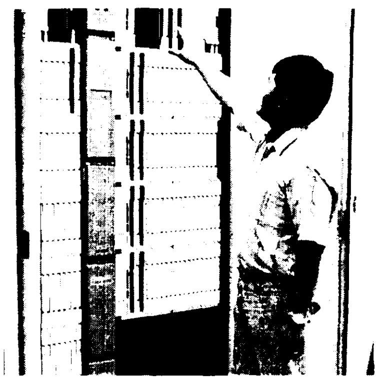
Telecommunications Infrastructure for Electronic Delivery 3

SUMMARY

The telecommunications infrastructure is vitally important to electronic delivery of Federal services because most of these services must, at some point, traverse the infrastructure. This infrastructure includes, among other components, the Federal Government's long-distance telecommunications program (known as FTS2000 and operated under contract with commercial vendors), and computer networks such as the Internet. The telecommunications infrastructure can facilitate or inhibit many opportunities in electronic service delivery. The role of the telecommunications infrastructure in electronic service delivery has not been defined, however. OTA identified four areas that warrant attention in clarifying the role of telecommunications.



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First, Congress and the administration could review and update the mission of FTS2000 and its follow-on contract in the context of electronic service delivery. The overall performance of FTS2000 shows significant improvement over the previous system, at least for basic telephone service. FTS2000 warrants continual review and monitoring, however, to assure that it is the best program to manage Federal telecommunications into the next century when electronic delivery of Federal services likely will be commonplace. Further studies and experiments are needed to properly evaluate the benefits and costs of FTS2000 follow-on options from the perspective of different sized agencies (small to large), diverse Federal programs and recipients, and the government as a whole.

Planning for the follow-on contract to FTS2000 could consider new or revised contracting arrangements that were not feasible when FTS2000 was conceived. An "overlapping vendor" approach to contracting, as one example, may provide a "win-win" situation for all parties and eliminate future debates about mandatory use and service upgrades. The General Services Administration (GSA) could conduct or sponsor experiments with agencies and vendors to test alternative contracting arrangements. Such experiments could help demonstrate and evaluate the ability of FTS2000 follow-on options to meet agency and governmentwide needs, and help assure equitable, innovative, and cost-effective use of telecommunications for electronic delivery of Federal services.

Second, Congress could review its overall intent for the National Research and Education Network (NREN) program regarding electronic service delivery. Current congressional efforts to support Internet applications using NREN, for health care and education for example, serve to promote widespread electronic service delivery, The Federal Government does not have to wait to resolve all NREN issues before using computer networking for electronic delivery. The government could deliver many more electronic services through the Internet, as some agencies are already doing for a few services. Under any scenario, the Internet needs to be more user-friendly by providing on-line directories or "on-line librarians" to help users find the government information and services they need. Agency applications need to be creative and relevant, yet require little training, to assure broad use.

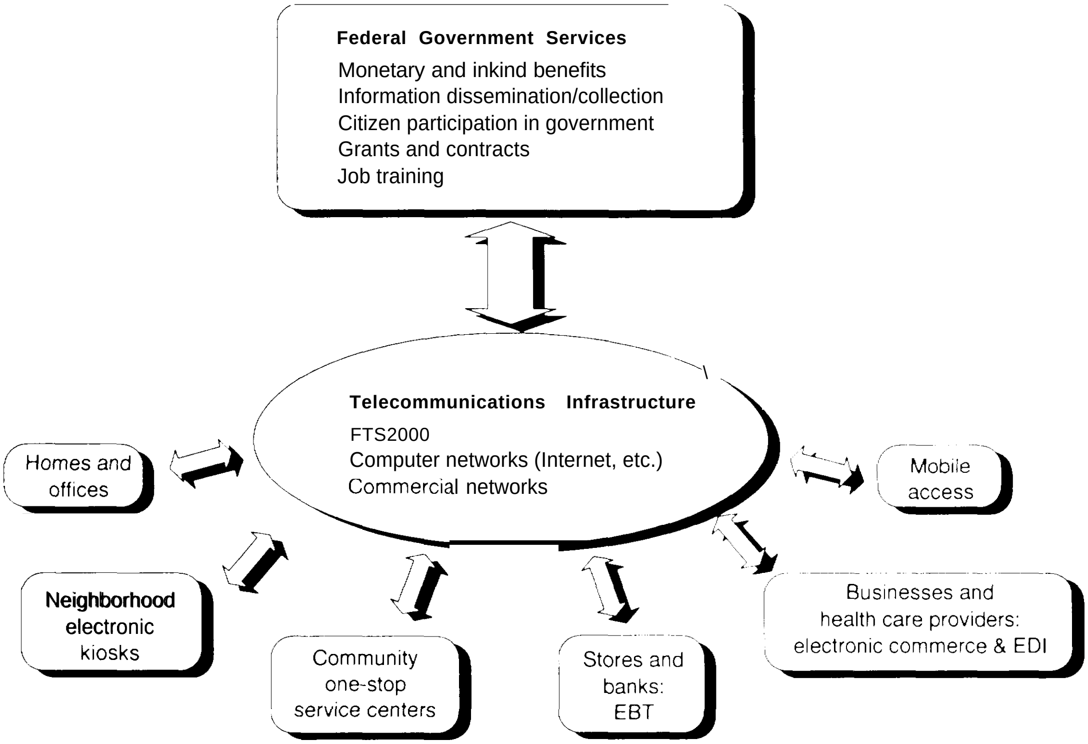
Third, Congress could review the commercial telecommunications infrastructure in light of electronic delivery. The "last mile" is particularly important for electronic delivery to the home; electronic information usually must traverse the lines of the local exchange carrier or other local provider at both ends, even for FTS2000 and Internet transmissions. This last mile can be a bottleneck for delivering affordable services in some areas of the United States, however. Access to Internet or other computer networking services can be expensive, and in many areas digital services needed for electronic service delivery are not available over the public switched network. The national infrastructure will be much stronger if users in all areas can electronically connect to compatible telecommunication systems in other areas of the Nation—the whole is greater than the sum of its parts. Congress could revise the concept of universal service to include nationwide affordable access to modem telecommunication services, such as the Internet, ISDN (Integrated Services Digital Network), and emerging broadband (high-transmission-rate) services. Vendors are testing fiber optics, coaxial cables, very-small-aperture satellite receivers, and digital mobile services for electronic delivery as alternatives to the copper wire pairs that still dominate the last mile.

Fourth, Congress could encourage Federal agencies not to wait for widespread implementation of fiber and broadband technologies to improve government services through electronic delivery. Many electronic services—Federal or otherwise---can be delivered affordably with the copper wires that deliver traditional telephone service; for example, using modems or ISDN services, ISDN in particular offers a significant improvement in the rate at which a user can send or receive data, and it can transport voice, data, or video messages. Switched broadband technologies, on the other hand, face many technical, standards-setting, financial, and regulatory issues that must be resolved before affordable nationwide access becomes a reality.

THE ROLE OF TELECOMMUNICATIONS IN ELECTRONIC DELIVERY: AN OVERVIEW

The six points of access in chapter 2 describe technologies that bring services directly to the recipient. These technologies frequently use telecommunications to deliver those services (see figure 3-1). This chapter discusses the role of the telecommunications infrastructure in electronic delivery, especially two components that are particularly important in delivering Federal services: 1) the Federal long-distance telecommunications program (known as FTS2000), and 2) the Internet and the evolving NREN program. These and other

Figure 3-1—Role of Telecommunications infrastructure in Delivering Federal Services Via Six Points of Access



NOTE: The Federal services and infrastructure components shown are illustrative, not comprehensive.

KEY: EBT=Electronic Benefits Transfer; EDI=Electronic Data Interchange; FTS2000=the Federal long-distance telecommunications program.

SOURCE: Office of Technology Assessment, 1993.

components of the infrastructure are also important economic catalysts, and enhance the long-term competitive position of the United States.[1]

The telecommunications industry is very different today from what it was when Congress enacted the Communications Act of 1934,[2] or even 10 years ago. The industry was once dominated by one telephone company (AT&T), but is now diversified with many different types of providers. Some providers are like wholesale stores, some like department stores, others like boutiques, and a single transmission often involves several vendors. Telecommunication services also have changed considerably due to advances in fiber optics, microelectronics, and software used for switching systems. Digital transmission is replacing analog even to the home and office. As a result, voice, text, and video all become simply data that

[1] See U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, January 1990); U.S. Congress, Office of Technology Assessment, *U.S. Telecommunications Services and European Markets*, OTA-TCT-548 (Washington, DC: U.S. Government Printing Office, August 1993), and Institute for Information Studies, *A National Information Network—Changing Our Lives in the 21st Century* (Queenstown, MD: Aspen Institute, 1992). For a review of point-to-point two-way telecommunications in the United States, see U.S. Department of Commerce, National Telecommunications and Information Administration, *The NTIA Infrastructure Report: Telecommunications in the Age of Information*, NTIA Special Publication 91-26 (Washington, DC: NTIA, October 1991).

[2] Communications Act of 1934, 47 U.S.C. 151, *et seq.*

computers can process and transmit more efficiently. Telephone, video, and computer transmissions become more alike—personal computers send data and video over telephone lines, and new telephones contain computer chips and video screens. The intelligence in the system also is becoming less centralized-the end-user has more direct control over functions.

The commercial telecommunications industry has many strengths that can facilitate electronic service delivery. These include its diversity of vendors, new and specialized services, and lower prices. Services can be delivered over copper wire for telephones; coaxial cable for cable television; and airwaves for cellular telephony, radio, and television, This fragmentation also can be a weakness, however. Before its divestiture, for example, AT&T could efficiently adopt a single standard nationwide; today, it is more difficult to achieve a nationwide standard, and users lack experience dealing with diverse providers and new services. Boundaries between these different modes of delivery have led to technical and market inefficiencies. Cable companies, for example, have installed broadband (high capacity) services to the home via coaxial cable, but without switching. Telephone companies have full switching capabilities, but offer much less capacity to the home.

The commercial infrastructure generally can provide telecommunication services better than the government or a single corporation can do directly. Thus, the Federal Government generally purchases telecommunication services from commercial vendors, rather than purchasing equipment and leasing lines itself. Likewise, the government supports commercial or nonprofit networks for computer networking, rather than building or managing a network itself. The "information superhighways of the future" are, in large part, already constructed or being developed by commercial vendors, The Federal Government's role is that of customer, collaborator, and regulator, rather than that of direct provider.

Technology developments—such as packet switching—also enhance electronic delivery. With packet switching, data are collected into packets that in turn are sent one at a time as needed, rather than tying up transmission lines continuously. This allows the telephone and other network operators to squeeze transmissions together more efficiently. Packet-switching is currently used for automated teller machines, computer-to-computer messages, and electronic mail, all useful for electronic service delivery.

Other significant technology developments, such as high-speed modems and ISDN, allow homes to receive larger capacity digital services over existing copper telephone lines. These technologies could expand access to on-line Federal Government services to homes, offices, schools, and libraries at affordable prices. Broadband (high-transmission-rate) services could be delivered via fiber optic cable for telecommuting, interactive multimedia presentations, or telemedicine applications, for example. While this technology could deliver even more advanced Federal services to the home, many formidable issues remain to be resolved.

Cost-effective electronic delivery depends on systems being interoperable and compatible—thus the need for technical standards. The government could play a greater role in encouraging standards,[3] and standards should be given a higher profile in the community-at-large as well.[4] (See also ch. 7.)

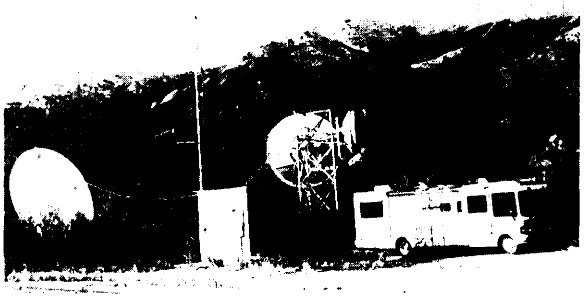
Security is an ongoing concern with any large telecommunications network, especially for networks used to electronically deliver Federal serv-

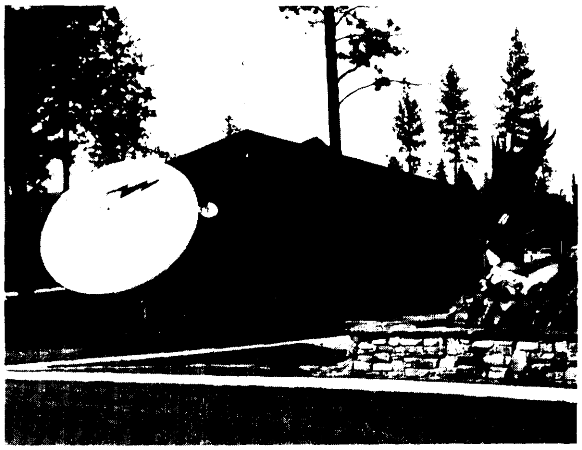
[3] U.S. Congress, Office of Technology Assessment, *Global Standards: Building Blocks for the Future, OTA-TCT-512* (Washington, DC: U.S. Government Printing Office, March 1992).

[4] Engineering and business schools generally do not teach standards-setting or its importance to business and production. Corporations and users alike lack a commitment to standards-setting, See Carl F. Cargill, *Information Technology Standardization: Them-y, Process, and Organizations* (Bedford, MA: Digital Press, 1989).

ices.[5] Absolute security is impossible, but various degrees of security can be obtained at correspond-

PHOTOS: FRED B. WOOD





Top: Satellite, radio, and microwave communications center at the Denali National Park airport, Alaska.

Bottom: Satellite earth station at the Salish Kootenai College on the Flathead Indian Reservation, Montana. The college downloads video programming via satellite to increase the diversity of educational materials used in the classrooms.

ing costs. Many adequate security measures—such as encryption, complex passwords, and smart card keys-already exist and can be easily implemented.[6] However, individual users typically underestimate security needs, and additional oversight by network management is usually necessary.[7] (Ch. 7 discusses security and privacy issues in more detail.)

USING FTS2000 FOR ELECTRONIC SERVICE DELIVERY

The Rationale and Role for FTS2000

Federal, nonmilitary long-distance telecommunications are purchased largely through two contracts for services known as the FTS2000 program, split 40/40 between AT&T and Sprint according to agency.[8] The Federal Government spends over $2.5 billion annually on telecommunications of all kinds (including local telephone service and special applications such as air traffic control and military command and control), of which about $500 million per year is on FTS2000.[9]

FTS2000 was designed to improve the internal and external communications of the Federal Government. A major strength of FTS2000 is that the government buys services, not equipment. FTS2000 is not intended to be technologically different from other large private or commercial networks. The contract was split between two vendors to promote a degree of ongoing competition and help to maintain equilibrium with the commercial sector. FTS2000 also is intended to provide the Federal Government with a universal and seamless telecommunications infrastructure:

[5] See the August 1992 issue of *Communications of the ACM*, vol. 35, No. 8. See also John Adam, "Cryptography y=Privacy?" *IEEE Spectrum*, vol. 29, No. 8, August 1992, p. 29,

[6] See the August 1992 issue of *IEEE Spectrum Magazine, vol. 29, No. 8.* See *also* U.S. Congress, Office of Technology Assessment, *Defending Secrets, Sharing Data*, OTA-CIT-355 (Washington, DC: U.S. Government Printing Office, October 1987).

[7] Foreign "hackers" once penetrated many sensitive military and intelligence networks using very simple techniques, such as using the default password supplied with off-the-shelf computers, See Clifford Stoll, *The Cuckoo's Egg (New* York, NY: Doubleday, 1989).

[8] FTS2000 vendors also lease lines from other long-distance carriers and satellite providers to obtain connectivity, and for primary and backup capacity. For example, in Alaska neither of the FTS2000 vendors provides direct commercial long-distance service, and they must therefore lease service from a regional carrier.

[9] Office of Management and Budget (OMB), *Current Information Technology Resource Requirements of the Federal Government: Fiscal Year /993* (Washington, DC: U.S. Government Printing Office, 1992).

a common denominator to allow government agencies and computers to be more interconnected and compatible. FTS2000 consolidates considerable telecommunications procurement costs for agencies. Finally, FTS2000 is intended to save money when compared with the previous system (FTS) and the commercial market, since the government can buy services at a bulk rate.

FTS2000 was initially designed without electronic service delivery specifically in mind, It is, however, being used increasingly for electronic delivery, such as on-line bulletin boards and toll-free telephone lines. The FTS2000-based toll-free telephone services of the Social Security Administration and the Internal Revenue Service, for example, are considered the largest in the world,

The General Services Administration (GSA) manages the two FTS2000 contracts, The contracts are for 10 years, expiring in 1998, with renegotiations in 1992 (now completed) and 1995.[10] GSA levies a surcharge on users of FTS2000 for its overhead services, which include performing system tests, overseeing billing, managing consulting services, and conducting planning, among other tasks. GSA and the agencies obtain local telephone service through smaller non-FTS2000 contracts with local exchange carriers, and through the leasing or ownership of switching equipment. Agencies can purchase international voice service through a separate non-mandatory and governmentwide contract, but can also make their own international service arrangements. Agencies purchase end-user equipment, cellular service, and encryption on their own or through GSA. Table 3-1 compares telecommunication services provided by FTS2000 and the commercial market.

FTS2000 Issues

FTS2000 provides more opportunities than barriers to the electronic delivery of Federal services. Despite criticism regarding its early implementation, it is widely accepted that FTS2000 is a great improvement over the previous system (known as FTS).[11] With the earlier FTS, GSA managed long-distance services through contracts for equipment and leased lines, but had difficulty keeping up with changes in telecommunications equipment and services and agencies' needs. GSA estimates that in its first 4 years, FTS2000 saved $500 million over FTS. Early FTS2000 problems can be attributed, in part, to lack of experience on the part of the government and the telecommunications industry in managing contracts of this size, complicated by major changes in the industry following the divestiture of AT&T.

Need for Creativity Using FTS2000

About 85 percent of FTS2000 use is plain voice or low-speed data transmission for computers and faxes. Most current electronic delivery needs can be met with these or other FTS2000 services such as compressed video or packet switching, The main inhibitor to using FTS2000 for delivering services is not FTS2000 itself, but the lack of creativity by agencies in applying the potential that FTS2000 and other telecommunications already offer. Separate and traditional telephone and computer cultures still exist within the government; many agencies are not thinking or planning in terms of what FTS2000, or modern telecommunications in general, has to offer.

Need to Upgrade Non-FTS2000 Equipment

Government agencies still own considerable obsolete PBX switching equipment. ISDN and other digital services, as well as many digital

10 At the negotiations, GSA can adjust each vendor's percentage of the total contract, to reflect comparative prices and services. Since each vendor is awarded entire agencies to achieve its percentage of total revenue, with each agency changing its usage each month, the revenue split is never exactly as projected.

11 For a history of FTS2000 and related congressional action, see U.S. Congress, House Committee On Government Operations, *FTS2000: Management Reforms and Intensive Congressional Oversight Ensure Savings of $500 Million for the Taxpayers* (Washington, DC: U.S. Government Printing Office, 1992). For a history of the events leading up to the final FTS2000 awards, see Bernard Bennington, "Beyond FTS2000: A Program for Change," app. A, "FTS2000 Case Study," 1989, report available from GSA.

Table 3-l—Comparison of Services Available: FTS2000 and the Commercial Market

Service	FTS2000	Commercial market[a]
Basic voice	Available	Available
Switched data	96, 56, and 64 kbps 1544 Mbps	9.6, 56, and 64 kbps 384, 512, and 768 kbps: 1.544 and 45 Mbps
Dedicated data	Up to 1.544 Mbps; 45 Mbps	Up to 1.544 Mbps; 2.6, 6.2, 7.7, and 10.5 Mbps; 45 Mbps
Packet-switching	X 25	X,25, frame relay TCP/IP (Internet), SMDS, ATM, and others
Compressed and wideband video	Available	Available
ISDN	Available	Available
EDI value-added services	Not available[b]	Available
International voice	Not available[b]	Available
Cellular	Not available	Available

[a] Not all services are Commercially available across the entire United States

[b] Available through a governmentwide contract other than FTS2000

KEY ATM=Asynchronous Transfer Mode, EDI=Electronic Data Interchange, ISDN=Integrated Services Digital Network, kbps=kilobits per second, Mbps=megabits per second, TCP/IP=Transmission Control Protocol Internet Protocol, SMDS=Switched Multi Megabit Data Service X 25=protocol from the X 25 Accredited Standards Committee (ASC) accredited by the American National Standards institute (ANSI)

SOURCE Office of Technology Assessment, 1993

security features, are not possible with such equipment. The government should, in most cases, lease digital PBX equipment or centrex switching to avoid risky equipment purchases, since telecommunications equipment becomes obsolete well before it wears out.

Service Quality, Billing, and Interoperability Problems

Agency users have filed various complaints about FTS2000, including incomplete or delayed billing information, poor response to service calls, and slow processing of procurement requests. Many complaints stemmed from confusion during the initial stages of the conversion to FTS2000,[12] and from the inevitable technical problems of converting to a sophisticated digital system.[13] The vendors did implement FTS2000 ahead of schedule, and FTS2000 service reportedly continues to improve.

Agencies also have complained that some FTS2000 services (e.g., compressed video) are not interoperable between the two vendor networks.

12 Some agencies had t. switch to an FTS2000 vendor from their preferred non-FTS2000 vendor to comply with the mandatory use policy. Others had to change FTS2000 vendors to meet quotas for the overall usage and revenue split between the two vendors.

13 Performance, price, and interoperability are not easily compared. User demands are very unpredictable, making system design difficult. Each vendor packages its services differently. Also, laboratories cannot truly simulate red-world conditions because telephone networks are extremely complex,

In fairness, the video compression industry itself has lacked standards for interoperability. GSA may lack the motivation or negotiating power to entice or force the vendors to adopt interoperability more quickly. In order to deliver services to citizens more effectively, agencies will have to work together more closely, and interoperability will be essential in future contracts. As one agency official noted, interoperability is the "light at the end of the tunnel" for delivering services to the citizen.

A study commissioned by the FTS2000 Interagency Management Council determined that GSA could adopt a more customer-oriented approach, including streamlining or transferring some FTS2000 management tasks to the vendors.[14] However, the study also concluded that "GSA staff are very effective in executing their assigned responsibilities and mission. Their performance is at the root of a high level of satisfaction with the telecommunications services delivered." The study found that many agency reservations about GSA's role are due to a lack of understanding of GSA's oversight activities and its low-key approach.

Pricing Complaints

A major criticism of FTS2000 concerns pricing. One intent of the FTS2000 contract is to obtain services at a discount. Some agencies and outside parties have claimed that parts (or all) of FTS2000 cost more than equivalent services purchased on the open market, and that GSA did not exercise enough control to drive the vendors' prices down.[15-16] GSA acknowledges that prices were overly high for some specific services. GSA claims, however, that as of the 1992 price redetermination, FTS2000 prices were "at least as good as" the "best equivalent" commercial prices. FTS2000 prices were actually about 3 percent *higher* than commercial prices, however, if inconclusive comparisons are not included in the total.[17] GSA notes that commercial prices have fallen since the price redetermination, and FTS2000 prices fell after the first 1993 price cap evaluation. The related FTS2000 Interagency Management Council's contractor study on which GSA based its conclusions notes that the new price cap mechanism "represents a significant improvement over its predecessors," but that it "is not a complete guarantee of the lowest prices, however. Specifi-

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[14] Booz-Allen & Hamilton, Inc., "Management Review of the GSA FTS2000 Program," Washington, DC, Nov. 20, 1992, Also see U.S. General Accounting Office, *FTS2000 Overhead: GSA Should Reassess Contract Requirements and Improve Efficiency*, report to the Chairman, House Committee on Government Operations, GAO-IMTEC-92-59 (Washington, DC: U.S. General Accounting Office, August 1992). GSA has reorganized its FTS2000 program office since these reports were issued.

[15] An early complaint was that the bidding process initially allowed the second lowest bidder (Sprint) to charge its agencies higher prices for equivalent services provided by the lowest bidder (AT&T). This resulted in higher prices for agencies forced to use the second lowest bidder. Later negotiations "levelized" or otherwise eliminated these differences.

[16] Jack Brock, General Accounting Office, *FTS2000: GSA Must Resolve Critical Pricing Issues*, report to the Chairman, Senate Committee on Governmental Affairs, GAO-IMTEC-91-79 (Gaithersburg, MD: U.S. General Accounting Office, September, 1991). A study by Putnam, Hayes, and Bartlett, commissioned by MCI, also found prices to be excessive. Putnam, Hayes, and Bartlett, Inc., "Money and Myth: Misconceptions That Shape Federal Telecommunications Procurement Policy," Cambridge, MA, Apr. 6, 1992.

[17] The breakdown is as follows: FTS2000 switched-voice prices, which constitute 78.1 percent of FTS2000 revenue, were equal to "best equivalent" commercial prices. For dedicated transmission and videoconferencing (about 16.7 percent of revenue), the FTS2000 prices were higher than commercial. FTS2000 packet-switching prices were less than commercial (4.7 percent), although the comparison cannot be considered conclusive since it "does not address the custom-designed packet systems. . . that dominate the market for large, sophisticated users. Further study may be required to determine the competitiveness of this service." Finally, the low volume of switched-data traffic (0.5 percent of revenue) "precludes a firm conclusion with respect to this service." U.S. General Services Administration, "The GSA Report to Congress on the Cost Effectiveness of the FTS2000 Program," February 1993; and Snavely, King & Associates, "FTS2000: Cost Effectiveness Comparison Acquisition Price Analysis," prepared for the Cost Effectiveness Subcommittee of the Interagency Management Council, January 1993. GAO concurs with GSA's conclusions. See Jack Brock, General Accounting Office, "GSA's Price Redetermination Yields a Reasonable Decision and Lower Prices," report to the Chairman, Committee on Governmental Affairs, U.S. Senate, March 1993.

cally, it cannot ensure the lowest FTS2000 price when most of the corresponding commercial services are purchased under individually negotiated, custom-designed contracts..."[18]

The contractor report estimated that the overall FTS2000 price is $17 million to $52 million (4 to 13 percent) *lower* than commercial prices when expected costs for "unique government requirements" are included in the commercial prices.[19] The value of these unique requirements is, in many cases, subject to debate, difficult to quantify, and varies as the contract ages. Does a vendor recover certain costs in the first years of the contract, for example, or over the life of the contract? To reduce the risk to the government, vendors accept greater risk, which increases prices. How great is that risk, and how does it differ from commercial contracts?

Finally, the study only addressed *prices* for purchasing equivalent telecommunication services, and did not include the *overhead costs* for GSA to award and administer the contracts. Large private buyers or single agencies also would have overhead costs if services were procured outside of the FTS2000 program, but no comparison has been made between agency and GSA costs. The study "therefore does not purport to evaluate the total cost effectiveness of FTS2000 to the government." Another Interagency y Management Council study determined that GSA could make changes to reduce its overhead operating charge, but that the overall effectiveness of FTS2000, not just a specific dollar number, is most important.[20]

Definition of Service Upgrade and Procurement Uncertainty

One objective of FTS2000 is that agencies should be able to choose from an up-to-date list of features and services. FTS2000 currently does not include many advanced telecommunication services. To obtain these services, GSA may add fea-*tures* to existing FTS2000 services, but the government is expected to issue separate competitive procurements for any new *services* unspecified in the original FTS2000 contracts. The result is ambiguity about what constitutes a typical upgraded "feature" to existing services, and what is an altogether new service outside the domain of FTS2000 that must be procured separately. Some new services are, as a consequence, disputed by FTS2000 competitors, and the provision of these services is delayed while the disputes are resolved.[21] These delays also increase uncertainty about FTS2000 within the agencies, and add to the existing overall uncertainty about rapidly changing telecommunications technologies.[22]

Optimum Contract Size

Customers who would otherwise negotiate very small contracts may gain the most from the economies of scale and scope of a larger contract; such economies result from reduced engineering costs per unit of service as more telecommunications traffic is aggregated.[23] Customers who are able to negotiate very large contracts, on the other hand, offer substantially more business to the winning vendor and therefore have greater negotiating power to obtain favorable prices and other contract

18 Snavely, King & Associates, op. cit., footnote 17, p. 70.

19 Without the unique government requirements, FTS2000 prices were found to be $6.7 million per year (2 percent) less than the "best equivalent" commercial prices. These requirements include assured and prioritized emergency service; billing arrangements; absorption of local access charges; and the government's options to terminate the contract at any time without liability, to reallocate more or less service, impose or change price-cap restrictions, etc. Ibid., p. 3.

20 Booz, Allen & Hamilton, Inc., op. Cit., fOOtnOte 14.

21 None of th, 23 FTS2000 protests (from over 200 contract modifications) has been decided against GSA, however. The GSA Board of Contract Appeals ruled against GSA in one case involving the addition of T3 services to FTS2000, but that case was recent] y overruled by the U.S. Court of Appeals,

22 For example, an agency might prefer a new packet service from Vendor X (outside of FTS2000), but suspects that the FTS2000 vendor (Vendor Y) might soon provide the same packet service. In that event, GSA might *later* require the agency to purchase the packet service from Vendor Y, and the time spent on the procurement with Vendor X is wasted,

23 Kalba Bowen Associates, Inc. and Economics & Technology, Inc., "Cost/Benefit Analysis of Alternatives for the Replacement of the Federal Telecommunications System Intercity Network," report prepared for GSA, Apr. 21, 1986.

considerations. Such large contracts, however, also carry greater risk and higher costs associated with moving the customer's business to another vendor, if necessary, in order to "carry out a threat" of selecting a lower priced competitor. Very large contracts can also influence the overall telecommunications market and therefore may have broader social and economic costs if competition is restricted as a result. The optimum contract size for procuring telecommunication services is unclear, and merits reconsideration given the substantial changes in the telecommunications industry.

FTS2000, in particular, may be much larger than the optimum size for a telecommunications contract. In any case, FTS2000 does not provide opportunities for agencies to experiment with smaller, competitive contracts. Some large agencies may be able to match their needs better outside of FTS2000, and maybe large enough to negotiate contracts at lower prices and with terms more favorable to the government. In its February 1993 report to Congress, GSA noted that "better commercial prices can sometimes be obtained for geographically limited contracts or contracts which define very specifically the items to be bought."[24] Shopping for prices in this way currently is not possible with FTS2000.

The Mandatory Use Provision

FTS2000 use is mandatory for all agencies, unless GSA or Congress grants a specific exemption.[25] Mandatory use makes the total FTS2000 procurement "sweeter" for potential contractors; the larger market should result in lower contract bids. During the initial FTS2000 procurement, mandatory use was intended to attract enough bidders to provide at least some competition against the dominant carrier, AT&T.[26] Today, the telecommunications industry is more competitive, and mandatory use may not be necessary to assure a competitive procurement. Relaxing the mandatory use provision, on the other hand, may complicate oversight of FTS2000 and agency telecommunications generally, may increase costs especially for smaller agencies with limited negotiating power, and may or may not increase government procurement costs overall. GSA has not analyzed the effects of alternative contracting arrangements on costs or oversight.

GSA could experiment with contracting alternatives for some services and agencies in order to compare procurement and operational costs within and outside of FTS2000, and to evaluate how well possible FTS2000 follow-on options might meet agency needs. A key issue that maybe illuminated is balancing the needs of smaller agencies and those with generic requirements that should benefit most from a full FTS2000 package, versus the needs of the larger agencies that maybe able to negotiate more favorable terms through non-FTS2000 procurement of advanced telecommunication services. Contracting experiments could help identify ways to put more pressure on the FTS2000 follow-on vendors to keep prices of advanced as well as basic services competitive. If FTS2000 follow-on prices and services were truly competitive in meeting a wide range of agency

24 U.S. General Services Administration, op. cit., fOOtnote 17, P. 3.

25 The mandatory use provision requires agencies to use FTS2000 for all long-distance telecommunications, with exemptions allowed by GSA for certain mission-critical operation-s. Notable exemptions currently include much of the Department of Defense's traffic, the Federal Aviation Administration's air traffic control network, the National Science Foundation's NSFNET backbone, the Department of Treasury's Treasury Communication System, and Congress. On the other hand, the quasi-governmental U.S. Postal Service is not required to use FTS2000, but opted to use it anyway. The provision is included in the request for proposals and in Federal regulation as FIRMA Interim Rule 1, "Mandatory Federal Telecommunications System Network," July 29, 1988, 53 *Federal Register 28638.* Congress also has included the provision in annual appropriations legislation (Public Law 102-393, Sec. 622; Public Law 102-141, Sec. 622; Public Law 101-509, Sec. 620; Public Law 1OI-136, Sec. 621; and Public Law 100-440, Sec. 621). H.R. 3161, the "Federal Property and Administrative Services Authorization Act of 1991 ," included a provision to make mandatory use permanent, but the bill was not enacted,

26 The first FTS2000 plan intended one vendor and voluntary use in order to keep prices low and make the transition to FTS2000 easier. This plan was revised to allow for two vendors, with mandatory use and price caps required for basic voice service, but not advanced services. The final FTS2000 plan included all services within the scope of the mandatory use provision. Price caps were extended to all services in 1990.

needs, then user agencies would presumably opt to stay with FTS2000, even in the absence of mandatory use, unless there were other compelling reasons to go outside.

Relationship to Other Networks and Users

FTS2000 could connect to other government networks in the same way that it currently connects to commercial networks. That is, the vendors providing FTS2000 services could arrange to have equipment installed that would allow a seamless connection between FTS2000 and the individual State and local government networks, Commercial networks charge access fees to use their networks, however, and access arrangements would be needed with State and local government networks as well. Federal, State, and local regulations[27] might have to be revised to allow such arrangements. Also, the FTS2000 mandatory use provision requires that Federal users make all long-distance (inter-LATA) calls over FTS2000, thereby bypassing any internal State network. Thus, GSA or Congress may need to amend or authorize exemptions to the mandatory use provision for these cases.[28]

FTS2000 has no direct relationship with the NREN program, but it does serve as a vehicle for delivering some computer networking services, Agencies most likely will continue to obtain local Internet access without the need for long-distance services. If necessary, however, agencies can use FTS2000 to obtain Internet services indirectly from Internet providers, or perhaps directly at some future time.

The Follow-onto FTS2000

Even its strongest critics agree that FTS2000 is an improvement over the previous system. As the FTS2000 contracts pass mid-term, GSA will add features to its existing six basic services. GSA also will use the remaining time before contract expiration to plan, prepare, and finalize procurement requests for a follow-on to FTS2000, whatever form that will take. Competitors for a FTS2000 follow-on might include not only long-distance companies, but possibly computer network providers, manufacturers, and system integrators, among others. Changes in the telecommunications industry suggest the need for a fresh look at the overall objectives of a centralized program such as FTS2000.

Clarifying the Purpose of FTS2000

Congress could ask GSA and the administration to address basic questions about the purpose of FTS2000 in planning the mission of an FTS2000 follow-on.

- Is a direct follow-on to FTS2000 desirable? The centralized approach is not necessarily appropriate for modern telecommunications. Different agencies have different missions and needs for telecommunications to support electronic delivery; are these compatible with a single centralized contract?
- Should the principal mission of FTS2000 be to reduce the *internal* telecommunications costs for the government, or should it also focus on a more active role in delivering electronic services to citizens? Should GSA extend FTS2000 beyond traditional users (agencies and certain agency contractors) to, for example, federally funded groups that work in the public interest, such as schools, libraries, or local governments? If libraries found FTS2000 to be less expensive than commercial offerings, for example, or if the needed commercial services were unavailable, then they could participate in FTS2000 and be billed accordingly, as is each agency.

27 Including Federal procurement statutes such as the Competition in Contracting Act of 1984, Public Law 98-369, Sections 2701 *et seq.*, 98 Stat. I 175.

28 The State of Iowa, for example, has installed fiber optic cables for its private network. A Federal agency calling from one county to a State office in another county might be required to use FTS2000 rather than the State system due to the mandatory use provision. See Iowa Communicant ions Network Working Group, Interagency Information Resources Management Infrastructure Task Group, "Iowa Communications Net work Study," report to the House Subcommittee on Treasury, Postal Service, and General Government, House Committee on Appropriations, U.S House of Representatives, Apr 1, 199.3, p. 49,

The current conditions under which FTS2000 services can be extended beyond Federal agencies are not clear, however, and would need to be reviewed.

- Should the FTS2000 follow-on emphasize basic low-cost telephone service; an interoperable, advanced telecommunications infrastructure; or something in between? In other words, how is universal service defined for the Federal Government as customer? The first option implies a program with only basic voice, perhaps including ISDN service. The second implies a program with a full range of advanced services common to all government agencies. While both of these may be achievable in principle, in practice priorities must be set, and not all goals may be met by the vendors. Requiring many features in a contract can also limit competition, since fewer companies can manage such large systems. A set of several governmentwide specialized contracts may provide the same interoperable infrastructure without the difficulties encountered in maintaining a single large contract.
- Should FTS2000 and its follow-on save money overall, or should it save money on a service-by-service and agency-by-agency comparative basis? If the latter, should GSA continue t. require agencies to purchase through FTS2000 to attract better rates from vendors, or should agencies have the option to go outside if they can get a better deal? In other words, should Congress and GSA retain the mandatory use provision? If so, should the provision be retained for all the services or only for some, such as basic voice and ISDN?

New Contracting Arrangements

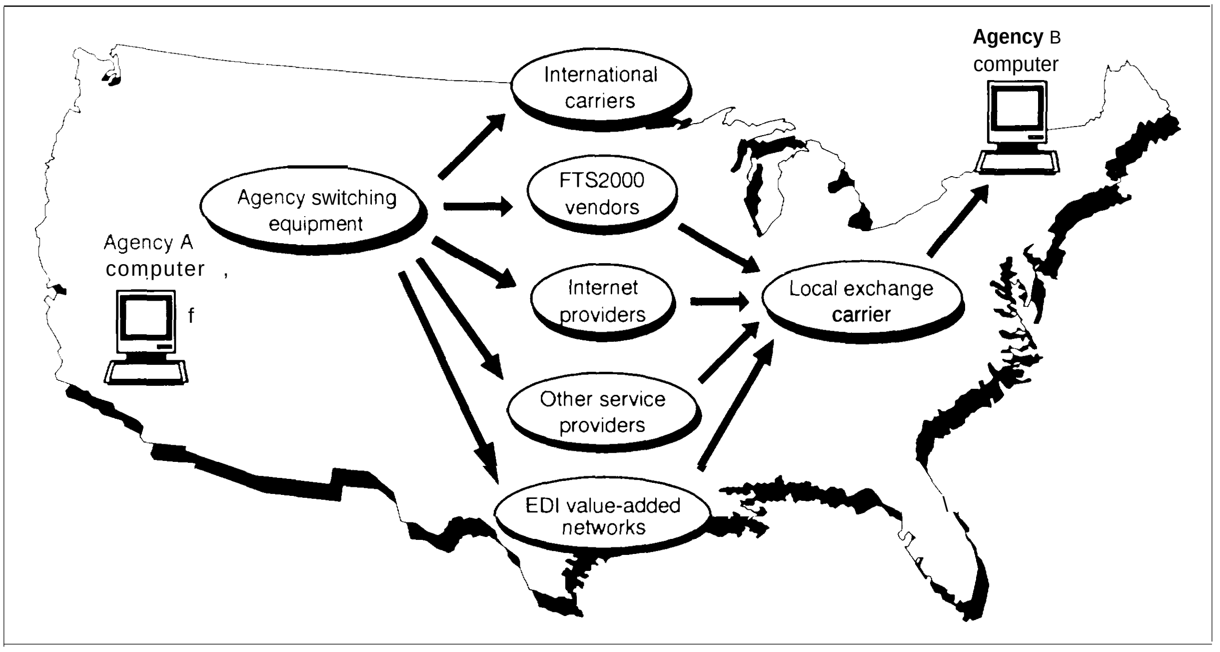
Congress could ask GSA to review different contracting arrangements for an FTS2000 follow-on that are now possible given changes in the telecommunications industry.

- How many vendors are desirable for the follow-on contract? Advances in technology now allow contracting arrangements that were impractical during the planning of the present program 10 years ago. Any number of vendors could be allowed access to the agency switching centers-an "overlapping vendor" approach. Vendors could be selected on a real-time basis according to quality, service, or price, Or, agency traffic could be divided equally among pre-selected vendors qualified for specific services.

  The concept of switched competitive vendors has worked for other purposes. A Federal agency can currently switch its own calls dynamically to many different vendors; for example, to local, FTS2000, international, value-added, and advanced packet-switching vendors (see figure 3-2). Residential customers also can change long-distance carriers regularly, often with only an access code. The overlapping vendor approach described here would simply take these modem arrangements one step further, A diversity of vendors would be more competitive, and make Federal telecommunications more flexible and, in principle, more responsive to changing requirements.
- How should the contract be split among vendors? The present FTS2000 awards entire agencies to one of the two vendors. If one vendor provides better prices or service, however, GSA may or may not increase its share of the contract at the following renegotiation. Other arrangements are possible; the contract could be overlapping (as described above) or split by geographic region.[29] The FTS2000 follow-on planning merits a full review of these options, including their economies of scale and scope.
- Should a mandatory use provision be included in the follow-on to FTS2000? Mandatory use and FTS2000 reflect a centralized or "mainframe" approach to telecommunications that may not necessarily be appropriate for the late

[29] Kalba Bowen Associates, Inc. and Economics & Technology, Inc., Op. Cit., footnote 23.

Figure 3-2—Existing Routes for Long-Distance Government Telecommunications



NOTE: The routes shown are illustrative. In this example, the sending agency (Agency A) switches the data directly to the appropriate telecommunications provider. At the receiving end, the local exchange carrier switches the data to the receiving agency (Agency B).

KEY: EDI=Electronic Data Interchange; FTS2000=Federal long-distance telecommunications program.

SOURCE: Office of Technology Assessment, 1993

1990s and beyond. The overlapping vendor arrangement, for example, represents a more open, dynamic contracting system that rewards vendors for low prices and good service and allows for innovation among agencies. Prior to expiration of the current FTS2000 contract, GSA could conduct or sponsor contracting experiments to see if other options would better meet agency needs. Such experiments could be used to "pilot-test" possible contracting modifications or alternatives for the FTS2000 follow-on, and to compare the costs and benefits of agency procurements under a comparable set of contracting options.

How long should the follow-on contract be? A 10-year contract may be too long and risky to plan modern telecommunication services, and it is longer than most large private-sector telecommunications contracts.

Adding FTS2000 Services

The overlapping vendor approach could also be used to obtain new telecommunication services as necessary through separate competitive contracts, eliminating debate over whether the services should be part of FTS2000 or not. If the overlapping vendor approach is *not* used for the follow-on, and if the FTS2000 follow-on includes a full range of services, should the contract be dynamic or static? What should constitute a new service requiring a separate procurement, and what is an acceptable modification to an existing contract? GSA could procure other advanced services either as part of the follow-on to FTS2000 or as separate governmentwide packages in order to realize discounts, simplify procurement, and encourage use. Separate procurements for telecommunication services outside the scope of FTS2000 may be more manageable in the short term, and perhaps could be implemented well before the follow-on to FTS2000. For the follow-on, including many or all services in a single FTS2000 package could strain the ability of the vendors to deliver the services well, and could limit competition. A large number of separate contracts, on the other hand, could significantly increase overall procurement and management costs.

- Either the follow-on or the current FTS2000 could include Internet access to simplify procurement and to encourage agencies to think more in terms of networking as part of normal operations. Internet access typically can be obtained through a local connection to a specialized Internet provider without the need for long-distance service.[30] Providing access to Internet services within FTS2000 could be straightforward, however. One of the two FTS2000 vendors (Sprint) already provides its own TCP/IP packet-switched network for Internet access. Adding TCP/IP capability to FTS2000 could be an additional feature to the present packet service, perhaps within the terms of the present contract. GSA could also procure a nonmandatory governmentwide Internet contract, or agencies could continue to procure Internet services independently.
- Similar options apply to value-added services. FTS2000 does not directly provide full value-added network (VAN)[31] services. An agency might transport data over FTS2000 to the nearest value-added net work gateway, but the traffic most likely travels to a local gateway and not over FTS2000 at all. Including value-added services that provide storing and forwarding of messages in the follow-on contract could encourage agencies to use electronic data interchange (EDI) and electronic benefits transfer (EBT). Value-added services maybe provided best by different specialty vendors that are experienced with electronic commerce, however. The nonmandatory, governmentwide, value-added service contract is currently held by Sprint.
- Agencies also can purchase cellular telephone equipment and services much like they purchase local telephone service. Since cellular service is significantly different from long-distance service, it may be managed better independently of the FTS2000 follow-on. International service also could be included in the follow-on to FTS2000, but with no clear advantages. The government's nonmandatory international switched voice service contract is currently held by MCI,

USING COMPUTER NETWORKS FOR ELECTRONIC SERVICE DELIVERY

The Role of Computer Networking

A large computer network such as the Internet[32] is actually a network of smaller networks that interconnects all types of computers, from mainframes to personal computers.[33] Users around the

30 Currently, FTS2000 does not directly provide full Internet services, but an agency might use the FTS2000 network to transport data to the nearest Internet gateway. An agency wishing to access Internet services must first arrange for the switching through a regional or commercial provider. Then it must separately arrange dial-up or dedicated access to the provider through the local carrier or FTS2000.

31 A value-added network provides special services such as storing and forwarding data packets for electronic data interchange. It may include special features for postmarking, archiving, retransmission, compliance checking, and interconnecting to other providers, FTS2000 users can send electronic documents using X.400 format electronic mail (called ITSMAIL), but without full value-added services.

32 The Internet is sometimes defined as all the interconnected smaller networks that use the TCP/IP format to send data. In practice, the degree to which a network is part of the Internet varies, and other formats are sent over the Internet or used within subnetworks. This section focuses mainly on the Internet and the related NREN. See Ed Krol, *The Whole Internet Users Guide and Catalog* (Sebastopol, CA: O'Reilly and Associates, 1992), For a discussion of other networks such as Bitnet, Usenet, or Fidonet, see John S. Quarterman, The *Matrix: Computer Networks and Conferencing Systems Worldwide* (Bedford, MA: Digital Press, 1990). For a review of computer networks and their applications and issues, see the September 1991 issue of *Scientific American*.

33 Banks and businesses have long used computer network for electronic funds transfer, automatic deposit Of checks, electronic data interchange, and so forth. However, these networks are managed privately or by commercial value-added providers, and are not discussed here. Commercial dial-up database services such as CompuServe, Prodigy, GEnie, or America Online are different yet, but have access to the Internet through electronic mail.

Nation can send messages, share computer memory and soft ware, and access files and programs as if the network were one large computer. This decentralized computing has been likened to the Nation's roads; houses (computers) form communities (local area networks—LANs—and other networks) linked through streets (local telephone access lines) and highways (telecommunication backbones).[34,35]

Net working provides a complete] y new form of communication. It is two-way, like telephones; it provides broad access to information at any time, like television weather or news channels or audiotext; it allows for community input, like a newspaper's letter page; and it can transport large documents, like the postal service. The full impact of the Internet and computer networks is not yet fully understood, as users continually find new ways to use them.

As of July 1993, over 100 Federal Government networks were attached to the Internet. Some Federal services on the Internet include the Department of Agriculture's commodity market reports, Food and Drug Administration's electronic bulletin board, U.S. Geological Survey's geological fault maps, State Department's travel advisories, U.S. Postal Service's zip code directory, Project Hermes Supreme Court decisions available over Cleveland's Freenet, Library of Congress' card catalogs and congressional information, and National Oceanic and Atmospheric Administration's weather and climate information.

The National Research and Education Network (NREN) is a program to develop and extend networking applications in research and education and is part of the High Performance Computing and Communications Program (HPCC).[36,37,38] One goal for the NREN program is to advance supercomputer networking, pushing transmission speeds between large users beyond 45 Mbps rates: the so-called "information superhighway s." Another NREN goal is to encourage new networking applications for educators, librarians, and others to provide much greater access to networked information. Pending legislation in Congress provides funding for computing and networking applications in manufacturing, education, libraries, health care, and government information.[39] NREN is intended to advance the overall national "information infrastructure" by helping to create new applications that will drive further private sector development of the collective telecommunications links, computer equipment, and other information technology needed to support computer networking.

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[34] Unfortunately the analogy is often misunderstood, and ignores the fact that large computer networks are *virtual* networks. That is, telephone companies already have high capacity fiber and microwave transmission in place throughout the United States. The fiber and microwave transmission is used for both voice and data. In fact, 95 percent of the customer traffic flowing over the collective AT&T, MCI, and Sprint backbone net work is over fiber, as is about 75 percent of the backbone traffic of the Bell operating companies. Some of this transmission capacity is then partitioned for the computer networks. Also, the analogy ignores the importance of developing new switching equipment and net work management techniques to manage data traffic, Finally, such "data highways" could bypass some rural and inner city "back roads' '—the Route 66 syndrome,

[35] The government role in computer networks would be different. Vice President Albert Gore, Jr. notes, "The idea of the Federal Government constructing, owning, and operating a nationwide fiber network to the home is a straw man. . . . This is a phony choice that some people see between a Federal public network, and no Federal involvement at all. In truth everyone agrees that there is an important role [for the government]. " Graeme Browning, "Search for Tomorrow," *National Journal, vol. 25, No. 12,* Mar. 20, 1993, p. 67.

[36] High-Performance Computing Act Of 1991, Public Law 102-194.

[37] For an explanation of gigabit research networks, see U.S. Congress, Office of Technology Assessment, *Advanced Network Technology,* OTA-BP-TCT-101 (Washington, DC: U.S. Government Printing Office, June 1993). See also Office of Science and Technology Policy, "Grand Challenges 1993: High Performance Computing and Communications," report by the Committee on Physical, Mathematical, and Engineering Sciences, Federal Coordinating Council for Science, Engineering, and Technology, n d.

[38] For a history of NREN and related policy options, see Charles R, McClure, Ann P. Bishop, Philip Doty, and Howard Rosenbaum, The *National Research and Education Network (NREN): Research and Policy Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1991). See also Brian Kahin (cd,), *Building Information Infrastructure* (New York, NY: McGraw-Hill, 1992).

[39] Introduced in 1993 as Title VI, the information Infrastructure and Technology Act of 1993 (renamed the information Technology Applications Act of 1993) included in S. 4, The National Competitiveness Act; and H.R. 1757, the High Performance Computing and High Speed Networking Applications Act of 1993 (renamed the National Information Infrastructure Act of 1993).

Computer Networking Issues

NREN and Electronic Service Delivery

Regardless of how the NREN program develops, Federal agencies can use the Internet for much of their computer networking and electronic service delivery. Relatively few government services are available on the Internet at present, however. Current use is mainly confined to electronic mail and file transfers, although the Internet has the potential to provide more powerful applications through such tools as Gopher software, Wide Area Information Servers (WAIS), searchable databases, graphics applications, information dissemination to subscriber lists, and so forth. Some agencies see the Internet as an important tool for reaching their client communities, while others perceive little value in the Internet and have no current plans to actively pursue its use. Many in government do not fully understand networking technologies and their potential applications.

Congress could clarify the purpose and intended beneficiaries of the NREN with respect to the delivery of government services.[40] Should government funding be provided to develop networking applications specifically for the delivery of services? Alternatively, should Federal funds directly subsidize recipients of networked Federal services?

Growing Pains

One strength of the Internet is its sheer connectivity— it is the largest computer network in the world. The Internet includes over 12,000 participating networks. It serves about 1.3 million computers and an estimated 10 to 15 million users in 127 countries.[41] Participation is growing by over 10 percent per month.[42]

The number of Internet users is growing so fast that the Internet is running out of available addresses, which necessitates changing the format of the packets used to send information.[43] The switches used to route the packets also are becoming overloaded. Higher network capacity requires new switches that are currently being tested in the HPCC testbed programs. The NREN progress is limited more by management and cost performance issues, however, than technology *per se.*[44] That is, participants have significant experience with the hardware, but a great deal remains to be learned about putting together and managing the system, Use of the Internet for electronic service delivery could place further stress on the system, and accentuate the need for upgrades.

Internet Pricing

An advantage for Internet users has been the flat fee structure and institutional support of portions of the Internet. Switching services and high-capacity dedicated links typically are provided at flat rates rather than based on direct usage. These fees are often offset by Federal and State grants to universities and other institutions, directly or indirectly. Institutions also pay for equipment and wiring, which often can be a substantial amount. Many individuals pay flat rates, or their costs are fully paid by an institution. The total Federal Government expenditures for Internet access are unknown, but may be less than 10 percent of total financing from governments, institutions, and corporate and individual users.

40 The NRENAISSANCE Study Committee of the National Research Council (NRC) has begun a study to develop a 5-year vision for the NREN program, including its relationship to the evolving national information infrastructure. NRC issued an earlier report on the issues of the NREN program, *Toward a National Research Network* (Washington, DC: National Academy Press, July 1988).

41 These data are as of June 1993, and are impossible to know exactly since each address may have many users and each is managed separately from the overall network. The Internet management structure is historically academic and decentralized, With no central management, no single person or organization can list all Internet users, Each Internet provider is centrally managed, however, resulting in an arrangement much like States that agree on traffic laws and connect their roads at borders.

42 Other networks are also growing rapidly. For example, Digital Equipment Corp. 's internal network includes over 80,000 computers in 37 countries. See Larry Press, "The Net: Progress and Opportunity," *Communications of the ACM, vol. 35, No. 12,* December 1992, p. 21.

43 This is analogous to running out of available telephone numbers in the telephone numbering system. See Daniel P. Dem, "Internet Running Out of 1P Address Space? Yes, No, and Maybe," *Internet World, vol.* 3, No, 7, September 1992, p. 13.

44 U.S Congress, Office of Technology Assessment, *Advanced Network Technology,* op. cit., footnote 37.

Prices for Internet access vary according to the application and the organization. If the connection is local, an individual might pay $9 per month for electronic mail access, or $19 per hour and up for full access. A rural school might spend $50 to $200 per month for dial-up or dedicated Internet access via modem; and a large corporation or university might pay $1,000 to $5,000 per month for 56 kbps to full 1.544 Mbps access. These Internet subscribers also must pay initial setup charges and the cost of leasing the necessary lines to get to the regional Internet provider. Dial-up 1-800 services are also available that bill the user according to minutes of service.

The Internet's rate structure likely will change in the future. New billing arrangements may make system management more complicated or expensive.[45-46] It is not clear how pricing may evolve and how changes might affect individual users. How will equity of access be assured? Will there be a tendency to serve wealthier commercial users, thereby pricing individuals, schools, and libraries out of the market? Will electronic advertising be allowed in order to support network providers? How will junk (unsolicited) electronic mail be defined and controlled, if at all? The utility of the Internet for government service delivery will be affected by decisions on how the Internet is priced.

Privatization of the NSFNET[47]

One of the participating Internet networks is the National Science Foundation's NSFNET. The NSFNET consists of three levels—the participating institutional networks, linked to regional not-for-profit and commercial network providers, which are, in turn, linked together through the high-capacity NSFNET backbone (see figure 3-3). The National Science Foundation partially sup ports the NSFNET backbone .[48,49]

The NSFNET is already essentially privatized, with the exception of the government support to some providers and many users described above. Privatization is expected to be complete in 1994, when NSF plans to award a new contract for very-high-speed-backbone network services (VBNS) limited to supercomputing applications. NSF will then end its support for the existing NSFNET backbone, and networks currently using it will have to make new arrangements, at some cost to each. These arrangements include leasing lines between networks and managing switching equipment. Several major network providers have formed a corporation—the Corporation for Regional and Enterprise Networking (CoREN)—to provide such backbone and other advanced computer networking services. The impacts of privatization on electronic delivery via the Internet are still unclear, and warrant close monitoring.

Local Access to the Internet

As with FTS2000, many Internet users depend on the local telephone carrier to enter the network and reach a user on the other end. This connection can be expensive for a rural user if the nearest Internet gateway requires a long-distance telephone call.[50] Internet access is therefore not equal for all citizens. If electronic service delivery over Internet becomes significant, the concept of uni-

45 One proposal for pricing Internet use, for example, has users bidding their maximum willingness to pay for access, with the priority given to the highest bidders on down until the network capacity is filled. At any given moment, however, all users on the network pay the same price, that of the last lowest priority user allowed on the network. See Jeffrey K. Mac Kie-Mason and Hal R. Varian, "Some Economics of the Internet," University of Michigan, Apr. 25,1993.

46 Eric Arnum, "The Internet Dilemma: Freeway or Tollway?" *Business Communications Review*, vol. 22, No. 12, December 1992, p. 28.

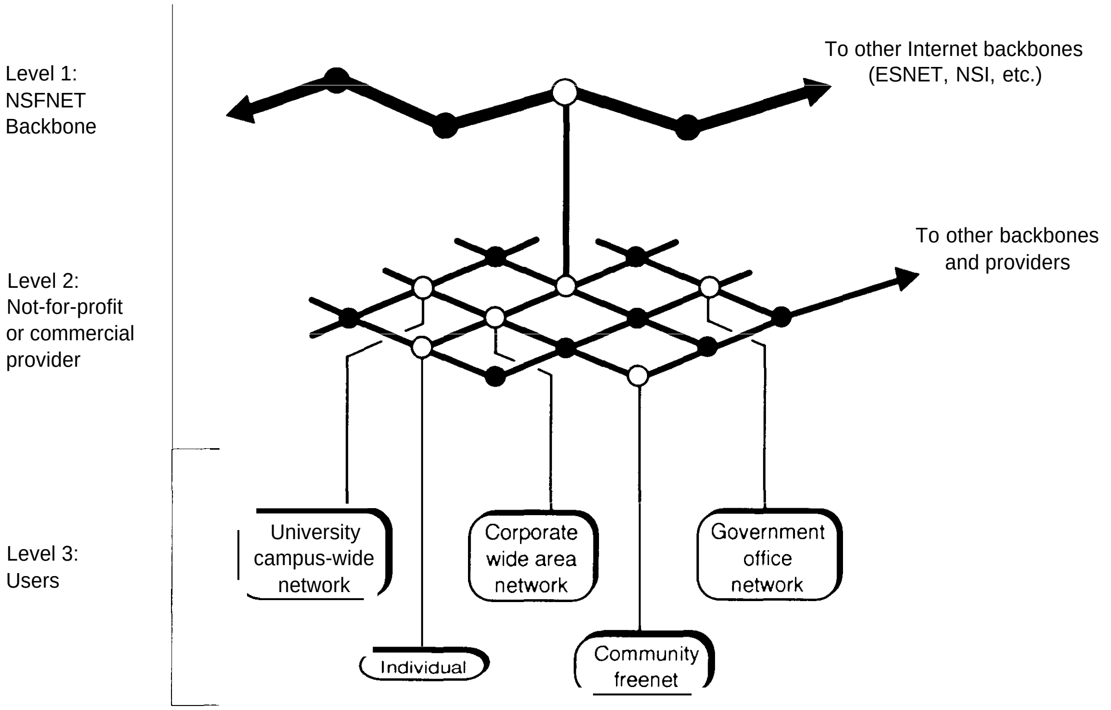
47 The NSFNET operations are reviewed in Office of the Inspector General, National Science Foundation, "Review of NSFNET," report to the Subcommittee on Science, Committee on Science, Space, and Technology, U.S. House of Representatives, Mar. 23, 1993.

48 Noncommercial networks and users are expected t. use the federally subsidized portions of the Internet only for nonprofit research or education purposes-the Acceptable Use Policy. Commercial networks are not subject to this restriction, and often sell services over their networks.

49 The NSFNET backbone itself has been supported by contributions from MCI and IBM ($60 million) and the State of Michigan ($S million), as well as NSF (about $10 million per year). Regional and campus networks may have invested over 10 times this total amount.

so The cost is sometimes reduced by using the long-distance call only to download or upload information, and reading this information off-line.

Figure 3-3-The Three Levels of the NSFNET



NOTE: The NSFNET backbone will be phased over to commercially provided backbones.

KEY: ESNET=Department of Energy's Energy Science Network; NSFNET=National Science Foundation Network; NSI=National Aeronautics and Space Administration's Science Internet.

SOURCE: Office of Technology Assessment, 1993.

versal service, usually referring to telephone service, could be redefined to include affordable access to Internet services.[51]

Local exchange carriers, FTS2000, long-distance carriers, or other providers could provide direct Internet access.[52] The local carrier could simply market or pass through the Internet access from a regional or commercial provider, for exampie, much as the local carrier currently connects and bills long-distance service to the home. Alternatively, the carrier could install its own gateways and sell the Internet access itself, in competition with other Internet providers, The local carrier would be acting much as it does with telephone service; that is, it provides connectivity to the outside world, but in this case through computer mail and file transfers rather than through voice communications.

Applications and User-Friendliness

As with the personal computer, the full potential of the Internet for citizens—whether for electronic service delivery or other purposes-will

[51] The Communications Act of 1934 creates the Federal Communications Commission to regulate commerce in communication "by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communications service with adequate facilities and reasonable charges, . . " Communications Act of 19.34, 47 U.S.C. 151, *et seq.* See *also* U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future,* op. cit., footnote 1; and U.S. Department of Commerce, National Telecommunications and Information Administration, *The NTIA Infrastructure Report: Telecommunications in the Age of Information,* op. cit., footnote 1.

[52] For example, Sprint already has its own commercial TCP/I P packet-switching service.

only be realized when applications are creative, easy to use, and relevant to their needs. If the government wishes to expand Internet use to schools, libraries, small businesses, or citizens-at-large through the NREN program, network applications and "information filters" must also help users manage the massive amounts of information appearing on the Internet. Otherwise, Internet use may continue to be concentrated primarily within the scientific, academic, and industrial research communities.

Novice users may also require some human interaction on the network, such as on-line assistants to help with a service or to find an electronic address. These "on-line librarians" or "network assistants" could be provided by the network providers (like telephone operators), by each service contributor (like 1-800 help lines), by libraries, or by new commercial companies. The assistants might respond over the network interactively via electronic mail or by telephone.

A locator to government services available via Internet would be particular y useful. It could be a simple index for finding services and other directories, and could be managed by each individual agency, a single governmentwide agency such as the National Technical Information Service (NTIS) or the U.S. Government Printing Office (GPO),[53] and/or a private company. Federal agencies already operate more than 50 electronic locators, but not all are accessible on-line, much less via the Internet.[54] NSF has cooperative agreements that promise to develop "first and last resort" information services (InterNIC) and a directory of directories (including types of directories equivalent to "white" and "yellow" pages). These arrangements may not be sufficient for citizens looking for government services, however. New types of network locators, such as Gopher, WAIS, Archie, and World Wide Web use software that directs users automatically to file or database servers, Locators to government Internet services would also be useful via telephone, dial-up electronic bulletin board, CD-ROM, magnetic diskette, and print, at least until the general public is fully acclimated to computer networking.

Network Privacy, Ownership, and Control

Computer networks raise new issues of privacy and confidentiality y, ownership and authentication, and information control and censorship-many of which are relevant to networked electronic service delivery. Regarding privacy,[55] what information can be gathered about users of computer networks such as the Internet? Should users be notified of all information gathered on them? Can the network provider sell that information? Should network users be able to obtain additional privacy? Who will enforce protection of network privacy? Commercial users often insist that their data traffic not travel over a competitor's network on the way to a destination. Some government applications may need to restrict network traffic to protect national security or the privacy of an individual's records. How will networks accommodate this? (Also see ch. 7.)

Regarding ownership, who owns the information on computer networks, and what can be copied legally?[56] Should the Internet be like a library, where one can borrow books and journals without a fee attached to the item? Should it be like the

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53 See the Government Printing Office Electronic Information Access Enhancement Act of 1993, Public Law 103-40.

54 Charles R, McClure, Joe Ryan, and William E, Moen, School of Information Studies, Syracuse University, "Identifying and Describing Federal Information Inventory/Locator Systems: Design for Network-Based Locators," report prepared for the Office of Management and Budget, the National Archives and Records Administration, and GSA, August 1992.

55 See James E. Katz and Richard F. Graveman, "Privacy Issues of a National Research and Education Net work," *Telematics and Informatics, vol. 8, Nos.* 1 and 2, 1991, p 71,

56 Copyright issues of electronic information are discussed in U. S Congress, Office of Technology Assessment, *Finding a Balance: Computer Software, Intellectual Property and the Challenge of Technological Change*, OTA-TCT-527 (Washington, DC: U.S. Government Printing Office, May 1992), See also Clifford A. Lynch, "The Accessibility and Integrity of Networked Information Collections," contractor report prepared for the Office of Technology Assessment, OTA-BP-TCT-109, March 1993; and Bruce Hartford and Jonathan Tasi ni, "Electronic Publishing Issues: A Working Paper," National Writers Union, New York, NY, June 30, 1993.

broadcast music industry, which pays songwriters a fee for every playing of a recording? Should it be like a bookstore, where one must pay in full for the book or journal? Current information gatekeepers maintain authenticity by producing recognizable publications or programs and through established reputations. Computer networks allow data to be easily manipulated or lifted from documents, however, and network data and document security is minimal at present. Who is responsible for maintaining the authenticity of documents transmitted over the network—authors/publishers, intermediaries, or users? Who should be liable for damage from, for example, a faulty software program obtained through the network—the user, the owner of a computer on which it was stored or distributed, or the author/publisher?

Who can or should control the information flowing over computer networks? Computer networks radically change the established methods and rules of free speech since the traditional gatekeepers—media owners and publishers--do not review the opinions. What rights and responsibilities do the new providers and users have? The government has a special responsibility to ensure fairness and protect free speech. If a statement is offensive or threatening, can a mediator edit or censor the discussion?[57] Widespread use of networking for electronic service delivery will intensify the need to address and resolve these issues. (Also see ch. 7.)

OTHER TELECOMMUNICATIONS INFRASTRUCTURE ISSUES

Importance of the Local Carrier—"The Last Mile"

Beyond FTS2000 and the Internet/NREN, several other telecommunications infrastructure issues are relevant to electronic delivery of Federal services. "The last mile"[58] is key for delivery of digital or high bandwidth government electronic services to citizens at home, If aging analog equipment is not replaced by more powerful digital equipment, regions with newer equipment may leave other regions behind. Booming regions with new fiber "superhighways" could leave behind many rural and inner city wire "back roads." Opportunities will be missed if sufficient telecommunication services are not available or affordable in the so-called "last mile" to disadvantaged Americans, telecommuters, librarians, and many others.

The local exchange carrier (LEC) has traditionally delivered telephone service the last mile to the home or office. Most switched transmissions must cross the LEC network at some point whether from the telephone, fax, modem, electronic kiosk, or automated teller machine, Even FTS2000 vendors must subcontract services from LECs, and Internet access requires transport through the LEC to reach the provider's switch.

There are some exceptions to using the LEC for electronic delivery of services over the last mile. New unregulated competitive access providers offer all-fiber digital telephone service in competition with LECs in some regions. Cellular and other wireless services can bypass the wire to the home, but cellular service is not available in many rural areas and is still quite expensive. Satellite 1 inks are effective for broadcasting or reaching remote or mobile locations, but currently are not practical for basic telephone services to the home. Cable television is available to about 97 percent of U.S. households; about 61 percent of all households subscribe.[59] Cable television, in theory, could be used for large-bandwidth switched services, but experiments with such switching are only in the earliest stages. Table 3-2 shows some telecommu-

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[57] The City of Santa Monica, CA, found that such "electronic town hall meetings" using their Public Electronic Network (PEN) system have been at times very useful, and allow the city to hear from a greater diversity of voices. The quality of a discussion sometimes degenerates, however, Although every user must register, the anonymity of a text-based discussion allows some users to dominate or intimidate others. See Pamela Varley, "Electronic Democracy," *Technology Review, vol.* 94, No. 8, November-December 1991, p. 43.

[58] "The last mile" refers t. the part of the system between the customer and the nearest telecommunications switch.

[59] Dr. Richard Green, Cable Television Laboratories, Inc., written testimony at a hearing before the House Committee On Science, Space, and Technology, Subcommittee on Technology, Environment, and Aviation, Mar. 23, 1993. The data are from A.C. Nielson Co. and Paul Kagan Associates, Inc.

nications providers and the services they can deliver in the last mile.

For digital or high bandwidth transmission to work, the carrier at each end of the line must have the necessary technical capability. New digital services such as ISDN are less useful if they are not universally available. Some high schools in Eastern Montana, for example, receive interactive two-way distance education via fiber optic lines, while the Little Big Horn College at a nearby Crow Indian Reservation still depends on analog telephone lines, and many of its residents have no telephone service at all. Despite the efforts of LECs to upgrade their physical plant, residents of rural areas, distressed inner cities, and other disadvantaged areas often receive upgrades last, since the LECs usually install new equipment first where their demand and revenues are greatest.

Federal and State policies on local carriers vary. Some State regulatory commissions perceive their role as keeping consumer prices low for basic telephone service, while others work proactively to implement advanced applications. This results in service variations across the Nation.

The Rural Electrification Administration (REA) has been successful in financing small private and cooperative LECs to deliver telephone service in rural regions, but the national standard of telephone service has been changing.[60] Almost 12 percent of rural households still do not have telephone service at all, and 12 percent of those that have service do not meet REA minimum specifications. Many who have standard service do not have access to ISDN or other digital services. Nearly all can access the Internet only through an expensive long-distance telephone call. The REA is still needed to finance existing and upgraded services, and it could redefine its minimum specifications to include more advanced services such as ISDN or local Internet access.

■ Traditional Copper, Modems, and ISDN

An alternative to installing new fiber optic cable and switched broadband to deliver information

Table 3-2—Providers and Technologies Delivering Services in the "Last Mile" to the Home

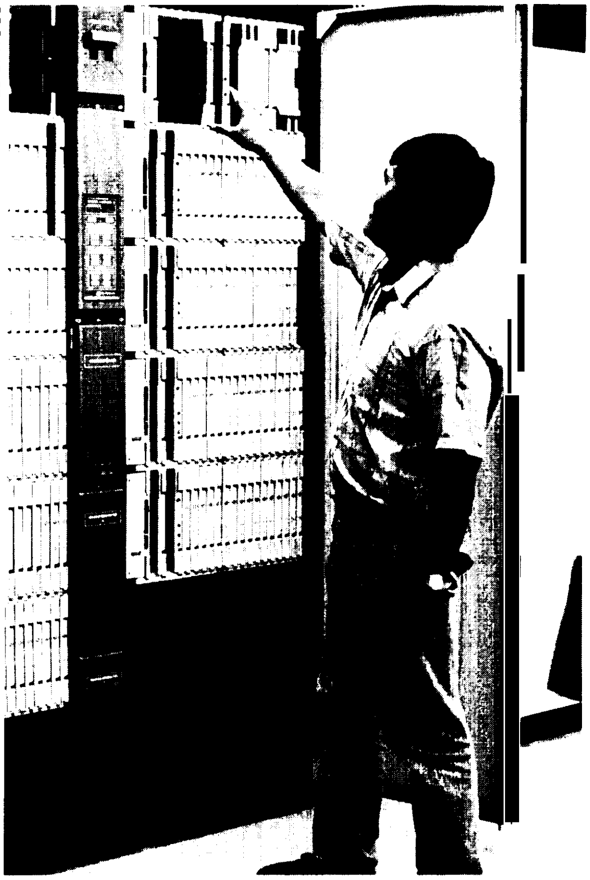
Service or technology	Telephone companies	Cable television companies	Mobile providers	Terrestrial broadcast stations	Satellite providers
Basic voice	Yes	Pilot/demo	Yes	Yes (one-way)	Proposed
Slow data	Yes	Pilot/demo	Some	Proposed (one-way)	Yes
Fast data	Proposed	Proposed	Proposed	No	Proposed
One-way broadband	Pilot,'demo	Yes	No	Yes	Yes
Two-way broadband	Proposed	Proposed	No	No	No
Packet-switching	Some	Proposed	Some	No	Yes

Some categorles overlap for example, two-way broadband will likely be delivered using packet-switching. Some services are available for large customers, but are not publicly available or available to the home

SO)URCI Office of Technology Assessment, 1993

[60] See also U.S. Congress, Office of Technology Assessment, *Rural America at the Crossroad!: Networking for the Future*, OTA-TCT-472 (Washington, DC: U.S. Government Printing Office, April 1991).

to homes, schools, libraries, and offices is to make better use of the present substantial investment in copper-wire cables. Fast modems can transmit data up to 28.8 kbps on analog lines, much taster than many of the current modems that operate at 1.2 or 2.4 kbps. Plain copper wires using ISDN services[61] or other digital technologies can achieve a tenfold improvement in data rate over most modems. Using high-bit-rate digital subscriber line (HDSL) and asynchronous digital subscriber line (ADSL) technology,[62] copper wires can reach one-half T1 (768 kbps) and full T1 (1.544 Mbps) rates at distances over 2 miles. Using local area net work protocols, copper can reach 100 Mbps over short distances. Whereas digital video once required 90 Mbps transmission, even 56 kbps is now sometimes acceptable for video due to advances in data compression. Put simply, ISDN, HDSL, and ADSL terminals serve as highly advanced transceivers—modems, in a sense—that correct for the limitations of the cop per wires. These advanced technologies may meet the needs of most users for years, and without the cost of new cable installation.[63]



Digital switching center at the OTZ Telephone Cooperative in Kotzebue, Alaska Rural and urban areas alike depend on modern digital switching and transmission technologies to provide high-quality, low-cost telephone service.

ISDN essentially moves much of the control features of the central switch to the user's telephone or switch. ISDN is well suited for telephone and on-line services and videoconferencing for users of all kinds, including small businesses, telecommuters, students, and health care workers. ISDN can send switched voice, fax, electronic mail, video, and packets over a single pair of copper wires that previously carried only voice or data-and more than one type of transmission at the same time. This is possible because ISDN is digital and uses "out-of-band signaling," which

[61] ISDN (Integrated Services Digital Network) is sometimes called *narrowband* ISDN to differentiate it from *broadband* ISDN (B ISDN). BISDN integrates digital voice, data, and video signals like ISDN, but is otherwise very different (see discussion of switched broadband in the following section).

[62] HDSL and ADSL are new services that also obtain more bandwidth out of the existing copper wires, but ISDN provides more control and functionality. Using the same copper wires needed for ordinary telephone service, but new technology at each end, one can obtain two-way 786 kbps transmission (HDSL), or one-way full 1.544 Mbps transmission with a 64 kbps voice channel in the other direction (ADSL). HDSL and ADSL may eventually provide video-on-demand entertainment, distance education, telemedicine, and videoconferencing to homes, schools, clinics, and businesses. See, for example, Gerald A. Greenen and William R. Murphy, "HDSL: Increasing the Utility of Copper-Based Transmission Networks," *Telecommunications, vol. 26, No. 8,* August 1992, p. 55. See also T. Russell Hsing, Cheng-Tie Chen, and Jules A. Bellisio, "Video Communications and Services in the Copper Loop," *IEEE Communications Magazine, vol. 31, No.* 1, January 1993, p. 62.

[63] Database servers also can be used to reduce the amount of information transmitted. The remote computer (the server) does the database queries quickly and sends only the results over a slow wire. The user's local computer (the client) receives the results and can display them off-1 ine, without tying up the wire with the entire database information.

allows for special control functions and variable bandwidths.

ISDN requires ISDN-compatible and independently powered equipment at each end, whether it be a telephone, fax, or computer interface. ISDN also requires that the long-distance and local telephone companies install software using the Common Channel Signaling System 7 (SS7) format in digital central office switches. The major long-distance companies have installed SS7, but the local telephone companies are moving more slowly. Only when SS7 is available is ISDN even an option for the consumer, who can then purchase ISDN terminal equipment and order the service. The first end-to-end long-distance ISDN call was made in summer 1992.

Like many services, ISDN is an example of the chicken-and-egg problem. New services often are not useful unless the y are ubiquitous, but they will not be ubiquitous unless users or providers perceive that the services are useful. Consequently, LECs vary in their marketing strategies and schedules to deploy ISDN.[64] Europe and Japan are ahead of the United States in percentage of telephone lines with ISDN accessibility, but the United States is ahead in lines actually used for ISDN.[65] Tariffs for private lines in Europe are relatively more expensive, however, making comparison of services difficult.

ISDN standards also vary nationally and internationally, but only to a small degree. The 25 or so different versions of ISDN standards are expected eventually to be interoperable, and will likely converge as companies upgrade their ISDN offerings.

Confusion over standards and high prices, and market ignorance about what ISDN real] y is, have resulted in delays and an image problem for ISDN implementation, Much of this delay is due to inexperience in planning and marketing on the part of the Bell operating companies after the divestiture of AT&T. Before divestiture, AT&T could more easily implement and market a single standard and compatible user equipment nationwide.[66] Europe also has had difficulties in planning and marketing ISDN, however, due to the transition from public monopolies to a competitive private sector.[67]

Recently, ISDN has received support on the basis of its lower overall cost to the consumer compared to a broadband fiber network,[68] although prices are still quite high (about $800) for an ISDN telephone. The cost of implementing ISDN has been placed at about $45 billion, excluding user equipment.[69] In comparison, local telephone companies spend about $20 billion per year for upgrades.[70] These upgrades include converting to the SS7 format, which is necessary for rapidly expanding 1-800 services as well as ISDN.[71] This $45 billion figure compares to over

64 Bell Atlantic, for example, had 49 percent of its network ISDN-capable in 1992, and expects to reach 87 Percent in 1994; Southwestern Bell had 16 percent deployment in 1992, and plans 21 percent in 1994. Daniel Briere and Mark Langner, "Users Wonder If JSDN Can Endure," *Network World, vol. 9, No. 38, Sept. 21, 1992*, p. 29.

65 France and Singapore had 100 percent ISDN-capability in 1990, and the former West Germany and Japan expect 100 percent capability by 1994. Department of Commerce, National Telecommunications and Information Administration, op. cit., footnote 1, p. 185. Dan Stokesberry and Shukri Wakid, "ISDN in North America," *IEEE Communications Magazine, vol. 31, No. 5*, May 1993, p. 93.

66 For an overview of ISDN implementation, see Kathleen M. Gregg, "The Status of ISDN in the USA," *Telecommunications Policy*, vol. 16, July 1992, p. 425.

67 Gerhard Fuchs, "ISDN—The Telecommunications Highway for Europe After 1992?" *Telecommunications Policy*, vol. 16, November 1992, p. 635. *See* also John Early, "Opening the Channels of ISDN," *Telecommunications*, vol. 27, No. 3, March 1993, p. 44,

68 See Mark N. Cooper, "Developing the Information Age in the 1990s: A pragmatic Consumer View," Consumer Federation of America, Washington, DC, June 8, 1992. See also "The Open Platform" and "Innovative Services Delivered Now," the Electronic Frontier Foundation, Washington, DC, n.d.

69 Bruce L. Egan, "Benefits and Costs of Public Information Networks: The Case for Narrowband ISDN," Columbia Institute for Tele-Information, Columbia University, New York, NY, February 1992.

70 About one-fourth of this amount is for new central office equipment, one-fourth for new copper installation, and 7 to 9 percent fOr new fiber cable installation. See Carol Wilson, "LECs Gear Up for Competition," *Telephony*, vol. 224, No. 4, Jan. 25, 1993, p. 33.

71 Karen Archer Perry, "The Race to Deploy SS7," *Telephony, vol. 223, No. 3*, July 20, 1992, p. 25. See also Dave Powell, "Signaling System 7: The Brains Behind ISDN," *Networking Management, vol. 10, No. 4*, March 1992, p. 36.

$200 billion for fiber installation and switched broadband, also excluding the user equipment.

Fiber and Switched Broadband Services

Another "last mile" issue is the replacement of copper wires with glass fibers to homes or neighborhoods. Fiberoptic transmission has been hailed as a means to revolutionize the delivery of government services, education, home entertainment, and the workplace. This "fiber-in-the-loop"[72] technology could ultimately deliver gigabits of information per second-equivalent to many channels of video information or tens of thousands of telephone calls. Telephone companies already use these fiber cables for telephone traffic between central offices. Many organizations use fiber for interoffice computer networks, and some telephone and cable companies have pilot programs using fiber in the last mile.

An important distinction in this discussion is between one-way broadband and two-way broadband services, or between unstitched and switched broadband. Fiber-in-the-loop currently is only capable of carrying mostly one-way, relatively unstitched transmissions, such as on-demand cable television. Two-way, fully switched services of all kinds may be possible in the future as the technology becomes available and affordable.[73] Such fully switched broadband services would integrate voice, data, and video, and would therefore require new end-user equipment.

Many experts and advocates agree on the eventual need for an improved telecommunications infrastructure using fiber and switched broadband services.[74] The question is how and when it should be implemented. Faster implementation would

Broadband network laboratory at the Pacific Bell facility in San Ramon, California. Many commercial companies are developing and testing systems for the transmission and switching of wide bandwidth signals.

presumably put the United States at a competitive advantage compared to other countries, much as it would give one State an advantage over others. But this investment has several risks:

1. Services delivered by fiber must compete with other technical and market alternatives. Cable television already supplies great bandwidth in one direction over coaxial cables or wireless technology. Cellular and other wireless technologies promise large bandwidths—some as high as one gigabit per second—and more flexibility.[75] With data compression technology, traditional copper wires can transport larger amounts of information more efficiently. Direct broadcast and other satellite providers could be strong competitors for data and video, and allow the customer to move locations easily. Compact video disks, vide-

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72 The fiber might go t. the home (fiber-to-the-home), to a neighborhood box (fiber-to-the-curb), or to the nearest neighborhood switch (fiber-to-the-neighborhood). In the latter two cases, existing coaxial cable and copper wires would carry the transmissions the final distance to the home. Unless otherwise specified, fiber-in-the-loop here refers to any of these three architectures.

73 The technology t. switch broadband for this and other applications (such as for supercomputers) is the focus of the High Performance Computing and Communications (HPCC) Program, which includes the NREN.

74 See Institute for Information Studies, op. cit., footnote 1. See also Martin C. J. Elton (cd,), *Integrated Broadband Networks: The Public Policy Issues* (New York, NY: Elsevier Science Pub. Co., 1991).

75 GTE Corp. recently made Quitaque, Texas the first wireless city when it converted the 700 residents from a wired to a wireless telephone system. See *Telecommunications Reports, vol. 58, No, 49, Dec. 7, 1992,* p. 15.

otapes, and CD-ROMs are strong competitors to provide entertainment and database information. Broadband *to the home is* more likely to redistribute revenues among these different providers than to drastically y increase net revenues and change consumer lifestyles. The redistributed revenues will come primarily from those citizens with more disposable income.

2. Switched broadband could be overkill for most consumers for man y years. FTS2000 and the commercial telephone systems are used main] y for voice calls or low-speed data transmission, even though many more services are possible. Previous experience with videophones failed, but not because of technology (which used existing analog switching and copper wires). Videophones failed because of the lack of customer interest and lack of connectivity (the chicken-and-egg problem of needing a minimum number of users to provide value).[76]

   Twenty years ago, interactive two-way service over coaxial cable also was heralded, much as fiber-to-the-home is today. The two-way cable movement failed because the switching technology was more costly than expected, consumers had little interest in two-way services, the cable industry was not interested or prepared to provide such systems, and the telephone industry was not interested in one-way television.[77]

   Today, the telephone industry is interested in providing one- and two-way video information and entertainment services if they can deliver advanced features such as video-on-demand, more channels, or better quality through high-definition television.[78] Such interest could drive fiber installation, and other equipment could be converted to switched broadband much later depending on cost and demand.

3. The cost of fiber-in-the-loop is high; the cost of switched broadband is even higher. Estimates of the total costs of implementing fiber-to-the-home by the telephone companies vary from $200 billion to over $1 trillion,[79-80] while fiber-to-the-curb or neighborhood would be much less. Cable television providers might provide nonswitched broadband using fiber and existing coaxial cables for about $20 billion. Costs include laying fiber cables to the user, and installing switching and other equipment. To fund the investment, regulatory agencies could allow telephone companies to shorten depreciation schedules to match true equipment lifetimes. Overall prices could be allowed to rise, or providers could finance the investment from sales of new services. Alternatively, a usage tax placed on all providers could subsidize the high-cost subscribers in order to guarantee universal service.[81]

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76 Many consumers have indicated that videophones Seemed useful to others, but were not perceived as Personally useful. In one study, consumers indicated they would actually pay *not* to be seen on a videophone, A. Michael Nell, "Anatomy of a Failure: Picturephone Revisited," *Telecommunications Policy,. vol. 16,* May/June 1992, p. 307.

77 A. Michael Nell, "The Broadbandwagon! A Personal View of optical Fibre to the Home," *Telecommunications Policy,* vol. 13, September 1989, p. 197,

78 Two telephone Companies recently announced plans to supply broadband services to the home using fikr-to-tk-neighborhood technology. US West plans to have 30 percent of its switches connected by the year 2000, with the rest connected by the year 2025. Pacific Bell plans to connect 50 percent of its lines by the year 2003, and 100 percent by the year 2015, A cable provider, Tele-Communications Inc. (TCI), recently announced a $2 billion fiber-to-the-neighborhood plan (using existing coaxial cable to the home) for 90 percent of its customers by 19%. The TCI system promises to carry the equivalent information of 500 compressed television channels compared to the present 50,

79 This is about $2,000 per household averaged over 100 million households. Bruce L. Egan, "The Case for Residential Broadband Telecommunications Networks," Columbia Institute for Tele-information, Columbia University, New York, NY, February 1992, See also Bruce L. Egan, *Information Superhighways: The Economics of Advanced Public Communication Networks* (Norwood, MA: Artech House, 1991); and David P. Reed, *Residential Fiber Optic Networks: An Engineering and Economic Analysis* (Norwood, MA: Artech House, 1992).

80 Nippon Telephone and Telegraph Corp. (NTT) recently abandoned its goal of installing fiber optics throughout Japan by the year 2015, and then reinstated it again. NTT estimates the investment at $400 billion. *Telecommunications Reports,* vol. 59, No. 16, Apr. 19, 1993, p. 8.

81 Bruce L, Egan and Steven S. Wildman, "Investing in Telecommunications Infrastructure: Economics and Policy Considerations," in Institute for Information Studies, op. cit., footnote 1.

4. Switched broadband must overcome significant technical problems.[82-83] Experts are concerned that packet delays and bandwidth management may be overly complex, adding to costs. Providing main and battery backup power to electronic transceivers is not a trivial engineering or regulatory problem and involves cost, safety, and maintenance trade-offs. Present analog (nondigital) video entertainment may be transmitted more cost effectively over coaxial cable due to the extreme requirements of analog transmission.
5. Without standards, switched broadband could develop with many noninteroperable formats and types of equipment, and the full opportunity would be missed. That is, users would face greater risks when choosing service and equipment, and participation would be much less inviting. The experience of narrowband ISDN proved that the divested Bell companies were less than successful in resolving such issues and marketing ISDN. The industry may have learned from that experience, however. The ATM Forum, for example, has over 150 members dedicated to standards for broadband packet-switching technology. The government also could act to promote standards--not to choose them, but rather to motivate industry to develop and adopt them.

   One solution to the problem of noninteroperable formats and equipment might be to require all local carriers-telephone companies, cable companies, etc.—to serve as common carriers for all types of content providers. They would then have a strong incentive to maximize connectivity and operability for all subscribers; at the same time, first amendment guarantees of free speech would be strengthened.[84] This might also lessen conflict between the interests of content providers versus connectivity providers.
6. While switched broadband and a fiber infrastructure are worthwhile long-term goals, intermediate solutions such as ISDN and fast modems will coexist, and should not be overlooked when forecasting future telecommunications needs. Even if switched broadband appears soon, it will develop in parallel with other services for the foreseeable future.[85,86,87] Federal agencies, in sum, need not wait for widespread implementation of fiber and broadband technologies to improve government services through electronic delivery.

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[82] See George T Hawley, "Break on Through to the Other Side," *Telephony*, vol. 220, No. 2, Jan. 14, 1991, p. 38; and Dustin J. Becker, "Power Problems in the Fiber Loop," *Telephony, vol. 218, No.* 3, Jan. 15, 1990, p. 46.

[83] Donald E.A. Clarke and Tetsuya Kanada, "Broadband: The Last Mile," *IEEE Telecommunications Magazine,* vol. 31, No. 3, March 1993, p. 94.

[84] Henry Geller, "Fiber optics: An Opportunity for a New Policy'?" Annenberg Washington Program, Northwestern University, Washington, DC, 1991.

[85] Vice President Albert Gore, Jr., said that "there is nothing inconsistent between pursuing ISDN as a useful stepping-stone, while at the same time encouraging more-rapid development of fiber and wireless networks capable of carrying full, uncompressed video and other applications . . . " "In fact, it's unlikely that the backbone network will involve a great deal of new fiber at all. It'll involve some, but most of the fiber we need is already there. What we need is new switches, new software, new standards that vastly upgrade the capacity of existing fiber to accommodate the extremely large data flows that a gigabyte network will feature." Graeme Browning, op. cit., footnote 35.

[86] John Sculley, former Chairman of Apple Computer, Inc. and an advocate of broadband technology, said that the collection of interconnected networks could use a variety of technologies including ISDN as a starting point, and that it would be a mistake to be "locked into a single technology." Sculley also said that fiber to the home is not current.ly a justifiable investment for the private sector, since it is not clear what services and products will sell. Testimony by John Sculley before the House Committee on Energy and Commerce, Subcommittee on Telecommunications and Finance, Jan. 19, 1993.

[87] Lawrence Gasman, "The Broadband Jigsaw Puzzle," *Business Communications Review,* vo1. 23, No. *, February 1993, p. 35.