mexico, interconnected the TIMSA network to the Telenet network and inaugurated packet network service between the U.S. and Mexico.

Interconnection between the U.S. and *overseas* carriers, however, was fraught with politics and obstacles. Traditionally, international "record" (i.e., message/data) communications was handled through "international record carriers" (IRCs) which operated as gateways between domestic U.S. record carriers and overseas foreign carriers. The FCC-authorized IRCs were Western Union International (WUI), ITT WorldCom, RCA Globcom, TRT Communications and French Telegraph Cable Communications (FTCC).

Since the IRCs would add cost and transmission delays, Telenet sought to bypass them and interconnect directly with overseas national packet networks.[34]

Through Larry Roberts' personal contacts in the UK, Telenet successfully sold a turnkey packet system to the British Post Office (BPO) for installation in London as a gateway node. The BPO also provided a "letter of intent" to interconnect. In early 1976, Telenet filed an IRC application with the FCC referencing the BPO letter of intent.

The IRCs lobbied heavily with the BPO and the FCC, and convinced the BPO that Telenet intended to provide international packet service at very low prices which would undermine the lucrative international telex business.

While opposing Telenet's proposal to provide international packet network service, the IRCs filed applications of their own to provide such services.

In January 1977, Telenet prevailed and received the first new international license issued by the FCC since that agency was formed in 1934.[35] But the FCC authorized the IRCs, as well as Telenet, to provide international packet network service. By this time, the IRCs convinced the BPO to disavow its letter of intent with Telenet, since the IRCs were now offering international packet service. Telenet was forced to interconnect with the IRC gateways (Telenet even furnished some of the gateway equipment to the IRCs).

In time, however, Telenet convinced the BPO to interconnect directly, and gained FCC approval to become an operational IRC with direct links to the UK. Most other PTTs would still not interconnect with Telenet directly — only through the established IRCs.[36] Gradually, Telenet was able to gain additional direct interconnect agreements, particularly after Telenet began selling turnkey packet switching systems to PTTs several years later.[37]

In the 1980's and 1990's, as competition among carriers increased in the U.S., and the FCC deregulated "enhanced services,"[38] other countries followed by pri-

[33] *VSATs are still widely used for dispersed data networks. Companies such as Equatorial Communications, the first VSAT operator in 1979, and Hughes Network Systems, played leading roles in developing this technology. As an interesting sidebar, Paul Baran, who first proposed the use of packet switching to build survivable networks while working at RAND in the 1960's, also developed and patented the concept of using spread spectrum transmission to receive signals on a satellite earth station smaller than would otherwise be possible, thus making VSATs practical. J. Alper et al, "The History of VSATs," in The Book on VSATs, Gilat Communications Ltd, 1991, pp 21-32.*

[34] *Telenet initially refused to interconnect with the IRCs and pursued direct interconnection with PTTs — that is, to become an IRC itself. In the long run, this approach would provide better service to customers and be more profitable to Telenet. In contrast, Tymnet decided to "accommodate" the IRCs and to provide international service cooperatively with the IRCs. Tymnet agreed to furnish the IRCs with packet switching gateways and to connect these gateways to the domestic Tymnet network. The IRC gateways would then be interconnected to the foreign packet networks.*

*Initially, few of the PTTs had operational packet networks and Tymnet was already operating overseas nodes to provide access to the Tymshare data processing services. In addition, the overseas nodes were being used to provide pure international data communication services. As the PTT's began to realize that Tymnet was providing third party communications services for hire using PTT leased lines, the PTTs pressed Tymnet to terminate such services. Instead, Tymnet proposed that the PTTs purchase the Tymnet packet switches and use them to furnish packet network gateway services to the U.S. Several PTTs acquired Tymnet packet switches in this way.*

[35] *63 FCC2d 402 (1977). The IRCs appealed this Order to the U.S. Court of Appeals, Second Circuit, which ruled that the FCC must impose a deadline on Telenet to obtain an interconnection agreement with the BPO. 595 F.2d 897 (1979). The FCC revised its Order accordingly, and Telenet was unable to meet this deadline, so the FCC authorization expired. Telenet later needed to re-file for FCC authority once it had obtained its agreement with the BPO.*

[36] *The IRCs claimed that there would be dozens of domestic packet networks and the PTTs would not want to interconnect with all of them. It would be simpler to interconnect only with a few gateway IRCs.*

[37] *The commercial "terms of interconnection" for X.25 carriers were based on "virtual calls" and followed the pattern for international telephone and telex interconnection, since most X.25 networks were operated by PTTs as national networks. The carrier collecting the revenue for a virtual call would pay a "settlement rate" to the other carrier. Some virtual calls were "caller-paid." Most virtual calls were "called-party-paid" or reverse charged in telephony parlance (e.g., from a user terminal to a host computer). The settlement rate was specified in USD/kilopacket and varied by country. Significantly, competing domestic X.25 operators generally did not interconnect with one another.*

*When commercial TCP/IP networks evolved in the 1980's and 1990's, the commercial terms of interconnection were quite different. With many local Internet service providers, and a few backbone network providers, many of the local operators would "peer" with one another. That is, they would interconnect and exchange traffic without any settlement charges. When a small, local ISP connected to one of the large TCP/IP backbone carriers, such as Sprint or MCI in the US, the smaller carrier would pay a "transit charge," for traffic transiting the backbone. Significantly, all public TCP/IP operators were directly or indirectly interconnected.*

[38] *In its Computer Inquiry II decision in 1980, the FCC ruled that "basic" communication services were subject to regulation, but "enhanced" services involving protocol conversion were not subject to regulation. Second Computer Inquiry, Final Decision, 77 FCC 2d 384 (1980).*

vatizing their PTTs and permitting competing carriers. As this occurred, Telenet and Tymnet had the opportunity to expand globally by operating packet networks in other countries. Telenet determined that the facilities-based carriers in other countries would have greater resources and capabilities to operate extensive packet networks throughout their countries, and Telenet continued its strategy of furnishing turnkey packet networks to PTTs and other foreign carriers, and then interconnecting directly with these carriers. In some countries Telenet installed and operated its own nodes in major cities.[39] Although Tymnet interconnected with the IRC gateways, it also continued building a global packet network which competed with the IRCs and foreign carriers.

## GTE ACQUIRES TELENET AND SPRINT

From the outset, Larry Roberts' strategy for Telenet was to grow as fast as possible and to capture market share before other larger organizations began providing competitive services. Larry directed the company to expand the network throughout the U.S. as quickly as possible. The strategy involved aggressive pricing, rapid expansion of the network and service into new cities, and gradual price increases as the network expanded and its value increased. From 1975 to 1980 Telenet revenues doubled each year. However, rapid growth came at the expense of profitability and a continuing need for increasing amounts of capital.

Telenet also needed credibility in order to capture multi-million dollar network service and systems contracts with large customers, such as government agencies, major corporations and PTTs. So Telenet initiated conversations in 1977 with potential "strategic partners" — such as ITT, TRW, Xerox, Aetna and others — which could furnish both capital and credibility to Telenet. However with AT&T's announced Advanced Communications Service (ACS) pending (discussed below), Telenet looked like a very risky investment.

Dave Horton, VP of the Computer Communications Group at Bell Canada, who had led the effort to create the international CCITT X.25 standard, left Bell Canada in 1977 to become the Computer and Communications Development Director at the Hawaiian Telephone Company (HawTel), a wholly owned subsidiary of GTE. Shortly after arriving at HawTel, Horton began discussions with Telenet to install a packet switch in Hawaii, interconnect with the Telenet network in the Continental U.S., and possibly establish the HawTel system as Telenet's gateway to the Pacific region. By the summer of 1977 the contractual arrangements with Telenet had been worked out and in August 1977 HawTel and Telenet filed a joint application with the FCC to extend Telenet network service to Hawaii.

In July 1977 Horton wrote a memo to his boss, Bernie Hill, at GTE which was titled "GTE Telenet."[40] He recommended that "serious consideration be given to purchase by GTE of a controlling interest in Telenet."

Over the next year and half, while GTE deliberated internally, Telenet went public and raised $12 million. But Telenet still believed that it required the support of a major strategic partner to enhance its credibility in the marketplace. By the end of 1978 GTE had concluded that it wished to acquire Telenet[41] and the parties negotiated the terms of the acquisition during the Christmas holiday in 1978, with a purchase price of $59 million.

It would require another six months to convince the FCC and the Antitrust Division of the Justice Department that the acquisition would increase competition by strengthening Telenet in the upcoming struggle with AT&T, IBM and other major corporations. The FCC and Justice were concerned that GTE would cooperate with AT&T, as it did in telephony, rather than compete.[42]

Tymnet opposed the acquisition and argued that GTE would abuse its monopoly position in its franchised local telephone company markets to favor Telenet in the provision of facilities, in sales and marketing, and in sharing information about customers and future plans. Telenet had made similar arguments against AT&T's provision of ACS on an integrated basis.

In other situations involving the provision of new, competitive telecom services by a strongly established carrier, the FCC imposed the "maximum separation" principle which required separate subsidiaries for the competitive services. For example, the FCC required carriers providing data processing services, and domestic satellite services, to do so through separate subsidiaries.

Telenet itself favored the separate subsidiary approach. First, Telenet believed that AT&T's ACS should be offered through a separate subsidiary, and second, Telenet believed that its integration with GTE would not provide much direct benefit and might actually be harmful. GTE might impose its traditional telephone company practices on Telenet, stifling its entrepreneurial and dynamic culture.

GTE's Chairman, Ted Brophy, in testimony to the Justice Department and the FCC, said that Telenet would have its own marketing force and would compete aggressively both inside and outside of Bell territory. The FCC accepted Brophy's commitment and approved the acquisition, subject to the conditions that Telenet should operate as a separate subsidiary of GTE, that only Telenet could market its services, that no other part of GTE could partic-

*[39] Telenet's largest owned network abroad was in Russia, where the company formed Sprint Russia in 1990 as a 50/50 joint venture with Central Telegraph, the data network operator under the then-Soviet (later Russian) Ministry of Communications. The JV built and operated an X.25 packet network spanning some 80 cities across Russia, and offered a range of services including e-mail, point-of-sale networking and later voice and VSAT services. It was renamed Global One Russia when Sprint formed Global One with France Telecom and Deutsche Telekom in 1996, and the Global One partners bought out Central Telegraph's share in 1999. Then in 2000, Global One became a wholly-owned part of France Telecom, and the former Sprint Russia now constitutes France Telecom's Russian network.*

*[40] Two years later Telenet would, in fact, be acquired by GTE and be renamed GTE Telenet.*

*[41] GTE prepared an "aggressive business plan" for Telenet which projected profitability in 1980 and revenues of $200 million in 1982. GTE Telenet revenues did actually approach $200 million in 1982, but due to higher than anticipated costs full-year profitability was not achieved until 1984.*

*[42] The FCC's experience with GTE's previously announced domestic satellite venture provided a reason to be skeptical of GTE willingness to compete aggressively with AT&T. In 1975 GTE was licensed by the FCC to operate an independent domestic satellite system with Hughes Aircraft, a pioneer in satellite communications. Shortly after the FCC approved the GTE-Hughes system, GTE announced a change in plans, abandoned its own satellite entry, and entered a joint ownership program with AT&T's Comstar satellite system.*

ipate in any other packet network service (such as ACS), and that Telenet had to obtain any services, facilities or equipment from GTE on an arm's length basis available to non-affiliated parties.[43]

J. David Hann became President of Telenet in 1980 and was given the mission of making the company profitable within five years. He achieved this goal in 1984.[44]

Shortly after acquiring Telenet, GTE explored ways to enter the long distance transmission and voice communications business. GTE considered acquiring Sprint or Western Union, as well as deploying a satellite or fiber network based nationwide voice network. During this period, Larry Roberts led a GTE team which concluded that a nationwide fiber optic network would provide the lowest cost and highest capacity solution for long haul voice/data transmission. In 1983, GTE acquired Sprint, then operating a nationwide microwave network to provide long distance services. In 1985 GTE searched for a partner to help fund construction of a national fiber network. Sprint and United Telecom subsequently merged their long distance operations to form U.S. Sprint. In this arrangement, United Telecom contributed U.S. Telecom, a long distance network; ISACOMM, another previously acquired carrier that had been formed to provide telecommunications services to large businesses; and Uninet, an X.25 network. GTE contributed Sprint and Telenet. As United had a business focus and Sprint had a residential focus the pieces nicely dovetailed. U.S. Sprint then invested three years in building America's first nationwide fiber network [24]. In 1989, United acquired a controlling interest in the joint venture and, in 1991, completed the acquisition of U. S. Sprint, while simultaneously renaming itself Sprint Corporation.

The international portion of Telenet, together with Sprint's international voice business, was combined to form Sprint International in 1990. Sprint International also was responsible for Telenet's turnkey systems business.[45] Paolo Guidi was appointed President of Sprint International. Sprint International would be merged into a joint venture with France Telecom and Deutsche Telekom called Global One in 1996 which was taken over by France Telecom in 2000.

The domestic part of Telenet became Sprint's SprintNet X.25 service. As of 1995, Sprint's domestic X.25 network handled more than 100 million data calls per month.

Sprint (and Sprint International) also launched a frame relay service in 1991 and a TCP/IP service in 1992. Frame relay (FR) provided a high-speed, permanent virtual circuit service by statistically multiplexing variable length "frames" through multiple switches without error detection/correction. With the widespread availability of low error rate fiber optic transmission facilities, error control within the network was unnecessary and was left to the end point hosts. The key individuals involved in developing the FR service were Ben Lisowski, Vini Handler and Alan Taffel, all Telenet alumni [25]. FR transport services were widely used by corporations to replace private lines for LAN-WAN inter-networking and for SNA wide area networking and grew into a multi-billion dollar business in the 1990's.[46]

Sprint positioned Frame Relay in the market as an alternative to private line networks for enterprises, a segment which, at the time, was dominated almost entirely by AT&T. And, while this was not widely known at the time 1990 — the year that saw the arrival of Frame Relay — also saw the arrival of the Web and the beginning of the Internet's transformation from research tool to ubiquitous household and corporate appliance.

Bob Collet, another Telenet alumnus, led Sprint's effort to launch a TCP/IP service, initially aimed at government agency customers. It is significant to note that the fragmented nature of the competing X.25 networks was in contrast to the open, fully interconnected network philosophy of the TCP/IP network service providers. By the late 1990's, Sprint was one of the "Tier One" backbone Internet providers. Internet service providers (ISPs) were all interconnected, either via peering or transiting through a backbone network, so that any user could access any host site (website in today's terminology). Although initially there were thousands of ISPs, any user could still access any host.

However, a great virtue, connectivity and universal access to web pages, can also become a great vice, a means of unauthorized access to corporate and government data. For this reason, corporate and government customers initially demurred from putting their internal data on the Internet, and remained on Frame Relay networks, until MPLS-based IP services were able to provide virtual circuit-style privacy on IP networks. Sprint (and other carriers) offered both a Public Internet Service for ISPs and a Private Internet Service for corporate customers. The selling point of the Private Service is that it guarantees no connectivity outside the small group of corporate customers.

In the early 2000's Sprint phased out the X.25 service, although certain foreign and enterprise X.25 networks continue to function to this day.

## THE COMPETITIVE STRUGGLE: AT&T AND THE BELL OPERATING COMPANIES

In the 1975–1980 timeframe, Telenet and Tymnet demonstrated strong market demand for public packet network services by expanding throughout the U.S. and nearly doubling their network revenues each year. Major computer and communication firms saw a potential opportunity and undertook to develop nationwide packet networks (or other types of public data networks) offering broad capabilities. These were among the world's largest and most technologically sophisticated organizations and included AT&T, IBM, ITT, Western Union, Xerox, RCA and GE. Billions of dollars were spent in these efforts, and most of these undertakings failed.[47] These undertakings were summarized in Table 1, above. AT&T's efforts to deploy a commercial packet switching service in the 1978-1984 timeframe were the most ambitious.

In the mid-1970s, Archie J. McGill, previously responsible for computer systems strategic planning at IBM, and the

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[43] *GTE-Telenet Merger, 72 FCC 2d 111, recon. 72 FCC 2d 516, recon. Denied 84 FCC 2d 18 (1979). GTE would later acquire Southern Pacific Communications, re-named Sprint, and would also challenge AT&T in the long distance voice communications marketplace.*

[44] *After achieving profitability and putting Telenet "in the black," Hann had the red columns in front of the Telenet headquarters building painted black.*

[45] *In the early 1990's, Sprint formed a joint venture with Alcatel to furnish packet network systems. Several years later, Alcatel acquired 100 percent of this JV.*

[46] *Vertical Systems Group in a September 2001 report estimated worldwide FR service revenues to be $12 billion in 2001.*

youngest IBM vice president at that time, joined AT&T as the director of market management and development. McGill was focused on the needs of business customers. One of the network service offerings which McGill and his staff proposed in 1976 was the so-called Bell Data Network. The BDN was to be a public packet network with additional communications processing capabilities. The service would include a high level Feature Definition Language to enable users to tailor the service to their needs. Pre-packaged communications processing services would include data entry services, transaction services, storage administration services and network management services. McGill envisioned "cloud computing services" forty years ago.

Coming from IBM, McGill knew well that IBM was encouraging major computer users to adopt IBM's Systems Network Architecture (SNA) approach to network-based data processing, which IBM had introduced in the early 1970's. Under IBM's SNA approach each corporation would unify all its data processing applications within a hierarchical network with a large centralized IBM mainframe computer. Later SNA was extended to allow multiple SNA networks to be interconnected [26]. All outlying locations would be tied into the mainframe by means of an SNA network. McGill felt that if AT&T waited too long before deploying the BDN, IBM would lock up all the major corporations with SNA networks. Potential customers would have no need for the BDN.

The BDN was formally announced when AT&T filed a petition with the FCC on July 10, 1978. AT&T sought to obtain the FCC's approval that it was not required to obtain construction authorization under Section 214 of the Communications Act to offer a vaguely described Advanced Communications Service (ACS). AT&T argued that

- ACS would use already authorized Digital Data Service private line facilities.
- No new transmission facilities were being constructed, and therefore no construction authorization was required.

The FCC informally suggested that AT&T file a standard Section 214 application to avoid delay, and on Nov 15, 1978 AT&T filed a Section 214 application for the ACS service with a start-of-service planned in 1979.[48] The FCC authorized the ACS service shortly thereafter. But as an outcome of the FCC Computer Inquiry II proceeding, AT&T was required to offer all "enhanced services" and customer premises equipment through a separate subsidiary.[49] For this purpose, AT&T had formed American Bell Inc. (ABI). ACS was to be offered to the public through ABI.

Early in 1979, AT&T indicated to the FCC that there would be a delay in the ACS rollout. Actually, AT&T had decided that its original design and equipment selection for ACS was inadequate and the system was being re-designed. AT&T abandoned its original approach of building within one system the packet transport functions and the communications processing functions, and designed a separate backbone packet network along with a separate set of communications processing nodes. The new architecture may have been influenced in part by the FCC's conclusion in Computer Inquiry II.

ACS was re-structured into two parts:

- A backbone packet switching network, to be called the Basic Packet Switching Service (BPSS), and
- The enhanced portions of the ACS service, to be called Net 1000.

It took considerable time to organize and re-structure ACS. The ABI capitalization plan for Net 1000 service was approved by the FCC in mid-1982 and Net 1000 was finally introduced as an unregulated service in January 1983.

Net 1000 consisted of multiple distributed processing centers, each containing several DEC VAX minicomputers and IBM Series 1 minicomputers as front end communication processors. Regional access to the processing centers was provided through remote concentrators in a hub and spoke topology. The processing centers were to be linked together through AT&T's regulated X.25 Basic Packet Switching Service (BPSS).

Functionally, Net 1000 was similar to Telenet's public packet network service and its Telemail electronic mail service, offering virtual call service and message service, with the exception that Net 1000 enabled customers to write COBOL programs, and to execute these programs and store data in the Net 1000 VAX computers.[50] Net 1000 would support the same terminal protocols as Telenet — namely, asynchronous TTY, and synchronous IBM 3270 and X780.

Significantly, AT&T did not offer X.25 access arrangements for customer

[47] *AT&T was the world's largest company, the largest telecom service provider and the largest telecom equipment manufacturer at the time. AT&T's legendary Bell Telephone Laboratories was the world's premier research organization in the telecom field. IBM was the world's largest computer company. ITT was a diverse conglomerate and one of the largest suppliers of telecom equipment. ITT also owned ITT WorldCom, a US international record carrier. Western Union was the leading domestic record (telex, message, and data) carrier in the US and was the prime contractor for DOD's Autodin message/data network. Xerox was one of the leading office automation companies, managed Xerox Park, a world-class research center, and acquired Scientific Data Systems (a computer manufacturer) in 1969 and Western Union International (a US international record carrier) in 1979. (Xerox sold WUI to MCI in 1982.) RCA was a leader in electronics and broadcasting and owned RCA Globcom, another of the IRCs. GE was among the world's largest electrical and electronic equipment suppliers and the world's largest provider of computer time sharing services.*

[48] *At the time of AT&T's ACS filing with the FCC, GTE was in discussions with Telenet regarding the possible acquisition of Telenet, and Xerox was getting ready to submit its application to the FCC for a proposed new packet satellite and packet radio system, called the XTEN system.*

[49] *The FCC initiated the Second Computer Inquiry in 1978 and concluded in 1980 (amended in 1981) that basic transmission services must be regulated and that enhanced services (e.g., protocol conversion) are to be de-regulated, and that AT&T can only offer the enhanced services through a separate subsidiary.*

[50] *When ACS was first announced in 1978, Telenet was in the process of planning and designing its Telemail service. Originally, Telemail was going to provide a pure interactive message composition and delivery service. However, after reviewing AT&T's ambitious plans for ACS, Telenet modified the design of the Telemail system in order to permit customers to write "information formatting programs" on the Telemail system These programs, called "Inform Scripts" enabled customers to create customized forms and menus and to use Telemail for data entry and collection applications. The Telemail system was largely designed by Marc Seriff, who would later become the chief architect for America Online's highly successful service.*

[51] *AT&T could have easily furnished X.25 access arrangements through its X.25 BPSS network.*

host computers, although it alluded to future support for X.25.[51] It is possible that AT&T wanted customers to utilize the limited processing facilities within Net 1000, rather than connecting customer-owned computers to the network. The lack of X.25 support made it difficult to connect hosts to the Net 1000 service, and this was probably a contributing factor in Net 1000's demise.

The time-sharing companies did not elect to use the Net 1000 service because Net 1000's processing capabilities made it appear more as a potential competitor to the them rather than as a communications service. However, the time-sharing companies were the most venturesome and receptive to savings in their communications costs. So Telenet and Tymnet targeted and signed up hundreds of such companies, as discussed earlier.

Net 1000 was rolled out during 1983 and sought to attract corporate clients. But the utility of Net 1000's programmability feature was contingent upon the willingness of customers and third parties to develop programs for Net 1000. By the time Net 1000 was introduced, personal computers were becoming popular (the IBM PC was introduced in mid-1981), and customers and third parties were now focusing on writing programs for PCs. Few companies wrote programs for Net 1000.

By mid-1984, it was clear that Net 1000 was a failure. The Wall Street Journal summarized the situation as follows:

"The results have indeed been disappointing. To develop the product, envisioned as a network enabling many dissimilar computers to talk to one another, AT&T has devoted 10 years, hundreds if not thousands of employees, and an estimated $1 billion. In the process, the system has had five names and suffered repeated delays, and even now never fulfilled its original purposes: to stave off International Business Machines Corp., in the fast paced world of data communications. Today, the product, now called Net 1000, has only a handful of paying customers." [27]

After AT&T quietly withdrew Net 1000 from the market, the X.25 BPSS was re-packaged and re-priced. BPSS became Accunet Packet Service or APS. Initially, most APS traffic was internal AT&T data network applications.

Further complicating AT&T's data communications planning, in August 1982 the U.S. District Court in Washington, DC, entered a Modification of Final Judgment (consent decree), settling an antitrust suit against AT&T brought by the U.S. Dept. of Justice in 1974, which prescribed the divestiture of the local Bell Operating Companies from AT&T. The BOCs were formally divested in January 1984 and subsequently organized into seven regional operating companies referred to as the "RBOCs."

The RBOCs could only provide regulated communications within their local exchange areas, referred to as Local Access and Transport Areas or LATAs. They could not provide long distance service of any kind. Long distance telephony services were provided by long distance companies — AT&T, MCI and Sprint plus a small number of resellers — who utilized the local telephone exchange facilities of the RBOCs for "local access."

After divestiture of the RBOCs, AT&T retained the intercity portion of the Bell System network, the Western Electric manufacturing operations, and portions of the Bell Telephone Laboratories. The re-organized AT&T, after divestiture, was permitted to engage in virtually any business, including computer manufacturing.[52]

The RBOCs, not to be left behind providing only "plain old telephone service," were anxious to provide advanced services such as public packet switching. The RBOCs envisioned provision of public packet services in the same manner as telephone service. That is, the RBOCs expected to provide intra-LATA public packet network services, and to interconnect on an "equal access" basis with the national packet network operators, such as Telenet and Tymnet and AT&T's ACS, to link the local packet networks together.

The RBOCs submitted proposals to the FCC to deploy local packet services, but these proposals raised policy issues. First, it was unclear whether the services should be authorized by the FCC or the local state public utility commissions. Second, the regulator had to determine if the services were "basic" or "enhanced." If enhanced, the services might have to be provided through separate subsidiaries and would require waivers from the FCC.

The proposed RBOC local packet services raised strategic issues for Telenet (and Tymnet). Should Telenet support the proposals of the RBOCs to build local packet networks, cooperate with them in the design and engineering of the local networks, furnish packet switching systems to the RBOCs, and then interconnect these local packet networks to the national Telenet network?

Or should Telenet treat the RBOCs as competitors, oppose them before the FCC, refuse to furnish packet systems to them, and refuse to interconnect their local networks to the Telenet network?

Many factors were considered. The RBOCs were likely to provide the lowest cost access arrangements and install packet facilities in a large number of locations. They were likely to purchase a substantial amount of packet switching equipment. Their proposals to the FCC forecast substantial local traffic, which would require hundreds of millions of dollars of equipment over several years. But they would divert substantial access revenues from Telenet.

J. David Hann, who was President of Telenet from 1980 until 1986, believed that Telenet could "have its cake and eat it too." Hann decided to sell turnkey packet systems to the RBOCs but not interconnect with them. He reasoned that if the RBOC packet networks were "islands" and were not interconnected together, they would have difficulty attracting customers. Telenet did not oppose RBOC provision of local packet service, but argued before the FCC that such services were enhanced and should be offered through separate subsidiaries.

Consequently, other equipment suppliers, such as Northern Telecom and Siemens, "positioned" Telenet as a competitor to the RBOCs, and convinced the RBOCs that they should not purchase equipment from a competitor. From 1984 through 1986 the RBOCs purchased more than $100 million worth of packet equipment. Telenet did not sell any packet equipment to the RBOCs for their local public packet networks, although Telenet did sell several packet systems to the RBOCs for their internal use.

Dave Hann's strategy worked, at

[52] *The re-organized AT&T was not permitted to engage in "electronic publishing." The newspaper lobby — which feared that AT&T would use its yellow pages business as a foundation for online classified ads and divert substantial revenue from the lucrative newspaper classified ads business — persuaded the NJ Court that AT&T should be excluded from online publishing. However, other companies offered online classified ads (e.g., Craigslist in the US) and eventually undermined the newspaper classified ad business.*

least in the short term. The local packet networks operated for several years without being linked together. Tymnet initially followed Telenet's strategy of isolating the local packet networks. Those customers that required national network capability generally did not sign up with the local packet networks. They continued to use Telenet and Tymnet, and by then Uninet, a new national packet network that was later to be merged with Telenet.

The RBOCs captured little national traffic on their local packet networks in the initial years of operation. Moreover, and more surprising to the RBOCs, the local networks also failed to capture the local traffic they had forecast.

Another problem encountered by the RBOCs was the variety of equipment they used. Some RBOCs even used different equipment in their several local exchange areas within their regions. Although the equipment conformed to international CCITT X.25 and related standards, the RBOCs were unable to provide a standard unified service across all their packet networks, especially considering that they were required to use other networks for inter-city packet transport.

In 1986, Paolo Guidi became President of Telenet. By this time, the RBOCs had established packet networks in a large number of local exchange areas. And other networks were being established to link the RBOC local packet networks together.[53] Guidi decided that Telenet should interconnect with all the RBOCs and Michael Hirsch negotiated interconnect agreements with most of the RBOCs by the end of 1988. But the RBOCs were still unsuccessful in selling to national corporations because such customers preferred to deal with a single organization such as Telenet or Tymnet for national network services, rather than multiple RBOCs.

By the time the RBOCs had extensive X.25 packet networks in operation, the industry began to move toward frame relay and TCP/IP networking.

## EPILOGUE AND CONCLUSION

The early X.25 packet switching networks, and subsequent frame relay networks, demonstrated the commercial viability and potential of packet switching services. Carriers around the world and large enterprises adopted packet switching for wide area networking. The early evolution of the packet network industry was influenced heavily by regulation and government policy, especially in the U.S. Initially, the packet network sector in the U.S. was driven by government-funded research and entrepreneurial companies, rather than by the leading communications carriers. In some respects, competition among domestic X.25 carriers limited the utility of the service, in contrast to the open and fully interconnected network architecture of the TCP/IP services. Improved functionality and government endorsement of TCP/IP eventually led to the demise of the X.25 and frame relay services at the turn of the millennium and the emergence of the TCP/IP-based Internet.

In the 1990's, high-speed, backbone TCP/IP networks — such as those of Sprint, MCI (now Verizon Business), AT&T, Qwest (now CenturyLink) and Level 3 — emerged in the U.S., built on fiber optic network infrastructure. By 2000, more than 7,000 regional Internet Service Providers offered local dial and dedicated access IP services in the U.S.[54] Regional ISPs, national ISPs (such as UUNet and PSINet) and backbone IP networks were interconnected to one another through interexchange points. The World Wide Web emerged in the mid-1990's and consumer access to the Internet grew rapidly. As broadband Internet access over telco ADSL facilities and cable TV networks became available at modest prices, the telcos and cable TV companies gradually replaced most of the regional ISPs as the leading Internet Service Providers in the U.S.[55]

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*[53] Northern Telecom invested $10 million in Data America, a company specifically formed to link the RBOC packet networks together. Northern Telecom furnished the packet equipment to Data America to build a national network. Another startup called Globnet also tried to build a national network to link the RBOC packet networks together. For unknown reasons, AT&T's BPSS did not become the national backbone for the RBOC local packet networks. When Telenet and Tymnet later agreed to interconnect with the RBOCs, the raison d'etre for Data America and Globnet disappeared and these companies ceased operations.*

*[54] "Directory of Internet Service Providers," 12th Edition, Boardwatch Magazine, Cleveland, OH, April 2000.*

*[55] "The deployment of the NSFNET backbone by the National Science Foundation in the late 1980's, the decommissioning of the ARPANET in 1990, the emergence of commercial IP backbone networks and interexchange/peering points in the 1990's, and the rise and consolidation of the many regional and local ISPs are beyond the scope and time period of this article. Further information on these topics can be found in the literature on the recent history of the Internet."*

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