(Re)Educating the Corporation

3

Many U.S. corporations are now facing the challenge of competing effectively in the global economy. These corporations cannot meet that goal without fostering a rapid and continuous process of learning among their employees, partners, and suppliers. Learning, however, is more than just corporate training and university education. It also encompasses collaborative research, in which employees share learning with each other, with customers, and with suppliers. Given this perspective, the purpose of this chapter is to: (1) explore the learning problems facing U.S. corporations and (2) define the existing and potential roles of distance learning technologies (applications and networking) in solving those problems.

To accomplish this mandate, the chapter first identifies the distance learning challenges facing U.S. corporations. The chapter than identifies the key distance learning applications that can meet those challenges. The chapter then describes each application.

The chapter is targeted at individuals who undertake *corporate support functions*, including line managers, financial managers, and accounting managers. The chapter is also targeted at people undertaking primary corporate functions, including marketing, customer service, and operations. In addition, the chapter is targeted at network service providers seeking distance learning marketing opportunities in the distance learning industry.

3.1 CORPORATE DISTANCE LEARNING CHALLENGES

Corporate management faces a number of business challenges, including the following:

- Upgrading the skills of corporate employees through corporate training programs;

- Upgrading the skills of corporate employees through formal university education;
- Establishing closer electronic ties with customers;
- Developing products and services rapidly and responding quickly to customer needs;
- Improving communications between upper management and employees.

3.2 CORPORATE DISTANCE LEARNING APPLICATIONS

IDL solutions can play a significant role in addressing each of the issues identified in the introductory section. To address those challenges, telecom/datacom managers need to understand how the challenges translate into specific IDL communications systems, applications, and solutions. Figure 3.1 provides a conceptual framework of the electronic links that corporate information entities at headquarters need to establish with remote corporate entities, as well as with customers and suppliers. These links are necessary to support the following IDL applications:

- Corporate training;
- Intracompany collaborative learning and research;
- Intercompany collaborative learning and research;
- Remote university education;
- Executive communication;
- Market research.

3.2.1 Corporate Training

Domestic corporations face growing competition from Japanese and European companies. Global competition will further intensify in the coming years as emerging Southeast Asian countries join the developed countries in competing head-to-head with the United States. The challenge facing U.S. corporations is how to prepare their workforce for effective participation in the skill-intensive industries that increasingly represent the backbone of the U.S. economy. Examples of these industries include computing, biochemical products, and telecommunications. The United States can no longer compete in low-wage, labor-intensive industries. Those industries have moved to the Far East and to third-world countries. Skill-intensive industries are increasingly replacing traditional labor-intensive industries as the key creators of new jobs in the U.S. economy. The success of U.S. corporations in these new industries will depend to a greater extent on the relative skills of their workforce and to a lesser extent on the availability of natural resources and the cost of labor.

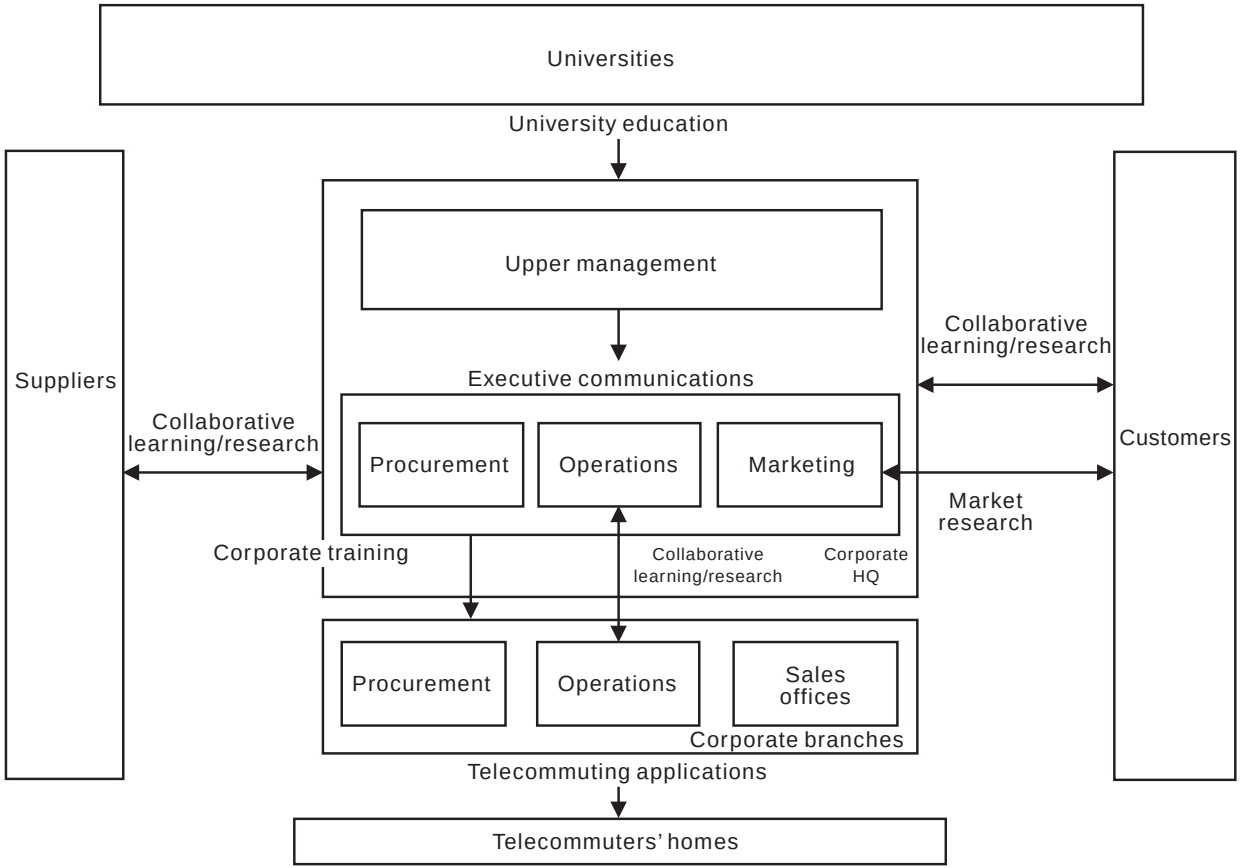


Figure 3.1 Corporate distance learning links and applications.

3.2.1.1 Corporate Training Participants

As Figure 3.1 shows, corporate training applies to corporate functions located in field offices and other remote corporate locations. This subsection describes the IDL needs of each of the remote corporate functions.

Blue-Collar Workers

One group of corporate employees that requires intensive training is blue-collar workers. Their training is necessary to increase productivity and to enhance their abilities to manage increasingly complex machines. According to experts in the field of corporate training, over 50 million U.S. workers need to be retrained. Workers need to acquire basic skills, including reading, writing, and computation, as well as interpersonal skills. Interpersonal skills are necessary because workers can no longer count on maintaining their jobs by performing repetitive jobs that are defined by rigid work rules. Instead, workers need to learn how to be more adaptive to be able to perform multiple tasks in a flexible manufacturing environment. They also need to learn how to operate as part of a team, since the teaming model is increasingly replacing the older model, in which workers were assigned specific tasks that they performed repeatedly. The previous paradigm limited the need for worker cooperation and multiple skills.

White-Collar Employees

While (re)training blue-collar workers is in itself a major national task, it is not the only demanding training task faced by U.S. corporations. The challenge of corporate (re)training also encompasses white-collar workers, who have to keep up with the latest developments in their fields. Technical functions, which represent about 80% of the U.S. workforce and receive about 30% of the annual corporate training budget, have the most demanding training needs. For example, technical applications are advancing so rapidly that a person performing a technical function needs to be constantly retrained to keep up with the latest advances in the field.

Product training is another important area of training for white-collar workers. In a competitive economy, corporations are racing to introduce new products and services. To be more effective, they need to speed the process and reduce the cost of disseminating information about new products to the sales force in the field. Such dissemination ensures that the sales force is educated about the specific features of new products and the value those products create for corporate customers. To accomplish this, organizations are seeking cost-effective IDL alternatives to the traditional face-to-face sales meeting paradigm. The need for such alternatives becomes more critical as (a) the size of the sales

force increases; (b) the sales force is more distributed among multiple locations, which may be scattered throughout a state, the country, or the world; and (c) the rate of new-product introduction increases. The alternative to direct face-to-face meetings could be one of several IDL technologies. Marketing and product managers play a vital role in the development and introduction of these products to salespeople in the field.

3.2.1.2 Problems With Current Corporate Training

Despite the importance of training, the United States has the lowest percentage of spending on training compared to the advanced European nations and Japan. The United States currently spends approximately $30 billion on corporate training, and about 10% of the U.S. workforce are beneficiaries of that training. While the monetary amount appears large, it pales in comparison to U.S. corporate expenditures on retooling (new plants and equipment), which exceed $475 billion. Considering the growing importance of human capital relative to the capital allocated to retooling, corporations need to find a better balance between the two outlets of capital expenditures. (Obviously, government can play a role in encouraging corporations to invest in education; this role of government is explored later.)

3.2.1.3 Technology Needs of Corporate Training

The technology requirements associated with corporate training differ from one function to another.

- Technical personnel are the most demanding in terms of the technology they need for corporate training. They value high-quality two-way videoconferencing solutions that can transmit quality video. Often they also need high-resolution still images related to the topic they are studying, which can range from CAD images for engineers to medical images for health services personnel.
- Marketing personnel may also be demanding in terms of the technology they need for product training. The quality of service required for product training is a function of the complexity of the product being introduced. If the topic of training is, for example, a new insurance product, the IDL solution may be as simple as audio conferencing. As the products become complex (e.g., technically oriented products), marketing managers need to add the visual component to their conferencing systems.
- Administrative personnel, such as accountants, lawyers, and human resource managers, are less demanding in terms of their IDL technology requirements and may be satisfied with one-way video/one-way audio solutions.

3.2.2 Executive Communication Applications

Corporate management in a headquarters location needs to establish (distance learning) communications links with corporate employees located in branch offices to formulate, create and disseminate corporate policy and to support emergency communications.

Corporate Policy Communication

The financial success of corporations is increasingly dependent on the ability of the upper management to anticipate competitive moves, to rapidly formulate and implement effective responses to those moves, and to mobilize employees to assume responsibility in implementing those moves.

To ensure the effective dissemination to and buy-in of employees, management needs to establish a continuing dialog with as many employees as possible throughout the process of developing and implementing the company's strategic plans. That dialog would accomplish two purposes: (1) to generate feedback from employees about planned changes, and (2) to create consensus among employees to ensure that the strategies are implemented, not undermined because of the lack of employee support or understanding. The keys to the effectiveness of these interactions are *speed, cost*, *interactivity*, and *reach.* Reach refers to the number of employees that can be contacted simultaneously by corporate management; interactivity is the ability of management to establish a two-way dialogue.

Traditionally, managers have communicated their messages and requested feedback from employees through memoranda or through field visits to branch offices. Increasingly, managers rely on e-mail to reach employees in various locations, an approach that enables employees to respond to the messages. E-mail is being complemented by other telecommunications approaches, including video broadcasting.

Emergency Communications

Corporations have been increasingly faced with emergencies, such as the Tylenol-tampering scare and the 1994 Intel defective-chip affair. Corporate management needs to rapidly reach employees in case of emergencies to ensure that all employees are making a concerted effort to contain and diffuse a crisis with minimum damage to corporate profits and corporate reputation. Upper management is (or should be) seeking cost-effective IDL approaches. The type of conferencing technology may be a function of the products being sold.

3.2.3 Intracompany Collaborative Learning and Research

In a competitive economy, corporations are racing to introduce new products and services. Product introduction involves extensive interactions at various stages of product development among engineers, product designers, sales people, marketing researchers and managers, and R&D. A successful process of idea generation, product development, and implementation must be *rapid*, *interactive*, *frequent*, and *inclusive* of all the departments and functions involved. It also must be a learning process in which all participants learn from each other and build on each other's knowledge and ideas. Of all the applications that have been explored in this chapter, this IDL application is probably the most demanding because it requires not only the visual/audio component of a conferencing solution but also the data component.

3.2.4 Remote University Education

Corporations provide donations and R&D-related funds to universities in exchange for R&D cooperation, recruitment assistance, and educational services. Educational services include university degrees offered to employees during after-work hours, as well as continuing education.

The corporate approach of meeting employees' needs for university courses and degree has been for employees to attend classes on campus. One shortcoming of this traditional approach is that many employees are unable to attend courses on university campuses due to physical distance.

3.2.5 The Telecommuting Distance Learning Application

Telecommuting is a growing corporate phenomenon that enables employees to work at home several times a week while retaining electronic communications links with the corporate office. According to industry figures, between 4 million and 8 million corporate U.S. employees have worked at least 8 hours per week from home as company employees and during business hours in recent years [1]. Employees are increasingly requesting permission to telecommute as a way to improve productivity, and at the same time spend more time with their families by reducing time on the road. Telecommuting saves money that employees spend on purchasing, maintaining, and fueling a car, on public transportation, and on summer and winter clothes. Employees believe that as telecommuters they can be more productive because they can work with no interruptions from coworkers, in more comfortable surroundings, with reduced exposure to air pollution, particularly in major urban areas, and without the stress associated with commuting.

Faced with increasing U.S. and international competition, regulatory pressures from federal, state, and local government, and increasing demands from their employees, employers are now developing and implementing telecommuting programs. Productivity gains can be achieved because telecommuters can work longer hours (6 to 10 hours per week) in view of eliminated commuting. Telecommuters also have improved work quality due to easier management of distractions and stronger work incentives resulting from a greater sense of being in control.

Employers are also developing and implementing telecommuting programs to reduce the costs of recruiting, relocation, and health insurance; to lower overhead costs associated with office space by making double use of desks; to reduce retraining costs resulting from employee turnover; and to recover from disasters more quickly by establishing communications links between corporate offices, including corporate data center locations, and the telecommuters' homes. Other sources of cost savings to employers include reduction in travel costs and reduction in penalties associated with noncompliance with government air quality mandates, which translates into fewer costs associated with penalty fees. Telecommuting also enables employers to reduce costs by utilizing untapped resources, including over 30 million disabled individuals who could join the workforce through solutions such as telecommuting.

The needs of telecommuters related to IDL are similar to those of their corporate colleagues working out of corporate offices. These needs include the following:

- *Collaborative research and education* with their corporate colleagues operating at corporate offices. Telecommuters would like to establish computer conferencing sessions with supervisors, partners, and technical colleagues on short notice to collaborate in the process of developing new products. For example, team members residing in different locations may be working on a design problem; establishment of a voice and data conference session would allow all the participants to view product illustrations, specifications, and graphics on their computer screens. That way, problems are discussed and resolved in real time. At the end of the conference, the latest version of the product design is available to all the participants and is saved in individual PC files or in a LAN server.
- *Access to university courses from their residences.*

3.2.6 Intercompany Collaborative Learning and Research

To speed the process of product development, corporate researchers, engineers, and marketing managers need to establish collaboration and learning links with their counterparts in other corporations, including their vendors and suppliers.

A successful process of idea generation, product development, and implementation must be *rapid*, *interactive*, *frequent*, and *inclusive.* Such a work paradigm can be viewed as another demanding IDL application. This application requires not only the visual/audio component of a conferencing-based solution but also the data component.

3.2.7 Market Research

To compete more effectively, marketing managers need to develop product features that meet customer needs. To keep in touch with their customers, many marketing managers conduct primary research, that is, gather information directly from customers. Traditionally, primary research has involved face-to-face meetings, telephone interviews, survey questionnaires, and focus groups. Each of these approaches has its limitations. For important customers, corporations may want to use complementary videoconferencing, which can be considered a distance learning application.

3.3 THE NEEDS OF IS CORPORATE MANAGERS

In selecting corporate IDL solutions, telecom/datacom managers should take into account the following factors:

- *Geographic coverage*. Telecom/datacom managers seek application solutions that support the geographic range of their end users. This range may encompass LANs, MANs, and WANs.
- *Range of applications and functions supported.* Telecom/datacom managers are concerned about a larger set of applications than those that are important to individual IDL receivers and providers. By definition, the needs of the entire organization have to be taken into account.
- *Support for installed base*. In selecting a distance learning solution, telecom/datacom managers seek a distance learning solution that enables them to overlay the IDL solution on their existing network infrastructure. The corporate infrastructure may include the following elements:
  - *A voice networking environment*, supported by a PBX or centrex and extended over MANs or WANs through either private lines or a public switched network system. Private lines for voice applications are increasingly being replaced by virtual private solutions and by circuit switched services.
  - *Legacy systems, including SNA. System network architecture* (SNA) systems interconnect hosts in one location (usually the headquarters location) with terminals in the same location or in other locations. Traditionally, hosts and terminals were interconnected through X.25

networks and private lines. Increasingly, these locations are interconnected through a frame relay network.
    - *A client/server environment.* Clients and servers may be in the same location and interconnected across LANs, such as Ethernet, token ring, and *fiber distributed data interface* (FDDI), or they may be remotely located. Until recently, client/server environments were extended over WANs through private line services. Now, FRS, ATM, and NMLIS are replacing private lines as WANs of choice to interconnect these environments.
    - *Satellite networks*. This technology is used widely for high-quality video distribution.
- *Access methods and speeds*. Telecom/datacom managers need different access methods and speeds to support these applications. Their requirements are shaped by the installed base as well as by cost factors. The range of access methods and speeds may differ from one company to another.
- *Ease of use and administration*. Telecom/datacom managers value application solutions that are easy for IDL receivers and providers and other corporate end users to use.
- *Low cost*. Telecom/datacom managers should take into account a number of elements in measuring the total cost associated with a new application solution, including the cost of acquisition, implementation, maintenance, and training.
- *Intracompany versus intercompany communications*. The appropriateness of the application solution may depend on the extent of the needs of telecom/datacom managers for intercompany versus intracompany communications.

3.4 DISTANCE LEARNING APPLICATION SOLUTIONS

The U.S. corporate training market is estimated to be a $100-billion-a-year business; upward of 35 million individuals receive formal, employer-sponsored education each year. A fair portion of that market can be served by wide range of IDL applications solutions which include the following:

- Dedicated institutional IDL systems, which can be further classified, in increasing order of complexity and sophistication, as one-way video/two-way audio, two-way video/two-way audio, and *n*-way video/*n*-way audio with continuous presence;
- Groupware;
- The Internet.

The following descriptions of these solutions assess to what extent each solution can support IDL applications.

3.4.1 The One-Way Video/Two-Way Audio Solution

This IDL solution is also referred to as "business TV." Business TV is based predominantly on satellite technology. As discussed in Chapter 1, two satellite approaches are available:

- Traditional satellite links, in which a transponder is dedicated to video;
- VSAT technology, which is less expensive than traditional satellite approaches but more limited.

Table 3.1 defines some key video-related terms that come into play in the discussion of production-level video.

Table 3.1
Key Video-Related Terms

Component video	Separate luminance and color signals supporting high-quality pictures.
Composite video	A video stream that combines red, green, blue, and synchronization signals into one so that it requires only one connector and/or connection. Composite video is employed by most television systems (e.g., NTSC, PAL) and VCRs.
Compression	Reduction in the number of bits used to represent an item of data.
D1 digital video	A high-end digital component video format that ensures minimal signal and generational loss.
Encoding (compression)	The process of compressing a digital and/or analog signal into a compressed digital signal (e.g., with MPEG-2 techniques).
Encoding (process)	A process, not specified in MPEG-1/MPEG-2, that reads a stream of input pictures or audio samples and produces a valid coded bit stream as defined in MPEG-1/MPEG-2.
Motion Picture Expert Group 1/2 (MPEG-1/2)	A set of international standards (ISO/IEC 11172 and 13818, respectively) for the digital compression of video to the 1.5- and 6-Mbps rate.
Noninterlaced video	Computer monitors use noninterlaced video, in which each line is scanned sequentially rather than in an alternative manner.
National Television System Committee (NTSC)	Organization that has set the TV standards for North America. Specifically for traditional TV, NTSC specifies a 525-line 30-frames-per-second format.

Table 3.1 (continued)

Phase alternate line (PAL)	Used in Europe. It employs 625 lines per frame and displays 25 frames per second (which results in more flicker than NTSC standards).
RGB	For red, green, and blue, the three additive colors used for television and computer monitor signals.
S-video	A video signal that employs two channels: luminance (Y; namely, brightness) and chrominance (C; namely, color). It is referred to as Y/C. Falls between component and composite video in terms of quality.
Sequential color and memory (SECAM)	TV system used in France and Russia (the chrominance is frequency modulated).
YUV	The color space used by PAL and some NTSC formats (Y is the luminance and UV are the color components)

3.4.1.1 Traditional Satellite Services

Commercial satellite communications began in the mid-1960s. Satellites now carry voice, data, and video traffic. Satellite communications offer certain advantages, such as broadcast capabilities and mobility. The technology, however, is under pressure from other high-quality transmission media that support broadband communications, particularly fiber optics.

Communications satellites act as relay stations in space for radio, telephone, and broadcast communications. Commercial communications satellites lie in the geostationary (geosynchronous) orbit at approximately 36,000 km (22,320 miles) over the equator. Small variations in the mass and the shape of the Earth affect a satellite's orbit, requiring that it be "repositioned" under spacecraft power to regain the proper position. More than 120 communications satellites occupy the 165,000-mile circumference of the geosynchronous orbit.

The characteristics of geosynchronous satellites include the following:

- Broad Earth coverage (corresponding to approximately one-third of the Earth);
- Orbital period of 24 hours;
- Round-trip delay of approximately 500 ms for half-duplex communication.

The location of a satellite is nominally defined by the longitude (degrees west) of the point on the Earth's equator over which the geostationary satellite appears to be positioned. Most satellite antennas must point to a predetermined area of coverage throughout the entire life of the satellite. The method used to control the antenna depends on whether the satellite is spin stabilized or three-

axis stabilized. Spin-stabillized satellites are stabilized by the induced rotation of the satellite according to the principle of the gyroscopic effect. The antenna is mounted on a counter-rotated platform so that it appears to be stationary in reference to the Earth's surface. In a three-axis-stabilized satellite, the antenna is mounted on a limited-motion gimbal, giving it flexibility in pointing; this antenna system requires a more complex control system than the spin-stabilized system. However, three-axis stabilized satellites have larger solar cell arrays compared to the surface of a spin-stabilized satellite, allowing them to have more operational power.

Satellites that are not in the geosynchronous orbit require Earth stations with movable antennas to track them; such is not the case for geosynchronous satellites. In the United States, which is the largest user of satellite resources, several organizations provide a spectrum of communications services over geostationary satellites operating around 4 and 6 GHz and around 12 and 14 GHz. Additional satellites in this frequency band are precluded by the lack of suitable orbit slots; hence, consideration is being given to higher-frequency operation (around 20 to 30 GHz).

The advantages of satellites include the following:

- The superiority of satellites for point-to-multipoint transmission makes them ideal for geographically dispersed broadcast TV (which requires transmission from a single location to many affiliate stations or to satellite dishes on roofs) and for private networks (e.g., teleconferencing and communications between corporate headquarters and branch locations).
- Satellite antennas are relatively easy to install and are even mobile, when installed on a small truck, and enable any ground station to become a network node. That makes satellites ideal for reaching remote or thinly populated areas where fiber optics cables would not be economically feasible. Fiber optics systems also require the establishment of a right-of-way for the cable to be laid, which can be difficult and costly.
- Satellites can be easily reconfigured while in orbit to cover different geographical areas.
- Total network failures are unlikely with satellite systems, except for catastrophic failure of the satellite itself. Storm damage to individual antennas will not affect the rest of the network.

Some factors that affect the applications of the technology to business communications include orbital spacing (e.g., only about 60 degrees of total equatorial orbit space are suitable for domestic satellite use), Earth station cost, antenna size, transponder power, and security. Difficulties in the late 1980s in delivering payloads into space have affected the availability of capacity for a number of years. Additionally, satellite orbits are close to being fully utilized. Other limitations include a lack of intrinsic security and propagation delays.

Nonetheless, many communication applications have emerged, including distance learning. What follows is a partial list of companies that use full-motion TV satellite–based technology for IDL. (Chapter 11 describes a case study that utilizes satellite technology.)

- Aetna Life Insurance
- Alabama Power
- Amdahl Corporation
- American Express Travel Related Services
- American Trucking Association
- Bell Communications Research
- BellSouth Corporation
- Channel Home Centers
- Computerland Corporation
- The Deparment of Energy
- The Department of Housing and Urban Development
- Digital Equipment Corp.
- Edward D. Jones & Corp.
- Electronic Data Systems Corporation (EDS)
- Equitable Life Assurance
- Federal Express Corporation
- The First Boston Corporation
- Ford Motor Company
- GE Appliances
- GE Capital
- GE Medical Systems
- GE Supply
- Georgia Power Company
- Georgia PublicTelecommunications Commission
- General Motors Corporation
- GMI Engineering and Management Institute
- Gulf Power Company
- Healthcare Satellite Broadcasting
- Hewlett-Packard Company
- IBM Corporation
- IDS Financial Services
- John Hancock Financial Services
- Johnson Controls
- Kidder, Peabody & Company, Inc.
- MCI Telecommunications Corporation
- Merck & Company
- Michigan Information Technology Network
- Mississippi Power Company
- MultiMedia Marketing Networks
- NBC Cable
- New York Life Insurance Company
- Phillips Consumer Electronics and Whittle Communications
- Prudential Insurance
- Redgate Communications Corporation
- Savannah Electric and Power Company
- Southern Company Services
- Southern Nuclear
- The State of Georgia
- Unisys Corporation
- The Upjohn Company
- U S WEST Communications
- Whirlpool Corporation
- Xerox Corporation

3.4.1.2 VSAT Technology

VSAT integrates transmission and switching functions to support on-demand links for point-to-point, point-to-multipoint applications. VSAT systems were deployed in relatively large numbers in the mid-1980s to early 1990s. Now with the plethora of new communications alternatives, it is not clear if the investment in hundreds of customer-owned satellite antennae is cost-justified with a reasonably short payback period.

One of the technological advances in the space segment has been increased transponder power, resulting in improved signal strength. This implies an acceptable signal quality even when smaller and less expensive Earth stations are used compared to traditional satellite systems. The term *very small aperture terminal* refers to the size of the antenna dish, which is usually 1.2m or 1.8m in diameter. The network topology is a star. Equipment prices have dropped to the point where a 1.2-m transmit/receive antenna now costs around $5,000.

During the past few years, there has been a general switch from C band to Ku band, providing even more signal directionality and increased effective iso-tropically radiated power. The FCC allocated the frequencies from 11.7 to 12.2 GHz and from 14.0 to 14.5 GHz—portions of what is commonly referred to as the Ku band—for primary use by fixed-satellite communications. With Ku band, some adjustment for rain attenuation can be made by using a stronger signal.

Users of VSAT networks can take advantage of the inherently broadcast nature of satellite communications. They can add or move sites within the footprint without concern for signal loss or increased monthly charges, since the signal is being continuously beamed across an entire area; however, moving does incur installation charges.

VSAT solutions are ideal for networks that have a star configuration, where a host computer site communicates with a number of geographically dispersed remote sites. As a rule, the outbound volume should be greater than the inbound volume. However, other configurations can be accommodated as well. VSAT applications are primarily for data and include point-of-sale, credit authorization, inventory control, and remote processing. In the early 1990s, video applications accounted for about 20% of the total VSAT traffic, and voice represented about 5%.

A VSAT network consists of three major elements:

- The master Earth station (MES);
- A number of remote VSAT Earth stations;
- A host computer site.

The MES, an intelligent node, is the communications hub for the rest of the network. Key to the successful use of small Earth stations is the star network topology, which enables the powerful MES to compensate for the relative weakness of the VSAT end of the channel. The large MES transmits a powerful signal to the satellite, so that the receiving VSATs can capture a high-quality signal. The transmit signal of the VSATs is relatively low powered, and the MES is needed to receive it, especially in a point-to-point network, where the VSATs are communicating with each other. The MES antenna is generally from 5m to about 9m in diameter. The MES must be designed specifically to support the type of equipment in use at the customer's host site. Most vendors' systems are designed to accommodate IBM SNA-based equipment, LANs, or both and are plug compatibles. The MES performs a variety of essential functions, including transponder monitoring and host interfacing. In addition to its antenna dish, the hub Earth station consists of RF/IF electronics, the network switching system, and a network management computer. Whether the MES for a network is shared among several organizations or is dedicated to one organization is a key question. The average network payback period for a network with a dedicated MES is estimated to be about five years, and it may be as short as one year in some cases. The cost of the hub—up to $1 million—places a fully private VSAT network out of the reach of most organizations. However, potential users will have access to full-service, shared-hub network offerings from satellite carriers and others.

The number of sites required to justify the choice of VSAT is variable. The vendors offering shared-hub network services claim there is no minimum number of sites (the emergence of shared-hub services offered by carriers is an important element in the size of the market). Whether the cost of a VSAT solution will be justifiable for a given organization is a complex decision and must finally be made on the basis of a detailed analysis.

The VSAT video solution offers several advantages to corporations:

- *Low monthly charges*. VSAT can help companies overcome the burden of local access charges. It can be cheaper than a regular transponder. To provide a sense of the possible costs involved in regular video/TV distribution, Table 3.2 lists "occasional service rates" in force at press time (for Vyvx's ImageNet service).
- *Access methods and speeds*. VSAT supports speeds up of DS1; hence, it supports H.261/H.262-video (i.e., videoconferencing quality), which is generally adequate for corporate users.
- *Range of applications supported.* VSAT networks can support the following IDL applications: corporate training, remote university education, and executive communication.
- *Support for installed base*. It requires minimum changes to corporate telecommunications infrastructure.

- *Geographic coverage*. VSAT can cover a wide geographic area, for example, major regions of the country or the entire country.
- *Ease of expansion*. Users can add a capacity to a network by requesting additional transponder bandwidth. Remote satellite antennae have to be installed. Generally, additional locations can be brought on line within a matter of days.
- *Intracompany versus intercompany communications*. VSAT technology is appropriate for both intercompany and intracompany communications.

Table 3.2
Occasional Service Rates

Point-to-Point Usage	*One-Way*	*Two-Way*	*Nonprime One-Way*
15 minutes	$140	$210	$95
30 minutes	$250	$375	$150
45 minutes	$360	$540	$205
1 hour	$440	$660	$265
More than one hour	Prorated 1-hour rate in 15-minute intervals (reservation needed)	Prorated 1-hour rate in 15-minute intervals (reservation needed)	Prorated 1-hour rate in 15-minute intervals (reservation needed)
Point to Multipoint Service			+
Reservation 1 hour or less	Rates are established by adding the appropriate one-way point-to-point charge and $50 for each additional destination per hour.		
Reservation greater than 1 hour	Rates are established by adding the appropriate one-way point-to-point 1-hour charge and $50 for each additional destination per hour, prorated in 15-minute increments		

The VSAT solution does have a number of limitations:

- *Inadequate support for some IDL applications*, including intracompany collaborative learning and research, intercompany collaborative learning and research, and market research. The VSAT solution cannot support these applications adequately because interactivity is limited to audio communications.

- *Increasing transponder cost*. The cost will likely be on the rise since many currently orbiting satellites are approaching the end of their useful lives and will not be replaced until the payload backlog is reduced.
- *Delay*. While VSAT is adequate for business TV, the half-second delay associated with VSAT transmission makes this technology less than optimal for two-way video/two-way audio communications with high interactivity.
- *Security*. Businesses need to encrypt the messages prior to transmission.

Example of a Business TV Implementation

A company that has implemented a VSAT system as an IDL solution is Ford Motor Company. A business TV system is used by Ford to train its engineers on the latest development in their fields. Recognizing that the shelf life of an engineering degree can be as little as 3 years, Ford allocates an annual budget of $240 million to retraining its engineers. Through its IDL program, Ford employees earn graduate credits and engineering degrees. The program was developed with Purdue University, the University of Maryland, and Wayne State University.

Ford also uses satellite technology in Europe to support the needs of its employees for IDL. The VSAT network of Ford supports 400 Ford dealers [2]. Through the satellite network, dealers are provided with updated information on products and services. The network also enables the dealers to provide direct feedback to senior management though live, on-the-air interactions. The network averages 2–3 hours of programming per week. According Ford, "There is no doubt that the satellite network has brought the company and its dealers closer together" [2]. The network enables Ford to establish instantaneous links with its employees and saves them the cost associated with planning national meetings and with producing and distributing reams of paper.

The computer industry is another major user of VSAT technologies. Examples of companies that use this technology for IDL purposes are Texas Instruments, Hewlett Packard, and IBM.

3.4.2 Two-Way Videoconferencing Systems

Terrestrially based video systems fall into two categories:

- Full-motion analog (6 MHz) or digital (45 Mbps) video;
- DS1 and $n \times 64$ Kbps videoconferencing systems.

Full-motion systems can be expensive and are used by only a few dozen companies. Videoconferencing systems (e.g., those using $n \times 64$ Kbps digital services) are currently used by more than 50% of all Fortune 1000 companies [4]. The largest users of videoconferencing are medical and educational institutions, with over 28% of the videoconferencing installed base, followed by

wholesale retail with 24% [5]. Corporations rely on videoconferencing systems to support the corporate training. For example, in the retail industry, videoconferencing systems are used to broadcast information on merchandise and new products to dispersed store locations. The timely delivery of this information provides store managers with several benefits, including the ability to be more responsive to the marketplace, the ability to reduce store costs associated with carrying unwanted inventory, and the elimination of discount sales to dispose of obsolete merchandise.

In the automotive industry, videoconferencing is used to keep car dealers informed of price changes, incentive programs, spare parts availability, and maintenance procedures [6].

3.4.2.1 Benefits and Drawbacks of Two-Way Videoconferencing

The two-way videoconferencing solution to corporate distance learning offers several advantages to corporations:

- *Access methods and speeds*. A wide range of networking solutions can support the two-way video conferencing solution.
- *Range of applications supported.* The two-way videoconferencing solution can support *all* the IDL applications: corporate training, remote university education, executive communication, intracompany collaborative learning and research, intercompany collaborative learning and research, and market research. In the case of the collaborative research/learning application, desktop solutions are superior to room-to-room solutions.
- *Support for installed base*. This solution requires minimum changes to the corporate telecommunications infrastructure.
- *Geographic coverage*. This solution can cover a wide geographic area.
- *Intracompany versus intercompany communications*. This solution is appropriate for both intercompany and intracompany communications.

The two-way videoconferencing solution, however, has one major limitation: cost. The cost factors differ, depending on the networking solution selected, the number of participants, and whether the solution is implemented room to room or desk to desk. Multicasting is more difficult with a terrestrially based system than with a satellite-based system.

3.4.2.2 Example of a Two-Way Videoconferencing System

An example of a two-way videoconferencing network is that offered by U S WEST. The U S WEST Star network service is based on a fully interactive, fiber optic–based solution. Examples of companies that have taken advantage of this network are Scientific-Atlanta and Zenith Electronics Corporation.

These companies provide cable TV engineers located in Minnesota with training. With the help of Wadena Technical College, in northwest Minnesota, engineers meet over the Star network by traveling short distances to one of two videoconferencing sites, which are located in Wadena and Wilmar. Scientific-Atlanta and Zenith provide the instruction from the Minneapolis suburb of Anoka. Each engineer pays a $25 registration fee and in return receives training in audio and video technologies.

3.4.2.3 Example of a Two-Way Video Distribution Network

This section focuses, for illustrative purposes, on two high-end video distribution services currently offered by Vyvx, Inc., a subsidiary of William Companies [10]. The services are in support of network-quality broadcast video.

ImageNet™ is a nationwide digital component transmission service that allows major video and film production houses, TV network facilities, advertising agencies, and corporate communications centers in the United States to communicate interactively among high-end graphics and production equipment. Component video is transmitted in real time end to end.

AtlanticVision™ is a one-stop video broadcasting (one-way video/two-way audio) service between the United States and the United Kingdom. The service is offered by a recently formed alliance between BT, Teleglobe Canada, and Vyvx.

The customer can supply either an analog TV signal or a digitized component video at 45 Mbps rate. The pricing structure of Vyvx takes into account the following factors:

- Direction of transmission (one-way video versus two-way video);
- Quality of service (ranging from presidential to economy);
- Access type (digital versus analog);
- Domestic versus international.

ImageNet is a nationwide digital component transmission service that allows major video and film production houses, TV network facilities, advertising agencies and corporate communications centers in the United States to communicate interactively among high-end graphics and production equipment (see Figure 3.2). Vyvx offers both the *digital codec* for inter-point-of-presence digital transmission and the inter-point-of-presence *digital transmission facilities*.

There are two nearly lossless methods of digitizing NTSC, PAL, or SECAM TV signals: *digital component video* and *digital composite video*. Digital component video, also known as 4:2:2, is a time-multiplexed digital stream of three video signals: luminance (Y), Cr (R-Y), and Cb (B-Y). The 4:2:2 refers to the ratio of sampling rates for each component. This format is also often called

D-1, referring to the tape format associated with the digital component recording. NTSC digital component video encoding systems have utilized the following parameters:

- Luminance sampling frequency: 13.5 MHz;
- Sampling frequency for color differences: 6.75 MHz;
- Pixels: 858 by 525.

At the final stage, the word length for digital image delivery is usually between 8 and 10 bits, but to maintain precision more bits may be utilized, particularly in the early stages of off-line processing (e.g., 16 bits). The ITU-R 601 standard supports both the 525-line, 60 fields/second format, and the 625-line, 50 fields/second format. The other lossless encoding method is digital composite video, known as 4fsc. This format also consists of three components: Y, I, and Q. I and Q are quadrature modulated and summed to the Y component. The result is a single information stream sampled at four times the color subcarrier rate. The term 4fsc refers to "4 times the frequency of the subcarrier." That format is often called D-2, referring to the associated tape format.

ImageNet has the following features:

- It provides compressed digital component video transmitted at 45 Mbps in accordance with ITU-R 601 and ITU-R 723. ImageNet also allows up to

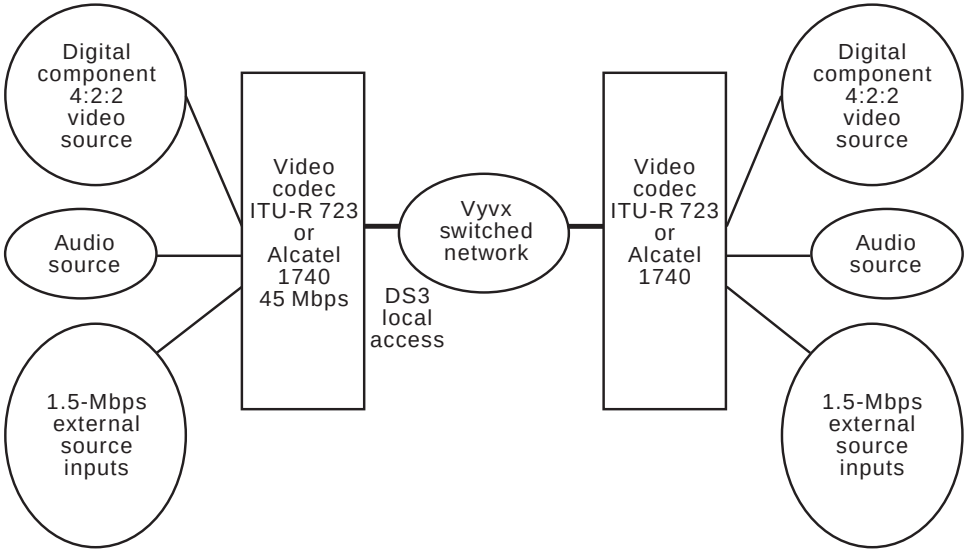


Figure 3.2 Vyvx service.

six 20-kHz AES/EBU digital audio channels transported at MPEG-1 layer 2 for high sound quality.

- ImageNet can support customer needs for either occasional service or dedicated service. The occasional service can be switched by customers to a variety of destinations at any time, anywhere in the United States.
- Vyvx can supply customers with digital component codecs and discount options.
- The service interfaces with standard video production equipment supporting ITU-R 601 digital video input standards.
- The service also supports international standard coding and transmission using equipment that conforms to ITU-R 723, and it supports Alcatel primary coding and transmission standards for their 1740 codec.
- Customers automatically receive 24-hour troubleshooting, network monitoring, and customer support.

Table 3.3 provides technical specifications for the services supported.

Table 3.3
ImageNet Technical Specifications for Component Video Transmission Service

Video coding specification	ITU-R 723
Audio coding specification	MPEG-1 LAYER II
Video I/F specification	ANSI/SMPTE 2J9M-1993 Serial component digital
Audio I/F specification	ANSI S4 40-1992 AES/EBV digital audio 4-6 channels
Transmission speed	DS3 44.734 Mbps
Data ports	DS1 1.554 Mbps
Access type	DS3 unchannelized

Table 3.4
ImageNet™ Technical Specifications for Alcatel 1740

Video coding specification	Alcatel 1740 VC
Audio coding specification	ITU-T J.41
Video I/F specification	SMPTE 12 SM-1992 Parallel component digital

Table 3.4 (continued)

Audio I/F specification	50–15 kHz, 600 Ohm, 4 Channel
Transmission speed	DS3 44.734 Mbps
Data ports	DS1 1.554 Mbps
Access type	DS3 unchannelized

AtlanticVision™ is a one-stop video broadcasting (one-way video/two-way audio) service between the United States and the United Kingdom. The service is offered by a recently formed alliance between BT, Teleglobe Canada, and Vyvx. The following are the key features of the service:

- Through the service, customers can send and receive broadcast-quality, full motion video via Teleglobe's CANTAT 3 transatlantic fiber-optic cable. The cable has a capacity of 96 digital fiber links and employs SDH technology.
- AtlanticVision™ transports signals between switching centers across North America to the main switching center in London (BT Tower).
- The service supports one-way digital transmission from either the United Kingdom or the United States.

In addition to ImageNet™ and Atlantic Vision™, Vyvx is currently developing and demonstrating new technologies and services, including digital archiving, ATM, remote movie production, and HDTV.

In the United States, access to Vyvx *television switching centers* (TSCs) is by way of analog facilities such as fiber, satellite, microwave, or coaxial cable. These services are called "first- and last-mile" service connections. The customer and the last-mile provider maintain responsibility for last-mile connections from the customer premises to the Vyvx *television center* (TC). However, Vyvx will provide special last-mile engineering services at customer's request.

In the service definition, TCs are the local access points to the Vyvx network with direct routing to the nearest Vyvx TSC. The TSC is the local-access point providing real-time rerouting, signal-quality monitoring, and service status and control.

Vyvx utilizes analog, rather than digital, first- and last-mile connections. Analog connections provide little degradation in picture quality while costing substantially less than digital connections. Additionally, Vyvx owns and maintains its codecs in its TSCs, further reducing the customer's transmission time.

In Canada, the first- and last-mile connections to TSCs are also established through analog facilities such as fiber, satellite, microwave, or coaxial cable.

However, the last-mile connections are provided and engineered by the Stentor-owner companies, which are BC Tel, AGT Ltd., Manitoba Telephone System, Bell Canada, NB Tel, Maritime Telephone and Telegraph, Island Tel, and Newfoundland Telephone.

Some establishments have "local accessibility." Those businesses, venues, TV facilities, cable systems, production companies, and other transmission networks are currently accessible to Vyvx through direct-loop or switchable connectivity at hubs. Vyvx/Stentor's accessibility to those local companies is considered "live," and connectivity can be accomplished soon after a request for transmission is submitted to Vyvx or Stentor.

A customer would use the following procedure to book a reservation from sites with existing connectivity:

1. Call Vyvx Traffic Center.
2. Supply event name, date of feed, start and end times of feed (EST), firm out or approximate end, and first- and last-mile city and circuit number.
3. Indicate if cross-connection at the hub will be made by the booking organization or by Vyvx.

The following procedure is used to book a reservation from a location without existing local loop or to request pricing information for installing local loops:

1. Check the Vyvx Local Connectivity Directory.
2. Call Vyvx TC.
3. Supply name of building or facility, street address and location of sites where local loops should be installed, local contact at facility, telephone number of contact, dates, and times.

Installing a local loop or getting pricing for the installation at most sites takes approximately a week to ten days, depending on the city and the available carriers; requests for sports facilities can sometimes be completed within eight hours, but it is best to allow at least 24 hours to order the loops from sports venues.

Although at a different range of service, Vyvx faces competition for business videoconferencing services offered by the major ICs, including AT&T, MCI, and Sprint. These ICs have a much larger share of the long-distance market (65%, 20%, and 13%, respectively).

Customers can choose from many sites in the United States and the United Kingdom, which are linked to the Vyvx network. These sites are summarized in Tables 3.5 and 3.6.

Table 3.5
First Video Network Affiliates

Albany	New York Network
Atlanta	Crawford Communications, Inc.
Baltimore/Owings Mills	Maryland Public Television
Boston	GBH Productions
Charlotte	Media Comm
Chicago	Nothwest Teleproductions
Cleveland	Classic Video
Dallas	AMS Productions
Denver	NORAC Production
Detroit	Producers Color Service, Inc.
Houston	Total Video, Inc.
Indianapolis	Sanders & Company
Jacksonville	Continental Cablevision of Jacksonville
Las Vegas	Creative Edge
Los Angeles	Pacific Television Center
Los Angeles	VDI
Miami	Comtel, Inc.
Minneapolis	Juntunen Video, Inc.
Nashille	TNN
Omaha	Cox Cable, Inc.
New York	All Mobil Video, Inc.
Newark	Prudential Television
Oklahoma City	Ackerman-McQueen, Inc.
Orlando	Century III
Phoenix	Southwest Television
Pittsburg	Production Masters, Inc.
Portland	KOPB
Raleigh/Durham	Capitol Satellite
St. Louis	Koplar Communications Center
Salt Lake City	STS Productions
San Antonio	Fibrcom
San Francisco/Oakland	Independent Television News

Table 3.5 (continued)

San Jose/Santa Clara	Transvideo Studios
Seattle	Third Avenue Productions
Southbend	Goldon Dome Productions
Tallahassee	Video Communications Southeast
Tampa	Telemation
Tulsa	Winner Communications
Washington	Interface Video Systems

Table 3.6
Canadian and U.K. Locations

Canadian Locations	*U.K. Locations*
Calgary	London
Edmonton	Belfast
Montreal	Birmingham
Ottawa	Bristol
Quebec	Cardiff
Regina	Carlisle
St. Johns	Granite Hill
Toronto	Kirk o' Shotts
Vancouver	Leeds
Winnipeg	Maidstone
	Manchester
	Newcastle
	Norwich
	Nottingham
	Plymouth
	Rowridge
	Southampton
	Tolsord Hill

The service is available as *occasional TV transmission service*, *cross-border occasional TV transmission service*, and *international service*. The following terminology applies to U.S. services (comparable terminology applies to international services):

- *Basic service—point to point*. Broadcast contribution quality TV transmission between two TSCs. Service is provided as one-way or two-way service in 15-minute increments.
- *Basic service—point to multipoint*. Broadcast contribution quality TV Transmission from one site to multiple sites. Service is provided as a one-way service.
- *Discounts*. Discounts are based on contract volume usage and are applied only to basic transmission services. At the end of the contracted discount term, charges are assessed based on the greater of the contractually committed hours multiplied by the applicable rate, or the actual hours used multiplied by the applicable rate. Applicable discount percentages are applied to the standard point-to-point and point-to-multipoint rates, thereby reducing the standard incremental rate for the appropriate reserved transmission period.
  - *Monthly usage discount.* Discount is based on committed monthly usage over a 1-month term.
  - *Annual usage discount.* Discount is based on committed annual usage over a 1-month term.
  - *Discount credit.* One-way service is credited 1 hour for each hour used. Two-way service is credited 1½ hours for each hour used. Multipoint service is credited 1 hour for each hour used.

Other charges include the following:

- *Overage*. Charges that are applied when a confirmed reservation is not canceled within a reasonable amount of time prior to the scheduled transmission start time (early acceptance, extensions, and overages do not apply if changes are made before the reservation begins).
- *Cancellation*. Charges that are applied when a confirmed reservation is not canceled within a reasonable amount of time prior to the scheduled transmission start time (early acceptance, extensions, and overages do not apply if changes are made before the reservation begins).
- *Rescheduling*. No charges apply for reservations that are rescheduled to a later time, provided the serving cities and duration of the reservation remain the same. Reservations that are rescheduled and then canceled are charged a cancellation charge of 100%. A reservation may be rescheduled only once (early acceptance, extensions, and overages do not constitute a rescheduling of a reservation).

- *Local switch charges*. Charges are applied when a customer requests that its first-mile or last-mile circuit be connected to another customer's first-mile circuit within the same TSC. Connections are for 24 hours.
- PGAD/secondary dropoff. A charge applies for each 1-hour increment of usage for each PGAD/secondary dropoff. PGAD/secondary dropoff originate from an authorized independent reservation but may terminate at different destinations.

Occasional-service rates for ImageNet were shown in Table 3.3.

3.4.3 The Internet

The Internet can support corporate needs for several IDL applications, including intracompany collaborative learning and research, intercompany collaborative learning and research, and corporate training.

The Internet supports corporate IDL applications through the following services:

- E-mail;
- File transfer;
- Host-to-host communications;
- Directory services;
- Online library catalog;
- Electronic whiteboards.

The Internet offers corporations the following IDL benefits:

- *Support by network service providers*. Access to the Internet is increasingly supported not only by the traditional Internet providers but also the AAPs, the LECs, and the IXCs.
- *A high-performance backbone*. The NSF backbone is migrating from a DS3 platform to a higher-performance network based on ATM and SONET.
- *An expanding range of applications*. The Internet can support collaborative learning and research applications (this was the original intent of the Internet).
- *Affordability*. The Internet remains one of the least costly approaches to providing interconnection.
- *Extensive information resources*. This represents another major source of strength of the Internet as an application solution to the distance learners. Through the Internet, the IDL community can access hundreds of libraries around the world, as well as library catalog and full-text delivery services.

- *Ease of use*. New services, such as WWW, make the Internet easier to access and to use, extending the use of the Internet beyond the corporate technical functions to encompass, for example, the marketing functions.

The Internet, however, cannot be considered as a complete IDL solution for the following reasons:

- *No guaranteed performance*. The IDL community needs to take into account that they cannot be guaranteed a given throughput across the Internet nor a consistent reliability level. That is because the Internet, while serving thousands of organizations and millions of individuals, lacks any mechanism for reserving bandwidth. In addition, the Internet is made up of many networks. Hence, the establishment of common reliability levels requires complex interactions among a large number of Internet providers.
- *Lack of extensive antiviral software*. Internet e-mail and downloaded files have been known to contain viruses. These viruses cannot be eliminated without the availability of antiviral software on every machine on the network.
- *Junk e-mail*. Corporations connected to the Internet can be flooded with useless and unwanted e-mail. Junk mail is particularly problematic to corporations, because their employees may spend valuable time reading the junk mail. Junk e-mail also consumes valuable disk space.
- *Security issues*. Probably the most important concern of the Internet is its security limitations. Several Internet security violations have occurred lately. The security limitation of the Internet restricts the usefulness of the Internet to interorganizational communications, including those associated with IDL solutions. For example, as long as security is a major concern, corporations cannot rely on the Internet to deliver corporate training courses, even when two-way videoconferencing over the Internet becomes more widely available.

3.4.4 Groupware

Groupware is an emerging data-oriented corporate IDL solution that can provide corporations with a private alternative to the Internet. As in the case of the Internet, groupware provides a solution to the collaborative learning application. While the Internet is a public solution, groupware can be implemented either as a private solution or as a public solution. Groupware refers to software that supports at least one of the following IDL applications:

- Electronic messaging;
- Data conferencing;
- Last messaging gateways.

Groupware offers IDL receivers and providers and other corporate employees several benefits:

- *Low cost*. In implementing groupware, telecom/datacom managers incur a nonrecurring cost. This cost is on either a user or a server basis.
- *Multiple applications*. Groupware supports multiple applications, including collaborative learning and research.
- *Ease of use*. Multifunctional groupware solutions are based on GUIs, which makes it easy to use by IDL receivers and providers and other corporate employers.
- *Security*. As a private solution, groupware provides a more secure solution for intracompany communications than the Internet.
- *Training and consulting*. The leading providers of multifunctional groupware provide their buyers with training or consulting as part of their product package.

While groupware offer corporations several benefits, telecom/datacom managers need to consider that groupware is predominantly implemented as a private application solution. They also need to consider the cost of selecting, implementing, and upgrading the groupware solution. In addition, they need to consider that groupware cannot adequately support corporate training, executive communication, or market research unless it is complemented by desktop videoconferencing.

3.5 CORPORATE NETWORKING SOLUTIONS

Currently, there are several distance networking solutions that can meet at least some of the telecom/datacom managers' requirements and that can support some of the IDL application solutions described in the previous section. These solutions include:

- Private DS1 lines;
- Switched/dialup services;
- SMDS;
- FRS;
- ATM/CRS.

In addition, several networking solutions are available to support the needs of telecommuters. These solutions include dialup analog services and ISDN. For each solution, a brief description is provided and its key strengths and limitations relative to IDL applications are highlighted.

3.5.1 Private Lines

A private line is a dedicated service that operates at DS1, DS3, and SONET speeds. This service provides a communication link between two locations through the establishment of a physical connection. Private lines are currently widely available in the United States and are offered by LECs, AAPs, and IXCs. As an IDL solution, the private DS1/DS3 solution provides a corporation with several benefits, including the following:

- *Support for IDL application solutions*. Private lines can support most IDL application solutions, including one-way video/two-way audio, two-way video/two-way audio, groupware, and the Internet.
- *Support for installed base*. Private networks became an integral part of corporate networks in the 1980s. The introduction or expansion of IDL solutions to a corporate networking environment may simply mean the allocation of a number of spare private-line channels to distance learning application solutions or the expansion of the installed base of private lines.
- *Security*. Private lines are perceived by telecom/datacom managers to be secure, since they are dedicated to individual customers. An increasing number of these lines are carried over fiber facilities.
- *Adequate bandwidth*. DS1 private lines provide corporations with adequate bandwidth. This bandwidth can be subdivided into multiple subchannels. Some of these channels can be dedicated to an IDL solution, while other subchannels can be used for other corporate applications. Each channel or group of channels can support various types of traffic, including voice, signaling, data, and video.
- *An established supply structure*. Private DS1 line services are established services. They are widely supported by LECs, IXCs, and AAPs. In addition, the increasing competition is driving down costs and making the service even more appealing.
- *Reliability*. DS1 private lines are reliable and proven. Information transport in dedicated bandwidth time slots guarantees throughput with no lost packets or processor bottlenecks.
- *Scalability*. DS1 private lines are scalable (e.g., DS3 lines), allowing for flexible network configuration, particularly for small networks.

Many organizations have now moved up to DS3 dedicated lines, providing 45 Mbps, or the equivalent of 28 DS1 lines. Typically the corporate telecom/datacom manager allocates some of this bandwidth to data applications (both legacy mainframe traffic and legacy LAN traffic), voice applications (PBXs), and video.

Private networking solutions are not, however, optimal in all situations. One of the drawbacks is that DS1 economics become less appealing to telecom/datacom managers as the number of corporate locations requiring interconnection increases. TDM-based private-line solutions are also bandwidth inefficient because they allocate bandwidth to devices that have nothing to send. Another shortcoming of DS1 private lines is that as private networking solutions they cannot support the IDL networking links of corporations with universities, high schools, suppliers, partners, customers, and telecommuters.

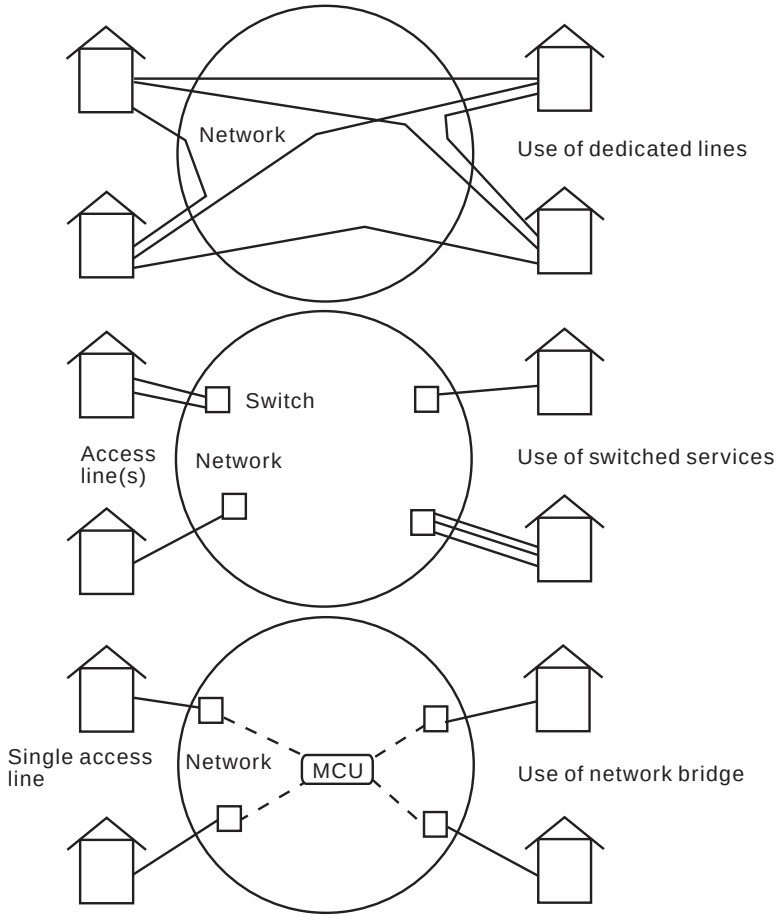
An example of a private line–based videoconferencing network is that offered by SBC [8]. This service connects corporate locations in Oklahoma with IDL providers, such as Oklahoma State University. Through the service, employees of companies such as Conoco and Philips Petroleum can enroll in university graduate courses in petroleum, electrical, and mechanical engineering. This IDL solution provides corporations with a recruiting edge and with the ability to enhance the skills of their employees, while saving those employees the time associated with traveling to a university location, which could be as far away as 60 miles.

3.5.2 Switched/Dialup Services

Switched/dialup digital services are circuit switched–based services that support speeds ranging from 56 Kbps to DS3 and support voice, video, and data traffic. With private lines, corporate participants need multiple dedicated lines to establish connections with multiple locations; with switched/dialup service, corporate participants need only one access line per required connection; with a network-resident bridge, only one line per location is needed (see Figure 3.3). To establish a connection with other locations, a corporate participant dials a number (call setup is based on the North American dialing plan). When the circuit switch receives the call request, a circuit is established for the duration of the call. This circuit is taken down as soon as the call is completed.

Switched/dialup services offer corporate participants several advantages over private lines:

- *Support for IDL application solutions*. Switched/dialup services can support most IDL application solutions, particularly at the higher speeds, including one-way video/two-way audio, two-way video/two-way audio, and the Internet.
- *Cost reduction*. Switched/dialup services could be more economical than dedicated DS1 lines, particularly when there are many sites to be interconnected, because with switched/dialup services each corporate site requires only one connection to reach all other destinations when a bridge is used (otherwise, multiple access lines are required). Switched/dialup



Fifgure 3.3 Dedicated versus switched connectivity.

services can also reduce corporate administrative costs if network connections of a corporation cannot be predicted in advance, or if these connections are constantly changing. Switched/dialup services also simplify network administration because they use the E.164 ISDN numbering plan. Switched/dialup services may also be more economical than private lines because they are usage sensitive, while private-line services are not. The economics depend on usage levels; at low usage, dialup lines are cheaper.

- *Extensive bandwidth capabilities*. Switched/dialup services provide the telecom/datacom manager with bandwidth capabilities that range from 56 Kbps to 45 Mbps. However, a set of dedicated access lines is required.

- *Flexibility*. Switched/dialup services are flexible because they enable telecom/datacom managers to include additional locations in their corporate networks without having to justify the expense of an end-to-end dedicated line.
- *Migration capabilities*. Switched/dialup services provide corporate participants with a migration path to more advanced switched services such as FRS and CRS.

While switched/dialup services can provide a corporation with several benefits, they have several limitations:

- They are not widely available yet, particularly at the higher speeds (this situation may change in the next few years, because RBOCs are increasingly deploying circuit switched services at DS1 speeds).
- As a circuit-switched technology, switched/dialup services have a relatively long call-setup time (3 seconds), although that should not be a problem for any IDL applications except data distribution.
- Switched/dialup services cannot support LAN interconnection applications, such as groupware, in the most effective manner, because bridges can be unstable when interconnected through switched/dial up services.

3.5.3 SMDS

As discussed in Chapter 1, SMDS is a connectionless WAN service that supports multiple-access classes. One of these access speeds can be supported by a DS1 access line, while the other speeds (4 Mbps, 10 Mbps, 16 Mbps, 25 Mbps, and 34 Mbps) can be obtained by using a portion of a DS3 line. SMDS is also available at 64 Kbps. SMDS offers low delay (5–10 ms for a DS3–DS3 link), high throughput (95% of packets are delivered in less than 20 ms), low error rates, high reliability, and availability (99.9%).

SMDS addressing scheme complies with ITU-T E.164 plan for ISDN/BISDN "telephone numbers," providing end users with transition to ATM, at least in terms of this feature. SMDS has several service capabilities, including multiple addresses per interface, and authentication of address in each packet. An SMDS customer can choose a list of addresses to communicate with; all other addresses are blocked. In addition to its addressing capabilities, SMDS enables corporations to establish *logical private networks*, which could be used by corporations to establish connectivity with a select number of corporate locations, suppliers, or customers. SMDS also has multicasting capabilities, which are similar to the broadcast/multicast capabilities of LANs. These capabilities are useful for address resolution, router updates, and resource discovery.

Corporations can deploy SMDS either as a new service or as a replacement of private lines. To deploy SMDS, a telecom/datacom manager needs to order the service from the local exchange carrier, install a DS1 or DS3 SMDS access line from the desired location to the service office of the local exchange carrier, purchase a router or an SMDS upgrade for an existing router, and install a DSU/CSU on the access line. SMDS is principally used for data.

SMDS provides corporations with several benefits, including the following:

- *Cost reduction*. SMDS could be more economical than dedicated DS1 lines, particularly when there are many sites to be interconnected, because with SMDS each corporate site requires only one access connection to reach all other destinations. SMDS can also reduce corporate administrative costs if network connections cannot be predicted in advance, or if those connections are constantly changing (of course, each potential remote location needs to have an access line). SMDS is also more economical for small organizations that have considerable data communications needs but cannot justify the expense of building a private network. SMDS could also be viewed as an economical service, because it provides a relatively graceful migration path to ATM technology. This comes about since SMDS and ATM have several technical similarities, including the ability to transfer data in fixed, 53-octet cells and the E.164 address plan.
- *Support for bursty data applications*. SMDS is well suited for corporations that want to implement data-oriented IDL solutions, such as groupware and the Internet.
- *Extensive bandwidth capabilities*. SMDS provides the telecom/datacom manager with a choice of access classes, enabling the manager to start at a lower bandwidth level and then migrate the network to a higher access class as the communications needs of the institution warrant the upgrade.
- *Flexibility*. SMDS is flexible because it enables telecom/datacom managers to include corporations in their corporate networks that do not justify the expense of a dedicated line.
- *Security*. SMDS has several appealing security features, enabling telecom/datacom managers to establish virtual private networks. Addresses can be screened so that only authorized destinations can receive data, and only authorized sources can send data. Through the group addressing capabilities, corporations can broadcast data to multiple locations at once.

While SMDS can provide a corporation with several benefits, it has several shortcomings: It supports only packet data traffic, and it cannot support voice and real-time video applications. Consequently, SMDS cannot support a number of IDL solutions, including one-way video/two-way audio and two-way video/two-way audio.

3.5.4 Frame Relay Solutions

Frame relay networks provide another data communications alternative for corporations. FRS is a (mostly) data-only, connection-oriented frame-transport service over assigned virtual connections. These virtual connections, which are supported through statistical multiplexing techniques, can be either permanent or switched. The FRS available on the market at press time was PVC based. A PVC connection is usually established when the service is provisioned at subscription time, eliminating the need for user-to-network signaling. FRS supports access speeds of 56 Kbps, $n \times 64$ Kbps, and 1.544 Mbps.

A frame relay network is based on ANSI standards, including T1.606, which specifies user-to-network interface requirements; ANSI T1.617 annex D, which specifies network management functions; and ANSI T1.618-1991 (LAP-F Core), which operates at the lower sublayer of the data link layer and is based on the core subset of T1.602 (LAP-D). The frame relay data transfer protocol defined in T1.618/LAP-F Core is intended to support multiple simultaneous end-user protocols within a single physical channel, since, above layer 2, this protocol is transparent. As a result, most existing protocols (e.g., TCP/IP) can ride over frame relay transparently to the end devices.

Frame relay can be implemented as either a private or a public solution. Frame relay can be implemented as a private networking solution by either (a) purchasing routers (or frame relay software additions to existing routers) and establishing point-to-point connections among those routers, or (b) using a customer-owned frame relay nodal processor (or a software upgrade to an existing packet switches or multiplexers), which is basically a frame relay switch.

Corporations can access a public frame relay network by (a) installing a software upgrade to a router or a bridge or purchasing a *frame relay access device* (FRAD) or direct firmware support on a host; (b) connecting an access line between the carrier and the corporations' CSU/DSU; (c) ordering FRS from a carrier offering the service; and (d) configuring PVCs for the sites to be linked to the network. A gamut of carriers currently support FRS, including RBOCs, the major IXCs, and several VAN providers.

FRS provides corporations with several benefits, including the following:

- *Economic benefits*. FRS offers a more economical networking solution than TDM-based DS1 lines because it is based on statistical multiplexing techniques. In the long term, FRS could also be viewed as an economic service, because it provides a migration path to ATM in the sense that it gets the organization on a packet-based paradigm.
- *Support for bursty data traffic*. FRS is well suited for specifically supporting data-based IDL application solutions, such as groupware and Internet access.

- *Availability*. FRS is widely available and is currently supported by IXCs, LECs, and RBOCs. FRS is also increasingly supported by the AAPs, such as Teleport Communications Group.

While FRS can provide a corporation with several benefits, it has a number of shortcomings, including:

- *Lack of support for isochronous traffic*. FRS supports only bursty packet data traffic. It cannot effectively support voice and real-time video applications. Consequently, FRS cannot support several IDL application solutions, including one-way video/two-way audio or two-way video/two-way audio.
- *Complex administration.* FRS requires careful administration for large PVC networks because the network administrator must define the connections for everyone on the network, including users who are added or changed. Network administration is becoming an increasingly important issue for large corporations, which are witnessing two conflicting but coterminous trends: network consolidation used as a cost-cutting measure and network expansion as a result of mergers and acquisitions or a reach for complete distributed computing (e.g., client/server).
- *Bandwidth limitations.* PVC FRS offerings support speeds of up to DS1 (E1 speeds in Europe). As result, frame relay may not be able to support the bandwidth requirements of technical IDL receivers and providers, for example, quality video.
- *Transmission delays.* FRS, which transmits information in relatively small data units, has slightly higher end-to-end delay compared to private lines of the same bandwidth because of the need to store and process packet headers and trailers. FRS are also prone to queuing delays because multiple sources are competing for a given trunk circuit.
- *Packet loss*. Higher layer protocols have to recover lost data.

3.5.5 ATM Networking

ATM is a high-bandwidth low-delay switching and multiplexing communication technology that supports both LAN and WAN communications. To be exact, ATM refers to the network platform, while CRS refers to the actual service obtainable over an ATM platform. It is the general industry consensus that ATM is the service of choice for multimedia and other high-capacity interactive video-based applications [9]. For readers familiar with the operation of a protocol stack, it is simply a matter of realizing what functional partitioning has been instituted by the designers of ATM and what are the peer entities in the user's equipment and in the network. The cell relay protocols approximately correspond to the functionality of the medium-access control layer of a traditional

LAN but with the following differences: random access is not utilized, channel sharing is done differently, and the underlying media may be different.

Connections in an ATM network support both circuit mode and packet mode services of a single media and/or mixed-media and multimedia. As covered in Chapter 2, ATM carries three major types of traffic: CBR, VBR, and ABR. For example, traditional video transmission (whether compressed or not) generates CBR traffic, while data applications (say, router traffic for a traditional LAN) generate VBR traffic.

Two remotely located corporate multimedia or video-based devices required to communicate over an ATM network can establish one or more bidirectional virtual (i.e., not hard-wired or dedicated) connections between them. That connection is identified by each user by an appropriate identifier. Once such a basic connection is established, user devices can utilize the virtual, connection-oriented channel for specific communication tasks. Each active channel has an associated bandwidth negotiated with the network at connection setup time. The transfer capacity at the *user network interface* (UNI) 155.52 Mbps; other interfaces are also being contemplated in the United States at the DS1 (1.544 Mbps) and DS3 (44.736 Mbps) rates.

The ATM architecture utilizes a logical protocol model to describe the functionality it supports. The ATM logical model is composed of a user plane, a control plane, and a management plane. The *user plane*, with its layered structure, supports user information transfer. The *control plane* also has a layered architecture and supports the call control and connection functions; it deals with the signaling necessary to set up, supervise, and release connections. The *management plane* provides network supervision functions. It provides two types of functions: layer management and plane management. Plane management performs management functions related to a system as a whole and provides coordination among all planes. Layer management performs management functions relating to resources and parameters residing in its protocol entities (see Figure 3.4).

In the user plane, the access protocol in the user equipment consists of a physical layer at the lowest level and of an ATM layer over it that provide information transfer for all services. Above the ATM layer, the *ATM adaptation layer* (AAL) provides service-dependent functions to the layer above the AAL. TCP/IP may continue to be used by users' PCs and hosts (note that AALs usually only go as high as the data link layer). There are currently three AAL protocols: AAL 1, AAL 3/4, and AAL 5. The service data units reaching the AAL consist of user information coming down the protocol stack, for example, from a TCP/IP stack or from a video codec; the information is segmented or cellularized by AAL into the 53-octet cells, so that they can be efficiently shipped through the network. For video and/or multimedia applications, AAL 1 (supporting CBR) can be employed by the user equipment; more recently, however, many have also advocated the use of AAL 5 for video.

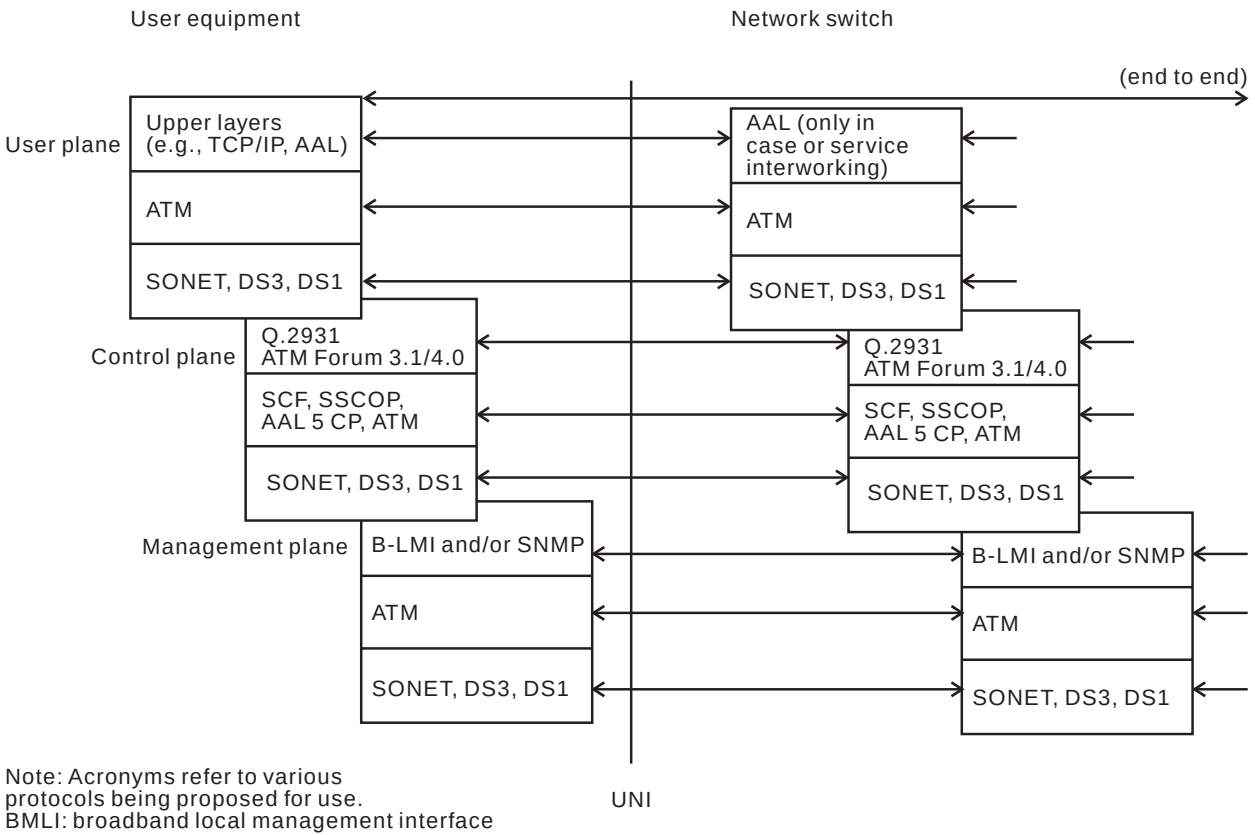


Figure 3.4 ATM protocol planes.

The AAL enhances the services provided by the ATM layer to support the functions required by the next-higher layer. The AAL-specific information is nested in the information field of the ATM cell. To minimize the number of AAL protocols, a service classification was defined in the late 1980s based on the following three parameters: timing relation between source and destination (required or not required); bit rate (constant or variable); and connection mode (connection oriented or connectionless). Five classes of applications were then defined, as follows:

- *Class A:* Timing required, bit rate constant, connection oriented;
- *Class B:* Timing required, bit rate variable, connection oriented;
- *Class C:* Timing not required, bit rate variable, connection oriented;
- *Class D:* Timing not required, bit rate variable, connectionless;
- *Class X:* There are no restrictions (bit rate variable, connection oriented, or connectionless).

Class A is similar to a circuit emulation (dedicated line) service. AAL 1 is used in conjunction with Class A service. A network supporting pure CRS, namely, the orderly, reliable, expeditious, high-throughput movement of user cells from an origination interface to a destination interface, supports Class X applications.

CRS can be used in a variety of ways to support multimedia and video-based applications. In supporting multimedia applications, several issues depend on whether one uses multiple "single-media" connections (performing multiplexing at the ATM layer) or a single multimedia connection (performing media multiplexing above the ATM layer). Some may contemplate using a single VBR cell relay connection for multimedia; here all media multiplexing is done by the application, using proprietary protocols at the AAL layer running over a network providing pure CRS. Another approach is to do multiplexing at the ATM layer, enabling the carrier to provide desirable value-added features. Figure 3.5 depicts a typical use of ATM in a video environment, for example, to support IDL, from a protocol perspective point of view.

More recently, the CBR/VBR/ABR/UBR view discussed in Chapter 2 has been advocated or adopted to describe the various services made available by ATM.

Multipoint connectivity is generally an important requirement for IDL. This follows from the fact that the instructor needs to be seen and heard by a (large) number of remote sites. Satellite transmission supports multipoint very well. However, terrestrial networks do not (yet) support that requirement in an effective manner. This fact has given impetus to the development of ATM/cell relay service: Point-to-multipoint and multipoint-to-multipoint connectivity will be supported as a key service feature.

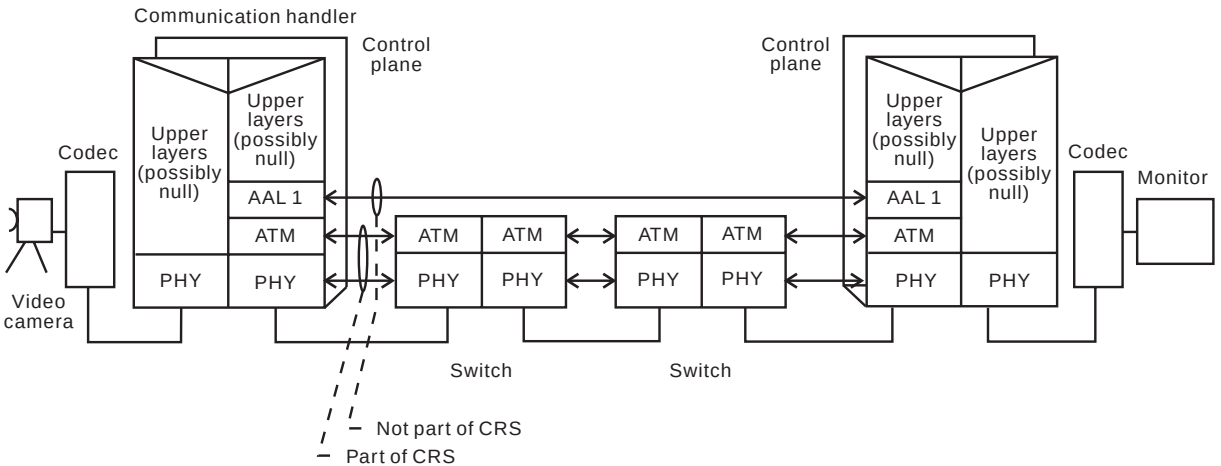


Figure 3.5 Using ATM to support video-based instruction.

ATM/CRS can provide corporations with several benefits, including the following:

- *Support for data, voice, video, and multimedia traffic*. CRS provides corporations with the versatility and flexibility of fixed-length cells, making the service well-suited for all IDL solutions because of the low latency incurred in switching.
- *Economic benefits*. CRS offers higher transmission speeds than SMDS and FRS. It is also more economical than TDM-based lines because a single access line is required to establish communications links between corporate locations; with private lines, multiple access lines are required. Generally, carriers are pricing ATM/CRS aggressively.

While CRS can provide a corporation with several benefits, CRS based on PVCs has one shortcoming: As a PVC service, CRS requires careful administration for large networks because the network administrator must define the connections for everyone on the network. SVC services will be added in the 1996–97 time frame.

3.5.6 Dialup Solutions

Analog dialup solutions can support the needs of corporate telecommuters for remote university education. For example, low speed is employed for NYU's Virtual College. Using their home personal computers and modems, corporate employees, who are university students, can receive instruction, ask questions, conduct analyses, resolve problems, and prepare professional studies—all largely at their own pace and convenience. The Virtual College is an electronic learning environment for the efficient production and delivery of a wide range of high-quality business and technical courses. NYU's Virtual College and its on-line educational network are designed to meet these expanding training needs in an efficient and effective fashion. The program employs Lotus Notes software. Lotus Notes is a group communications program (groupware) giving people who work together an electronic environment within which to create, access, and share information, using networked personal computers. Lotus Notes support such business applications as computer conferencing, information distribution, status reporting, project management, and electronic mail.

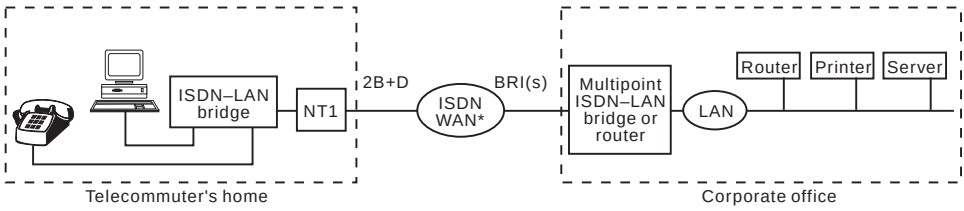
To access a course offered by NYU's Virtual College, students must have an IBM-compatible PC with Microsoft Windows, a minimum of 2 MB of memory, 8 MB of available hard disk space, 1.44-MB 3.5-inch diskette drive, VGA monitor, and a 2,400- or 9,600-bps Hayes or Hayes-compatible modem. Optionally, users can access the telecourse from a work location using a LAN-based PC that either has direct-dialout capability or utilizes a communication server (mo-

dem pool). However, there is a trend up to ISDN. This topic is examined further in Chapter 10.

3.5.7 ISDN

ISDN is a networking solution that can support the IDL needs of corporate employees through digital switched channels operating at speeds that fill the gap between traditional analog dialup and dedicated or switched DS1 lines. An example of an ISDN-based solution is shown in Figure 3.6, which depicts a telecommuting/distance learning application. This solution provides the telecommuter with the ability to participate in a LAN-based screen-sharing conference that is taking place at a corporate location and to conduct a voice conference with the LAN participants as well. The voice conference is established using an existing non-ISDN conference bridge. The LAN-connected participants then establish screen-sharing sessions with the LAN conference bridge. The LAN conference bridge supports multipoint conferencing functions. As a result, the software on each participant's PC only needs to handle a point-to-point conference with the bridge. The telecommuter establishes a circuit-data connection to the communication server that makes the computer appear to be on the LAN. The telecommuter then runs the same software as to set up a conference with the LAN conference bridge.

As Figure 3.6 shows, to establish an ISDN link with the corporate office, a user needs an analog phone, which enables the telecommuter, acting as a conference controller, to establish a voice conference using a non-ISDN conference bridge. The user also needs a PC or workstation equipped with an ISDN adapter, applications software compatible with software on the corporate site. This PC also has several B-channel capabilities, including simultaneous voice and circuit-data calling, support for two directory numbers and service profile ID, and support for rate adaptation for rates lower than 64 Kbps.



* WAN = Wide area network

Figure 3.6 Telecommuter/corporate office link: the ISDN solution.

On the corporate side, a communications server is required. This server must have application software compatible with communications software and with far end. This server must also have multiple BRI capabilities, the same B-channel capabilities as the PCs. A LAN conference bridge and PCs are also needed at the corporate site. In addition, the LAN conference bridge must have must multipoint conferencing functions to support four or more users.

3.6 SUMMARY

IDL can play a vital role in addressing the following key challenges of corporations: corporate training, intracompany collaborative learning and research, remote university education, intercompany collaborative learning and research, executive communication, and market research. These applications can be addressed by a diverse range of application solutions, as shown in Table 3.7. A number of networking solutions can support each application solution and are shown in Table 3.8.

Table 3.7
Corporate Distance Learning Application Solutions

	Corporate Application Solutions				
Application Solutions	*Corporate Training*	*Executive Communication*	*Intracompany Collaboration*	*Intercompany Collaboration*	*University Education*
Business TV	×	×			×
Two-way video conferencing	×	×	×	×	×
Groupware			×	×	×
Internet			×		×

Table 3.8
Corporate Distance Learning Application/Networking Solutions Mix

Application Solutions	*Corporate Networking Solutions*					
	Private Lines	*Circuit Switched*	*ISDN*	*FRS*	*ATM*	*SMDS*
Business TV	×	×	×		×	
Video conferencing	×	×	×		×	
Groupware	×			×	×	×
Internet	×	×	×	×	×	×

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