FUTURE APPLICATIONS FOR TELECOMMUNICATIONS TECHNOLOGY

Submitted to the
Department of Communications
of the
GOVERNMENT OF CANADA

by

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A. SUMMARY

This report examines the future business applications (including products and services) to which a range of emerging technologies may be put.

Technologies examined include **videoconferencing, multimedia, facsimile, wireless communications, personal and information access technologies, voice recognition and voice response, and high speed networks.**

Most of these technologies are really *clusters* of technologies; and there are synergies among the clusters. For example, videoconferencing is closely related to multimedia and to high speed networks; "personal number" and "personal agent" are closely connected to wireless networks and the concept of seamless interoperability between multiple networks.

The report concludes that all of these are promising technologies, with a range of products and services which can meet significant needs in the business community as well as among consumers.

Some of the technologies (high speed networks and multimedia, for example) will facilitate the "information economy": the restructured high-value economy which many view as our country's best opportunity to prosper in the future.

Other technologies (e.g. personal agents and voice response) will "humanize" technology which could otherwise be bewildering and even annoying to individuals. These personal access technologies will allow the individual to customize the way he/she wants to interact with the technology.

So, for example, wireless networks promise to make people "reachable anywhere, anytime." But this is not an unmixed blessing: people will need ways to prevent "junk phone calls" from intruding at unwelcome moments, yet to receive important calls when they arrive.

These technologies, taken together, will transform our daily lives, both business and personal. They are beginning to do so now. By the end of this decade, most of the "futures" discussed in this document will be be part of the business telecommunications environment, though not necessarily widely deployed. By the end of the following decade — the year 2010 — most of the products and services described in this report (or their replacements and equivalents) will either be commonplace, or will have been superseded by more advanced products.

We are moving into a future where new technical capabilities appear to have stepped from the pages of science fiction. We can attempt to forecast the uses of such technology — but to a great extent, those uses will await the inventive ideas of future entrepreneurs, who will come up with unanticipated ways to apply new technology to their business challenges.

B. OBJECTIVES AND METHODOLOGY

1. Objectives

The purpose of this study was to outline some of the user applications – including possible products and services – to which certain technologies may give rise in the next 5-10 years. The focus was on applications for business users.

This assessment will be used by the Department of Communications in the development of an R&D strategy, aimed at focusing the DOC's activities, policies, and programs to meet the needs of Canadian businesses.

The list of technologies to be examined include:

- Videoconferencing
- Multimedia
- Facsimile
- Wireless communications
- Personal and information access technologies (e.g. smart cards, personal service agents, personal number, messaging)
- Voice Recognition and Voice Response
- High Speed Networks (SONET, Frame Relay, SMDS, ATM)

2. Methodology

A literature review was undertaken, primarily covering articles appearing in 1990 - 1992, in periodicals which focus on user applications of technology. (See bibliography appended.) Some earlier articles were also included where relevant.

A summary of potential applications of each of the technologies was prepared, based on the literature review as well as on the consultant's knowledge of user requirements.

In so far as the literature indicated market forecasts, these are included in the summary, but no independent assessment of markets was undertaken.

C.APPLICATION AREAS

The discussion of each technology area below begins with a brief outline of the needs which the technology can address, followed by a summary of possible applications for the technology.

Most of the "technologies" listed are, in reality, clusters of technologies. There are synergies between the clusters, as well: for example, the futures of videoconferencing, multimedia, and high bandwidth networks have many overlaps.

The list of possible applications is not intended to be exhaustive; rather, it is intended to indicate the range of ways in which the technology can meet user needs, and to highlight some important ones.

In most cases, the applications discussed are not entirely "blue sky". To have commercial success in 5-10 years, the application is likely to be grounded in needs which are apparent today.

A summary of relevant market forecasts from the literature review appears at the end of each section, along with the consultants' views on the technology potential.

1. VIDEOCONFERENCING

The business benefits of videoconferencing generally fall into two areas:

- **Displaced travel costs**: Videoconference meetings generally cost less and take less time than if everyone travelled to the meeting.
- **Increased effectiveness**: Meetings take place which otherwise wouldn't have happened at all. People attend who otherwise wouldn't have been sent to the meeting. Processes are completed more quickly (e.g. product development, contract negotiations, customer service.) For example, Boeing Aircraft is said to have reduced the development time of the 767 aircraft by one year using videoconferencing. (*Halhed & Scott, June 1992*)

The second benefit – increased effectiveness – is likely to be the most important driver for videoconferencing, in many cases in conjunction with multimedia communications (sharing of graphics, images, text, spreadsheets and/or other information as part of the conference.) The technology will facilitate teamwork between groups of people who would otherwise likely not meet face-to-face. As costs come down (both for equipment and transmission) and the capability of the technology increases, videoconferencing will become an increasingly integral part of the normal range of communications tools available to business organizations over the next decade.

In addition, as interactive video technology is extended to residential neighborhoods and remote communities in the future, the technology will support a wide range of services to the home, including entertainment, education, and telecommuting applications. Videoconferencing may be point-to-point (a two-way meeting), point to multi-point (broadcast or business TV), or multipoint (a meeting with people in several locations.)

Some applications of videoconferencing include:

- business meetings
- employee training and information dissemination
- product announcements and news conferences
- annual corporate meetings
- product launches
- workgroup meetings
- training
- real estate sales
- monitoring of remote locations

There are also applications outside the business environment, including:

- remote classroom education courses (distance learning)
- remote diagnostics and consultation (medical, technical, or scientific applications)
- courtroom testimony
- entertainment
- community-of-interest networking, casual calling

The required quality of the visual image varies with the application. Some applications (such as business TV or entertainment services) require studio quality video. Others (desk-to-desk conferencing) demand a recognizable face and expression, but not necessarily studio-quality motion. Other applications (e.g. medical imaging, remote equipment diagnostics) require image transmission but not necessarily full motion.

The audio component of videoconferencing is – perhaps surprisingly – more important than the visual component. Participants tolerate a poor visual image more easily than poor sound. However, the visual image must fall within the range expected by the participants or they will conclude that an audioconference would have met the same need. Participants' expectations of video quality are quite high, and rising.

Users' expectations of picture and sound quality change over time. A decade from

now, users are likely to expect studio- quality video on even small desktop or home-based videophone units. (Even the definition of "studio quality" is changing. Research with broadcast audiences indicates that the lowest level accepted today as "acceptable" video is higher than the level considered to be "studio quality" two decades ago.)

Image quality and **cost** are closely related, but compression techniques for video as well as voice have steadily reduced the bandwidth required (and therefore the cost) for videoconferencing.

Nevertheless, ubiquitous high-quality video conferencing (especially if accompanied by other multimedia support) will probably require high-bandwidth switched services in the public telephone network – or the introduction of video/multimedia switching capability in cable TV networks – or both.

Some product areas which videoconferencing is spawning include:

a) Mass-produced codecs

The coder-decoders required for videoconferencing are falling dramatically in price. "Codecs on a chip" can be incorporated into mass-produced equipment to make videophones and desktop videoconference units commercially feasible.

b) Inverse multiplexers

These devices combine multiple 56 or 64 Kbps switched circuits into a single high-bandwidth transmission, to make full-motion video or LAN connectivity possible over the public network. Until high-bandwidth switched services are available – and, even after they are, if the prices are higher than that of multiple low-bandwidth circuits – inverse multiplexers will find a ready and growing market. The originating supplier in this market currently is Ascend Communications, but others are entering the market.

c) Video switches

- **Video Switches, Multipoint Control Units**: Devices which manage and switch the compressed digital signals produced by and for video codecs, when more than two locations are involved. Designed for multipoint video conferences, they typically handle digitized video, audio, computer data, graphics and annotation, connecting a number of locations.
- **PBXs as video switches**: some PBX makers are adding support for dial-up video conferencing over digital connections to the switched public network, or over dedicated high-bandwidth lines. This can support desk-to-desk videoconferencing or video meetings between videoconference rooms.

d) Desktop video/multimedia units

Typically connected to a PC to facilitate dial-up connections as well as screen

sharing of data and other information. Software to drive the application resides on the PC. Current products of this type are designed for one-to-one meetings, but can accommodate small meetings of up to 3 people at either end. They are typically geared for ad-hoc consultations, not formal meetings.

Deployment is hindered by the fact that most desktops don't have digital connections to the network yet. "The lion's share of [today's] desktop video solutions use proprietary technologies....Until cost-effective digital facilities make it to the desktop, only a small percentage of companies are likely to opt for the costly, all-digital, CCITT-compliant [H.261] solutions for desktop video telephone applications....While there are those who suggest that desktop video will become pervasive by the end of the decade, prices today are high and standards are unsettled." *(Halhed, January 1992)*

By the end of the decade, however, digital connections to most desktops are likely to be widely available through the public network and digital connections behind PBXs.

e) Home videoconferencing

The home market for interactive video – whether for casual calling, telecommuting applications, distance learning, or entertainment – is one of the areas affected by the convergence of cable TV and telephone networks. Both technologies could offer such services, but each faces different challenges in providing them. The question of whether telephone companies or cable companies – or both – will offer home videoconference services does not yet have a clear answer.

Service and product areas affecting service to the home market include:

- **Digital Service to Homes**: Cable and telephone networks are each moving toward fiber ring architectures and digital transmission in their networks. But both have further challenges to meet in order to provide dial-up digital videoconferencing to the home.

  - » Cable's challenge is *switching*: cable networks would require video switches if subscribers are to call each other, not just signal the broadcaster as to which point-to- multipoint transmission they want to receive. Current cable industry plans for service enhancements focus on providing "near video on demand" (customer selection among a wide selection of transmissions) rather than switched video service for customer-to-customer calling.

  - » Telephone networks' challenge is *bandwidth*: either through "fiber to the home" or techniques to provide high-bandwidth service over current copper circuits to the home. Both of these are within reach. The biggest cost component in fiber to the home is not the cost of cable, but the optical switching costs. In June 1992, Bell Northern Research announced

a "breakthrough laser", smaller than a grain of sand, which can be manufactured in volume and operate under a wide temperature tolerance: BNR says this will greatly facilitate extending SONET fiber service to the home, or to other remote locations. BNR has also been extending the bandwidth which can be carried over copper wires, and has now announced 120 Mbps transmission over copper in the laboratory. This far exceeds the bandwidth which would be required to deliver interactive video services over copper access to residential communities.

- **Analog Videophones**: until digital services are widely available to homes, residence-based videoconferencing over the public network will require analog videophones.

  Despite improvements in video compression and voice compression, which make it possible to transmit a video call over a single analog line, the picture quality and sound quality of such units is not equal to that of digital units served by higher-bandwidth connections. Since residence consumers are used to TV-quality video at home, products which provide poor-quality transmission on a small screen are unlikely to receive wide acceptance.

  Further improvements may occur: the potential market for analog videophones depends on how quickly digital services are extended to homes. It seems likely that a significant percentage of homes will still have analog connections to the network by the end of the decade. Thus, if there is demand for interactive video-based services (whether entertainment, education, or casual calling) there will be a market for analog-based terminals.

- **Digital Videophones**: Basic Rate ISDN, where available, can provide digital service to homes and small businesses now. Initially homes may use business desktop video units, connected to PCs, operating over one or two digital lines. (These are most likely to be used for business purposes such as telecommuting.) If competitive markets bring digital services more widely to homes, however, there will be demand for mass-market videophones, whether as adjuncts to TVs, or as telephones with video displays.

MARKET PROJECTIONS

Most analysts view videoconferencing as a technology whose time has come, or is about to come. They differ on how quickly the market for services and products will develop, and what is required to have the market "take off". However, most expect continued growth over the next few years and significant use by the end of the decade. For example:

- **cautious projection for home video**: "Tom Nolle [a prominent US consultant] thinks the high entry cost of video will bar casual use for at least five more years....Until public network broadband services – and much

more sophisticated, lower-cost codecs — become more widely available, a videophone in the kitchen remains in the domain of science fiction." *(Feldman, 1991)*

- **optimistic projection for business video:** "The annual growth rate in video equipment will be between 25 percent and 50 percent through the mid-1990s....It is not unreasonable to assume that the market acceptance [of video switching through PBXs] will increase to more than 5 percent [of PBX shipments] by 1995, and even higher in the market segments for large and very large PBX systems." *(Sulkin, 1991)*

These two views are not antithetical. The first says residential video service will be slower to develop, requiring high bandwidth networks and lower-cost terminals. The second says that business use of videoconferencing will grow relatively rapidly, and that video-switching-equipped PBXs will be a component of that market.

CONSULTANT'S VIEW

Videoconferencing, combined with multimedia conferencing, will be an increasingly important tool for business, as well as for educational, medical, and scientific applications, by the end of the decade.

The key to deployment will be cost reductions (in the cost of terminals as well as transmission) and continued improvements in the quality of the image transmitted.

In addition, there will be a critical mass effect: once a certain percentage of businesses and other organizations have easily- dialable videoconferencing capabilities (desktop or room-based), others will follow.

The market for interactive home video services will also grow. It is not clear whether services to the residential market will be served by digital connections to the high-speed telephone network, or by enhanced cable TV services: it may well be both, with cable TV providing entertainment and educational services, and the telephone network providing dial-up videocall services. Just as in the business market, deployment in the residential market will depend on low cost, and high-quality images.

2. MULTIMEDIA

"Multimedia" services are literally those which combine multiple media for storing or transmitting information. Popular usage of the term commonly refers to voice and video supplemented by graphic displays, screen sharing of text or data, or fax.

Video is not a necessary component of multimedia. Some successful applications, for example in distance learning or medical imaging, use graphic images but not motion video.

Multimedia may include remote conferencing, but it can also refer to the combined storage and display of multiple images (e.g. documents, video, animation) on a single display unit.

Some applications for multimedia include:

- Telemedicine
- Distance learning
- Financial/trading desks (viewing remote databases while manipulating spreadsheets, placing orders)
- Electronic magazines
- Executive information centers

Multimedia technologies will be more widely used in these, and other, applications in the decade ahead. (See the section on videoconferencing for additional applications: many of those will use multimedia in addition to videoconferencing.)

Some argue that compression techniques are important to further development of multimedia technology – both to reduce the bandwidth required for multimedia conferencing, and to facilitate multiplexing, display, storage and manipulation of multimedia records.

Others argue that compression reduces information and quality, and is only used because "today's equipment can't deal with multimedia in its raw form. But that won't always be true." *(McQuillan, June 1992)*

The future of multimedia applications will likely require both developments: the availability of high-bandwidth networks, as well as improvements in compression techniques to make most effective use of storage and transmission capabilities.

Some of the types of products and services arising out of multimedia requirements include:

- **Interactive Digital Graphics (IDG) systems:** These allow the multipoint sharing of drawings, photographs and other documents – for example, engineering drawings, contracts, documents, teaching materials. IDG has

been successful in distance learning applications. Typical equipment includes PCs with IDG software, along with a graphics tablet, and sometimes a document scanner and printer, connected via a data bridge and audio bridge. Speech/data multiplex technology is enabling systems which deliver IDG as well as voice and/or video over a single telephone line, and a single teleconference bridge. (Two companies, IIS and Video Telecom, currently offer systems running IDG and video on a single computer.)

- **Digital imaging/database systems:** Medical application trials include digital storage of X-rays, central storage in patient databases, and voice-annotation capability by the radiologist or other medical personnel. Physicians in different geographic locations can view the images simultaneously and discuss them, or they can exchange recorded voice messages specific to the patient's file. Similar applications could be extended to non-medical situations: e.g. distance education, product development, engineering, maintenance applications, etc.
- **High resolution digital scanners:** Required for the type of digital imaging system discussed above.
- **Multimedia software:** PC software to manage the components of a multimedia session (digitizing, compressing and combining) so that all components of the session can go economically over the same transmission link, and be effectively decoded at the other end.
- **Multimedia workstations:** Workstations – either specialized or PC-based – designed for viewing multimedia images (including video if part of the session). Requires high- resolution display capability, zooming and pointing capability, and may be associated with other devices such as scanners and printers. May have integrated handsets or simply be associated with a telephone. Could be used for teleconferencing sessions, or for remote viewing of the stored results of a multimedia session.
- **Multimedia PC cards:** plug-in cards to convert a PC into a multimedia workstation. These may be extensions of PC fax cards, with added interfaces to other capabilities such as voice annotation of image or text files.
- **Pointing devices:** for use with multimedia workstations, such as a powerglove, trackballs, wireless mouse. These allow easier interaction with the multimedia system by untrained operators.
- **Multimedia LANs:** LANs facilitating storage and network routing of multimedia information. Metropolitan area and wider network versions – distributed multimedia information systems – are also possible, using high bandwidth technologies (e.g. ATM).
- **"Smart" boards:** PC-supported whiteboards capable of displaying PC screen information or handwritten notes, linked digitally to similar screens located remotely, editable by any party on the conference, and which can save the entire session output (for printouts or further use). A useful adjunct

to distance learning, business teleconference meetings, etc. (One version was on display at the 1992 CBTA Telecon show in Toronto, manufactured by a Calgary-based company, Smart Technologies Inc.)

MARKET PROJECTIONS

The literature suggests that multimedia applications will develop rapidly in the next few years. The rate of deployment of high- bandwidth networks will be a constraint on multimedia applications, though compression techniques are reducing the amount of bandwidth required.

Some views:

- "You'll hear a lot about multimedia throughout the '90s." *(Little, 1991)*
- "Multimedia....will begin to be implemented on a standalone basis and then, in 1993 and 1994, we'll see it on LANs and, in 1995-96, on WANS." *(McQuillan, September 1992)*

CONSULTANT'S VIEW

By the end of the decade, multimedia applications will be widespread.

Business users will, by that time, simply expect leading-edge business software tools to allow the incorporation of graphics, video, voice annotation, spreadsheet output, hand-drawn diagrams, and text. They will also expect that a composite of all of these components can be shared over the network (local or wide area) in a multimedia conference, and that the results can be stored and recovered for future viewing and editing.

3. FACSIMILE

Fax has been the technological surprise of the 1980's, and shows continuing promise for the decade ahead.

Facsimile was virtually unknown in the 1970s, but in 1992 almost all businesses have fax machines, and many departments and individuals have their own. Home fax is appearing. Fax traffic has resulted in large increases in local and long distance telephone traffic, and has become a ubiquitous form of e-mail.

Fax futures include:

a) Enhanced Group 3 fax

In mid-1992 the CCITT approved extensions to Group 3 fax standards — the standard used by virtually all fax machines today. These extensions will permit:

- subaddressing of fax machines (and other fax devices, such as fax boards in PCs or fax servers) so that they can be addressed within networks.
- laser-quality output: 400 dots per inch resolution (compared to 100 or 200 dots per inch on most fax machines today), as well as transmission of halftone images.
- selective polling of fax machines.
- transmission speeds of up to 64 Kbps. In the handshake with a remote fax machine, the sending fax would determine the speed at which images could be received. In sending to a Group 4 fax machine, signalling over the D channel could be utilized. In sending to an enhanced Group 3 machine, in-band signalling would be used. If the receiving machine were a non-enhanced Group 3 machine, transmission would occur at a slower speed.
- transfer of binary and EDI files by fax.

With these enhancements, the Group 3 standard has overtaken the set of capabilities previously viewed as the domain of Group 4 fax (and Group 5). The futures of Group 4 and Group 5 fax are still unclear, but Canadian participants in the standards process think it likely that enhanced Group 3 will become the dominant international fax standard, with little or no further development of the Group 4 or Group 5 standards.

b) Fax boards in PCs

PC fax boards are rapidly gaining ground as a driver for the fax market. Some industry observers project that by the year 2000, fax boards will be 75% of the fax market.

With a fax board, facsimile messages can be generated and sent by the PC, without

having to be printed and manually fed into a fax machine. The PC can send faxes in background mode, even broadcasting them to a list of people or sending them at a predetermined time (e.g. at night when rates are lower.)

Incoming faxes can be stored as an editable file, by fax boards which include an optical character reader.

c) Fax servers, LAN routing

Systems for routing incoming faxes are less common so far, but with network routing ability being incorporated into the Group 3 standard, fax servers will likely grow in appeal. These may be part of a LAN server, or an adjunct to a PBX, or may use computer-PBX links to integrate with both.

- Fax transmissions can be received electronically on a fax board in a LAN server, and routed to the intended recipient: to a fax near his desk, or to a PC, much as telephone calls are routed now. Outgoing faxes can be sent via the server to a fax machine.
- The *heading information* on an incoming fax can be read electronically and sent to the intended recipient at several locations – even over a pager with alphanumeric readout – and he/she can call to have the fax routed to wherever is most convenient. For example, the fax can be sent to a hotel if the person is on a business trip, or to the person's home.

d) Mainframe to Fax

Many companies generate purchase orders automatically on mainframe or mini computers. However, not all suppliers are prepared to receive these orders by EDI. "Mainframe to fax" allows the purchase orders (or other electronically- produced information) to be converted to a fax image and transmitted over the phone lines to a receiving fax. This technology can also facilitate electronic generation of confirmations to customers, reservations to tourist resorts, and other applications.

With reception of EDI information as part of the extended Group 3 standard, fax machines (and in-board fax boards) will likely become more tightly integrated into EDI systems, making it possible for EDI penetration to grow rapidly.

e) Broadcast, store-and-forward fax

Carriers and service bureaus provide broadcast fax services, along with other enhancements such as customized cover sheets, after-hours transmission, etc. These services have the benefit of off-loading the work (or time) involved in sending multiple faxes. In the future, providers will have to meet customers' needs for greater control: for example, the ability to generate one-time broadcast lists on a PC and uploading these lists directly, or to associate different cover sheets with different lists.

Users may find the ability of PC fax boards to send broadcast faxes in background, without slowing down the operation of other applications, preferable to service bureaus for store-and- broadcast fax. The issues will be relative cost, ease of use, and ease of user-customization of lists and options.

f) Color fax

Color fax exists today (Sharp has a $30,000 color fax machine on the market) using proprietary protocols. However, it is expected that color will become part of the enhanced Group 3 fax standard, making color fax much more accessible.

The most likely application of color fax is in PC-to-PC transmission of color images, as part of multi-media transmissions, rather than in color transmissions to a fax machine. Participants in the standards process believe that the new Group 3 fax standards will become the dominant international standard for PC-to-PC communication of images, replacing the various PC image standards in use today.

g) Fax to the home

Home fax machines, and PC fax boards in home PCs, have begun to penetrate the residential market. So far, this is primarily for work-at-home applications.

However – due in part to the trend to increased telecommuting, and in part to the expected growth in multimedia applications in the home (education, entertainment, etc.) fax is expected to penetrate the home market rapidly. Some observers expect that home fax and multimedia will be the driver for "ISDN to the home", and that there may be 80 Million fax devices in homes by the year 2010. *(St. Arnaud, November 1992).*

MARKET PROJECTIONS

As already indicated above, fax is expected to be of continuing importance as a communications tool in the years ahead.

"...Fax has succeeded in the marketplace and will remain a major communications tool for several decades." *(Tetchner, February 1992)*

"Fax is, and will remain, the most common method for transmitting documents between organizations and will be the e- mail of choice for the rest of us." *(St. Arnaud, October 1992)*

CONSULTANT'S VIEW

Two factors have fueled the fax explosion of the past decade:

- the development of **standards** which made it possible for one fax machine to communicate over regular phone lines with another anywhere in the

world, regardless of manufacturer.

- **ease of use:** "sending a fax" is a simple act which anyone can master without any special technical knowledge or complicated procedures to master.

Future fax enhancements will be successful to the extent that they build on these two factors.

The addition of optical character readers to fax boards means that fax images can be stored and edited. Fax will become a PC-to-PC interchange capability, rather than just a one-way transmission which is currently the norm. This will be required if fax is to become a part of – and a driver of – the EDI world.

Integration of fax, and fax standards, into multimedia technology and devices will be an important driver for fax penetration. At the same time, fax's ease of use and ready accessibility may enhance the accessibility of multimedia.

4. WIRELESS COMMUNICATIONS

The ability of wireless technologies to allow communications with people regardless of where they are – to facilitate mobile communications – has been receiving increasing attention in the media. These technologies include microwave, cellular (both analog and digital), digital cordless systems (PCS: both in- building and public), and satellite-based systems.

International standards for the next generation of mobile communications are being developed under the umbrella term "Future Public Land Mobile Telecommunications Systems (FPLMTS)" by Study Group 8 of the International Radio Consultative Committee (CCIR) which advises the International Telecommunications Union (ITU) on radio-related communications requirements.

The "next generation" of wireless technology refers to technology beyond the current analog cellular phones primarily deployed in vehicles. It includes digital cellular service, personal communications services (PCS: public and private cordless telephones services), paging and air-to-ground services, as well as mobile satellite-based services.

"Seamless voice/data communications between people and/or machines anywhere, anytime," is the phrase used to describe the goal of future wireless technologies. The concept of *personal number* (discussed further on, in the section on Personal Access Technologies) is closely tied to the vision of "reachable anytime, anywhere."

Providers involved in developing wireless standards and services, including Northern Telecom and BCE Mobile, consider that wireless and wired networks will need to interwork, including interoperability of signalling messages to locate and reach subscribers no matter where located on the network.

Wireless services will be supported by a variety of systems, including indoor and outdoor microcells, macrocells (digital cellular), very large cells (air-to-ground) and mobile satellite interfaces. They are envisaged as wireless extensions of PSTN/ISDN services. (Microcells are envisaged as operating at up to ISDN Primary Rate speeds, while macrocells could offer ISDN Basic Rate connectivity into the network.)

The aim is to develop worldwide standards for seamless wired and wireless networks, with both terrestrial and satellite components, which will be deployed into the next century.

The IRIDIUM project, consisting of low-altitute satellites covering most of the world, is expected to provide a range of international networking service, and access to geographically remote areas, which terrestrial-based systems are less suited to provide. On the other hand, coverage in high-density areas such as cities and buildings will be more readily provided by local terrestrial facilities.

Possible applications of wireless communications include:

a) Local loop replacement or substitution.

Competitive carriers may use wireless technologies to connect customers to their networks, rather than rely on wired connections leased from the local telephone company.

b) Personal communications.

"Communicating with people, not with places."

- Combined with **personal numbers** and **personal agent software**, along with the network capability to locate a person and route calls over diverse networks (whether wired or wireless), this technology promises to make people reachable wherever they are, whether at home, work, in the neighborhood, or on a trip.
- **Public PCS**: This technology would allow people to receive or make calls as they travel around the neighborhood or within the city: a similar use to cellular, except at a lower cost both to providers and to users. National PCS providers could provide access to travellers in other cities, though likely not en route (though an interface to digital cellular or air-to- ground services could extend en route reachability.)
- **Wireless PBXs.** In-building or campus telephone systems can include wireless handsets for people who are not at their desks some or all of the time. (Eg. personnel in hospitals, warehouses, outdoor workers.)
- **Wireless handsets.** Users will likely prefer to have a single handset (a "pocket phone") that they can use interchangeably with their in-building systems at work and home and also in public. Alternatively, they may need separate handsets to connect to separate systems: consumers are likely to find this confusing, so there will be a demand for multipurpose handsets. Light weight, low cost, quality sound, and easy functionality will be the parameters of a competitive market in handsets.

c) Mobile data communications.

Applications for wireless data communications include:

- **remote meter readers**: terminals for transmitting data from utility meters will be required.
- **Wireless modems:** built into laptops, pen-and-pad computers, notebook PCs, and portable fax machines.
- **Wireless LANs**: Local area networks which laptops and other mobile terminals can access without a wired connection.
- **Personal communicators.** Wireless terminals which combine fax, e-mail,

wireless phone (cellular or PCS), and PC capability in one device. A variant of such a device has just been announced (November 4, 1992) by California-based EO Inc., which combines a cellular phone, pen-based computer, and a free subscription to AT&T EasyLink Services.

- **Wireless price stickers:** Some retail stores are already using systems in which electronic shelf stickers are automatically updated from the store computer as prices change. This technology could have other applications for situations where information needs frequent updating.

MARKET PROJECTIONS

Cellular providers will be converting to **digital cellular** service during the next few years. Digital cellular requires less than half of the per-subscriber investment of analog cellular service, largely by increasing the coverage and traffic handling ability of each cell. Providers believe that this will extend cellular use in the middle and last half of the decade, beyond the current base of high-volume users. The end-user price of digital cellular terminals is also projected to fall rapidly, from $1,100 in 1993 to under $300 by 1995. (These figures are in US dollars.)

However, providers of **personal communications systems (PCS)** believe that this technology will outstrip the penetration which cellular service can reach — even with the advances of digital cellular — for two reasons:

- It costs less to provision a subscriber in a PCS network than in either analog or digital cellular networks. Therefore, a lower base fee can be charged, eliminating part of the price barrier to customers. (Northern Telecom estimates that the per-subscriber investment required will be approximately $250 for PCS, as compared to nearly $1000 for each analog cellular subscriber.
- PCS handsets will be less expensive (providers project end-user prices of $100 by 1995). They will also be lighter, and will provide more talk time and standby time without recharging.

Forecasts for wireless technologies are very optimistic. "Some prognosticators believe that wireless radio-based systems will be responsible for worldwide growth in the installed base of voice telephone lines from about 400 million now to one billion by the year 2000." *(Arnum, July 1992)*

The same writer says, "Just as we chuckle at the thought of our grandparents turning a crank and asking Central to make a telephone call, our grandchildren will laugh when we tell them we used to have to stand next to the wall to talk on the phone in the kitchen. They will think it just as humorous and inconvenient that we tethered our fax machines and PCs to the same wireline services. They will carry their telephones and terminals in their pockets, purses and lunchbags."

CONSULTANT'S VIEW

In the decade ahead, wireless access to telephone and data networks will become an important supplement to wired access.

Increasingly, it will be important for wired and wireless networks to operate functionally as a single network. In other words, the concept of "the public switched telephone network" will no longer be a single, wired network, but will expand to include multiple interoperating networks (wired and wireless). Particularly as concepts like "personal number" are implemented, in which the network locates the person no matter where on the network he/she is located, it will be important that signalling between networks be seamless and transparent to callers and to the people being called.

Private and "virtual private" corporate networks will also increasingly need to have signalling interfaces to both wired and wireless networks – particularly since corporate networks will likely include wireless components themselves (wireless PBXs, wireless LANs, remote data readers, etc.) This will be a challenge for corporate network management systems.

There will be demand for inexpensive yet function-rich and easy to use "pocket phones", and for wireless accesses in portable PCs and other terminal devices, interfacing to LANs as well as the PSTN.

At the same time, there will be consumer resistance to being "instantly reachable" everywhere. Though people want to receive the calls they are waiting for, they don't want to be pestered by junk calls at inopportune moments. People will want to ensure some privacy, with user-determined control over who can reach them and when. Thus the concept of "personal agent" will have considerable appeal.

Another issue to be resolved is the rapid increase in the number of phone numbers required, and the ability of the North American Numbering Plan to allot sufficient numbers.

Individuals will likely interface with the network in various ways. People will still have wired phones at home and at work – some of these may even have video screens, as discussed earlier: in fact, some may be PCs or TVs with a handset and keypad attached, rather than simply phones. But increasingly, people will have wireless units as well. Users' preference will be to have multifunction "pocket phones" rather than several different ones: units which can receive and place calls over the public PCS network, from in-building wireless systems, or from the cellular network would be preferable to single- function terminals.

"Pocket phones" will bring another set of concerns. Will small, lightweight units be too easy to lose? How to carry them when wearing outfits with no pockets? What about etiquette issues? Security issues?

Some business users may prefer to have an "office in a briefcase": a lightweight portable unit containing a phone, a fax, a computer, a screen and keyboard, using a single wireless interface to the network.

For businesses with employees working remotely, the problem of high-bandwidth digital access to homes or satellite offices may, in some cases at least, be solved by wireless access services. (Microcell technology may provide up to ISDN Primary Rate service.)

5. PERSONAL and INFORMATION ACCESS TECHNOLOGIES

These technologies connect each individual to the network, or to information databases, in individualized ways.

a) SMART CARDS

These cards include a microchip in which personal information can be encoded and changed.

- **Debit cards** These are the most widely publicized version of "smart cards". They would include information on the person's bank balance, and systems would simultaneously deduct each purchase from the buyers' bank balance (and card) and transfer the same amount to the retailer's bank account.
- **Purchase cards** A simpler version is often used for public photocopy machines, public transit payments, etc. In Europe, they are used in pay phones. A user buys a card with a certain predetermined value – eg. $5 or $10 – and then each purchase is deducted from the balance. When the amount has all been used up, the user can add money to the card balance, or buy a new card.
- **Entertainment and education.** Museums and exhibits are beginning to use "smart cards" to customize their interactive displays to the needs of the attendee. The Smithsonian has implemented such a system, and the ICOMM telecommunications science center (to open in 1993 in Brantford, Ontario) is planning to use this system. The card is issued to a visitor when he/she arrives, and encoded with information such as preferred language, age of visitor, level of interactivity desired, etc.
- **Identification cards and documents.** (e.g. health cards, social insurance cards, passports, etc.) Updatable computer chips would allow constant updating of information, eg. a running tally of drug purchases or medical tests, travel history, employment location.

To some extent, "smart card" technology competes with current magnetic stripe technology (such as used on credit cards); but it can also be viewed as complementary. The information on a magnetic stripe is fixed, rather than changeable: a person's name, credit card account, etc. is generally unchanging or infrequently changing information. Smart cards, on the other hand, provide the ability to update constantly changing information: the remaining balance in an account, a person's progress through a series of exhibits, etc. For this reason, the two technologies may co-exist on many cards for some time. (Credit and debit card providers, for example, may want to use magnetic stripes as well as "smart" chips in new cards.)

b) PERSONAL SERVICE AGENTS

The concept of a personal service agent is that of a software module, residing in the

telephone network or in a device connected to the network, which performs some or all of the following functions:

- monitoring information about a subscriber's location (where on the network, or on multiple networks, he is located.)
- handling messages and screens calls, based on customer- defined priorities.
- allowing the customer to give instructions or requests verbally, by using voice-recognition technology.
- using text-to-speech technology to "speak" to the customer.

In short, it is to be perceived as a "personal assistant", as though the customer is interacting with a person rather than a piece of software. Its function is to enable the network to route calls in customer-programmed ways.

Personal service agents could also perform functions such as monitoring databases (eg the stock market, newswire services). A message could be sent to the individual's pocket phone or pager to alert the person of urgent items.

Personal service agents could be *services* leased from a network carrier (similar to today's "invisible answering machine", really a messaging service provided by equipment and software which the carrier attaches to the switched network.) Or they could be customer-owned (or leased) *devices* (hardware and software) residing in telephone sets, PCs, or other appliances. It is also possible to have a hierarchy of agents: each individual might have one main agent — the one he/she interfaces with directly — which in turn interacts with subordinate, special-purpose agents.

Northern Telecom projects that "intuitive dialog" capability in speech recognition technologies will be available by the mid-90's. This would enhance the natural-language interaction aspect of the personal agent concept.

c) PERSONAL NUMBER

The concept of a personal number is closely connected to that of wireless, interconnecting networks. In this concept, an individual's phone number would be associated with him/her, not with a particular location, and a call to that number would reach him/her no matter where located. (The network locator capability would also be necessary for the concept of a personal service agent, described above.)

Northern Telecom is currently promoting the concept of two or three personal numbers per individual, not one. Each number would be associated with a particular *role* the person fills. For example, an individual might want:

- a business number for work-related calls;
- a home number for family or social calls;
- a number associated with another role, e.g. as hockey coach or United Way chairman.

The concept of a "personal service agent" could work well with that of personal numbers: the "agent" could keep track of calls to each of the personal numbers, and route them appropriately, including performing triage on simultaneous calls or messages (for example, to inform the person of an urgent call coming in to one number while he/she is on another call.) The individual could instruct the agent to "route all business calls to my voice messaging, but when my daughter calls, send her through."

Personal Communications Systems, other wireless systems, fax, and now "personal numbers" are driving up the potential requirements for phone numbers. A major restructuring of the North American numbering plan is scheduled for January 1, 1995; the hope is the new system will last until 2025. However, further work is under way, including a plan for a PCS worldwide numbering systems being developed for presentation to the CCITT this year.

d) MESSAGING

Users increasingly are accessible on a variety of messaging systems, and the trend is toward "multimessage platforms". These typically integrate between e-mail, fax, and voice messaging. Some simply let the subscriber know that various types of messages have been received, in some cases using voice processing to inform the subscriber how many of each type of message have been received.

Multimessage platforms in the future will likely have the following capabilities:

- voice messaging, with mailbox-to-mailbox communications capabilities, even between mailboxes on different systems.
- voice response: the ability to access and modify information on a remote database.
- fax: the ability to store and retrieve documents based on caller input (for example, routing a fax to home, car, or hotel faxes, and/or to a computer file for text manipulation.) E- mail messages could also be delivered by fax.
- electronic mail notification: cross-notification between the multimessage system and standard e-mail packages.

Combined with wireless networks and personal agent technology, the systems could conduct triage on incoming messages and ensure that urgent messages were transmitted quickly, while less urgent messages could be stored and retrieved at a convenient time.

Multimessage platforms are being developed both by voice messaging suppliers (VMX, Octel, Centigram), voice response suppliers (InterVoice, Periphonics, Syntellect), and computer vendors (IBM, DEC).

e) CONSULTANTS' VIEW

As we move further toward the "information economy", the range of information available, and the range of ways it is possible to access that information, will multiply – to the point where it may be bewildering, or annoying, for the individual to keep track of a multitude of different systems.

Technology should enhance our lives, not add annoyances. The technologies discussed above have, potentially at least, two powerful benefits:

- They can simplify an individual's interaction with databases or with networks.
- They allow the individual to customize the way he/she wants that interaction to take place: to "personalize" the interface to technology which otherwise can appear quite impersonal.

To that degree, such personal access technologies have promise. Their market penetration, and acceptance by consumers, will really depend on whether consumers perceive that promise as being met: do these services enhance people's lives – at an acceptable price – or not?

Forecasts of consumer perceptions are notoriously risky. Track records of market penetration of other technology services and devices, however – VCRs, microwaves, cellular phones, answering machines, etc. – suggest that new technology can take decades to be adopted by a majority of the population, even when the technology itself operates well and early users are pleased.

Some "personal access" technologies will be accepted before others. For example, voice messaging has already gained widespread acceptance, and systems which integrate various messaging systems (and allow communications between them) can be expected to penetrate at least into major segments of the business community quickly as we move through the decade.

Others, such as personal number or personal agent, will take longer to gain acceptance, because they require considerably more behavioral change on the part of consumers. They also require a more complex infrastructure to deliver. If network providers start making these the standard ways of interfacing with the network, these systems will gain rapid penetration – but that will not likely happen until into the new century. In the meantime, we are more likely to see trials and optional service packages for early adopters.

6. SPEECH RECOGNITION AND VOICE RESPONSE

Star Trek fans are familiar with Captain Kirk's ability to converse with his shipboard computer, giving instructions verbally (e.g. to change course or "fire phasers"), and receiving verbal confirmation or warnings from the computer.

These capabilities are emerging from the realm of science fiction into the real world.

Three separate technologies are involved in the Star Trek scenario described above:

- speech recognition: the computer recognizes verbal instructions.
- interactive voice response: the computer responds to the instructions given, by taking certain actions.
- speech synthesis, using text-to-speech conversion (the computer "reads" the results of its actions – e.g. looking up an item in a database – and converts this into speech) or assembling messages from a library of recorded speech.

a) Speech Recognition

Researchers at AT&T Labs and elsewhere have been working since at least the mid-1970's on developing algorithms to allow a computer to decipher spoken instructions and convert it to text.

Today, this technology has emerged from the lab. Current applications include automation of collect call placement in telephone networks (Bell Canada) and credit card verification (American Express).

Today's speech recognition systems still have limitations. Typically they are limited to a relatively small vocabulary (nine digits plus yes or no, or a few other words). To some degree they are now speaker-independent (earlier versions required the computer to "train" with each new speaker) – though regional or foreign accents may interfere with the accuracy of the recognition. Some systems can spot key words in a stream of continuous speech, though extraneous words and sounds may still cause problems.

Future developments will likely include:

- algorithms based on **sub-word units** (phonemes, diphones, or syllables), which allow much larger vocabularies to be built up than if each possible word needs to be separately added to the system. Bell Northern research and Northern Telecom are working on a phoneme-based system which is nearing commercial release, for example.
- **word spotting:** the ability to respond to words or sounds embedded in other words or sounds. This eliminates regimented ways of speaking.
- **noise immunity,** based on improved speech-enhancement algorithms so that speech recognizers will be more accurate in noisy environments.

- the incorporation of **language analyzers**, which will use semantic and grammar rules, and a large vocabulary database, to increase the system's ability to predict (and confirm) the essence of the whole sentence even when not all words are recognized. This will allow computers to respond better to "natural language" input, with improved accuracy.
- improved **speaker adaptation**, to allow computers to adjust more rapidly to dialects and accents in speech.
- systems which allow speakers to **override voice prompts** if they wish, to reach a live operator or to skip past instructions with which they are already familiar.
- **voice print technology** may also be incorporated, to confirm the identity of a speaker based on a computer analysis of the voice tones (similar to a bar code or a fingerprint: each speaker's voice print is unique.) This could allow voice input to applications where security is important, e.g. banking and financial transactions, access to confidential databases, etc.
- **acquired-language systems**: these acquire language automatically, using a neural network to "learn words the way children do, by starting small....the model incorporates new pronunciation, vocabulary, syntax and semantics from successive speech inputs." (*Olive, Roe & Tschirgi, 1991.*) Such systems are currently under study, though no commercial products based on this technology have yet been announced.

b) Interactive Voice Response

IVR systems — also referred to as voice processing systems — use caller input over the telephone (whether spoken or by touchtone tones) to interact with a computer.

Applications used today include cancelling a newspaper, checking credit card balances and frequent flyer point levels, registering for a university course, inquiring about railroad schedules, or using an automated attendant to be reach a particular telephone extension.

Many of these use touchtone input today, but in future will likely incorporate speech recognition technology. This would allow:

- rotary-dial users access to the IVR applications.
- access for older people and handicapped people who may be uncomfortable with — or unable to use — touchtone dialpad input.
- easier access to menu choices. (Long numeric menus tend to be confusing.)
- a greater variety of menu choices. For example, if using an IVR system to allow callers to order theatre tickets — the system does not need to be reprogrammed each time the show lineups change.
- input of information which is not easily done on a touchtone dial pad: alphabetic information, for example.

Though only about 1% of IVR systems shipped in the US in 1990 had any speech recognition capability – and that fairly limited – by the mid-1990's this may increase to 11% or more. By the end of the decade, most IVR systems are likely to include some type of speech recognition, and to allow near-natural language input.

c) Speech Synthesis:

In order for the computer to respond verbally (through a microphone or over the telephone line), it must either convert text to speech, or assemble a message from a library of pre- recorded speech.

- **Text-to-Voice conversion**: This is an easier task than speech-to-text; acceptable algorithms have been available for several years. Digital Equipment Corporation's "DECTALK" is widely used, despite its unmistakable "Swedish sea- captain" accent. Other suppliers include Centigram("Tru- Voice") and Intervoice. Kurzweil provided a text-to-speech synthesizer to physicist Stephen Hawking, which allows him to "speak" and even deliver lectures, even though he himself has lost the ability to speak.
- **Speech storage**: Though pre-recorded messages sound more natural than constructed speech, the challenge is to provide instant access to recorded speech storage in voice libraries in order to respond to callers.

Ultimately, text-to-speech is more flexible than pre-recorded speech. As algorithms improve, the speech quality of text-to- speech will make pre-recorded speech unnecessary.

CONSULTANT'S VIEW

Examples of applications which could make significant use of voice recognition technology in the next few years include banking by phone, credit card authorization, and stock-market inquiries.

By mid-decade, systems which are speaker-independent and with relatively large vocabularies will be available; AT&T, Northern Telecom, and others are poised to provide such services.

Together with language analyzers and speech synthesis technology, by the end of the decade systems will be possible which approximate the "Captain Kirk" scenario of a natural- language conversation with a computer.

This will greatly enhance business' ability to automate – yet personalize – many aspects of their sales and customer support functions, including providing access to a wide range of information and services at any time of the day or night, eliminating long waiting lists or queues of people who can be off-loaded from live agents.

Speech recognition and synthesis will be important if "personal agents" and related technologies are to meet their promise: to simplify access to the network and to databases, and allow the user to customize the way he/she personally wants to be connected to callers and information.

The development of the "voice-activated typewriter" will take somewhat longer to arrive: that requires the computer to recognize *all words* (rather than simply recognize key words in a flow of speech) and to understand spelling, grammar, and punctuation as well. We will probably need further development of artifical intelligence and neural net language learning capability before the voice-activated typewriter (ie. automated production of text output from voice input) is truly a reality.

7. HIGH SPEED NETWORKS

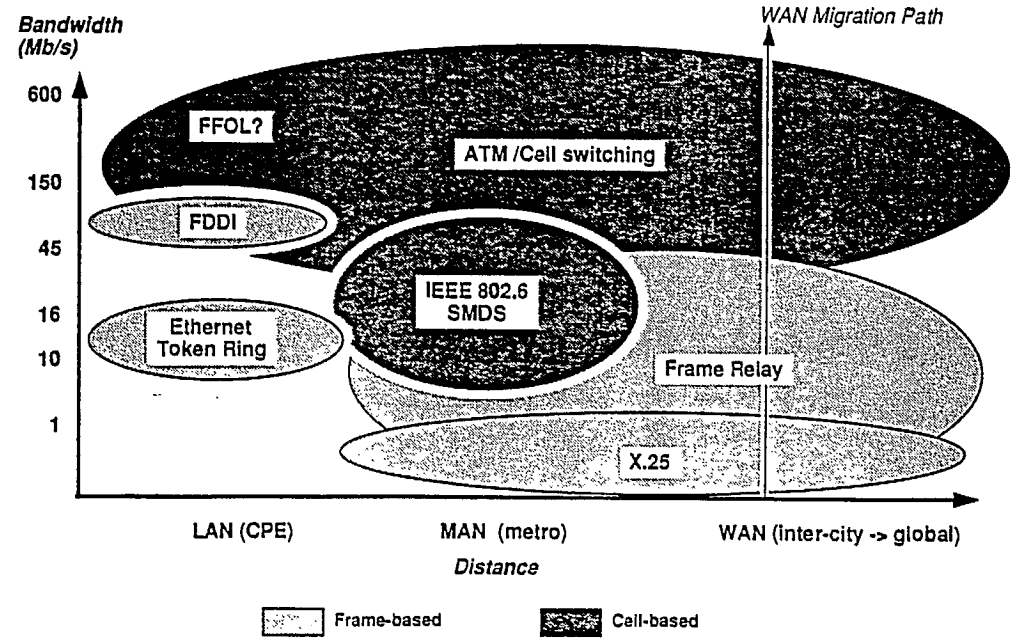
Technologies such as videoconferencing and multimedia, and applications such as medical imaging and distance learning, exist today and would grow even without the existence of high bandwidth networks. However, high speed networks will make such applications more effective, increasingly their functionality and reducing their cost.

"High speed" and "high bandwidth" are adjectives used interchangeably to refer to networks and services which can transmit large amounts of information very quickly.

Narrowband or "low speed" network circuits typically operate at speeds of up to 56 Kbps or 64 Kbps. This is the bandwidth normally required for a single voice conversation, over a basic analog phone line, or a DS-0 or ISDN Basic Rate digital circuit. Two 56 or 64 kbps channels can be combined for acceptable (though not studio-quality) dial-up videoconferencing.

In contrast, the bandwidth offered by "high speed" networks extends from 1.544 Mbps at the low end – T-1 or DS-1 rate for access to Frame Relay or ATM services, though Frame Relay can also be accessed at lower speeds – and goes up to 2,488 Mbps (OC-48 rate, the equivalent of 1600 T-1s) or higher on intercity SONET networks. By the late 1990's, intercity speeds of **10,000 Mbps** will likely be possible over SONET (OC-192) and ATM.

It is important to point out that these are not alternate network technologies, but complementary ones.



Map of Bandwidth/Application Territories

Source: Northern Telecom

a) SONET (Synchronous Optical NETwork)

SONET is an international standard for optical fiber networks. It will be the basic operating standard of carrier networks into the next century.

Using lasers and fiber optic technology – in switching and access, as well as transmission – it allows the sending of vastly more information than today's networks can handle. Due to a separate network management channel, SONET will also improve carrier provisioning costs and network reliability.

SONET signals are referred to as Optical Carrier (OC) signals. The basic SONET building block is OC-1 (a 51.84 Mbps signal). Higher bandwidths are multiples of this base rate: OC-3, OC-12, and OC-48 are the basis for products currently being manufactured. Rates as high as OC-192 – 9953 Mbps, or nearly 10 Gigabits per second – are under study, and will be in commercial production by 1996.

SONET is already being deployed: Northern Telecom claims to have shipped in the neighborhood of 2,000 S/DMS Transport Node terminals and regenerators to telcos in North America by mid- 1992. (Northern Telecom refers to its SONET products as "Fiberworld.") Other network switch manufacturers, including AT&T and Alcatel are also manufacturing SONET products.

The SONET standard includes interfaces to existing network services which use copper or non-SONET fiber media. Low-speed electrical signals are interleaved to form a synchronous high speed signal. This permits access to low speed signals (e.g DS-0, DS-1) without multi-stage multiplexing and demultiplexing.

Initially, interexchange carriers and telephone companies will be the primary customers for SONET products. However, a recent US poll of large private network customers suggested that some of them expect to install private SONET networks, perhaps by 1994 or 1995. (*McQuillan, January 1992.*)

SONET networks – public or private – will support services like Frame Relay, SMDS and ATM.

CONSULTANT'S VIEW

SONET will be absolutely essential to the delivery of services which require high-bandwith access and switching, as we move toward the next century.

The main market will be telephone companies and network carriers, for whom SONET promises not only vastly more traffic-handling capability than pre-SONET technology can deliver, but also increased survivability and lower provisioning costs on the network.

Large private network users may also migrate to SONET switching. However, the trend toward "virtual private networks" – using the public network intelligence to

provide customized private-network-like capabilities over the public switched network – may mean that private leased networks as we understand them today will decrease in importance.

Carriers say they expect hybrid networks (mixtures of leased, virtual, and public service) to be in use by corporations through the rest of this decade, but they hope to migrate increasing amounts of private traffic onto the switched network in the next century.

This seems a possible scenario, though corporations which rely heavily on private networks to move core-business data will be reluctant to relinquish control; they will only do so if virtual networks given them equivalent control and security. The need for high-bandwidth networks to move increasing quantities of data, including multimedia information, will mean that private network users will be looking at what SONET can offer them.

b) Frame Relay

Frame relay is a type of packet switched service, developed to handle the "bursty" characteristics of data traffic.

Today's X.25 packet switched services typically operate at up to 9.6 Kbps. (For example, Bell Canada's options for Datapac access through the D-channel on a Basic Rate ISDN connection includes a "high speed" rate of 9.6 Kbps, though the ISDN standard allows for packet data speeds of up to 64 Kbps on the D-channel.)

Frame relay, in contrast, supports speeds of 64 Kbps to 2 Mbps.

Frame Relay was developed as part of the ISDN standards. The Frame Relay protocol is based on ISDN D-channel specifications, and switched connections are established using ISDN access signalling.

Public Frame Relay services were first introduced in the US, on a limited basis, in 1991. US Sprint, in particular, has marketed its service aggressively. In Canada, both Unitel and Stentor have promised Frame Relay offerings in the near future.

Uses for Frame Relay include:

- LAN interworking, either locally or over the wider network. Canada Post, for example, is using Frame Relay to support its Priority Post service, by sending scanned images of the Priority Post labels over the network to track package progress.
- SNA network connections.
- Mainframe connections
- Image transfer
- Graphics and CAD/CAM
- File transfer.
- Networked voice messaging. A large US professional services firm, interviewed in February 1992 (*Angus & Cukier, 1992*) reports that it has linked many of its US offices with frame relay (over a virtual private network service) to provide company-wide voice messaging and access to corporate networks. They plan to add LAN connectivity and mainframe connectivity, and will be a beta test for international frame relay between the US and Europe.

Hybrid public and private frame relay networks may allow users to interconnect widely dispersed LANS, in some locations with full- time leased lines, in others over public services. (Switched virtual circuit connections on frame relay services can allow connections to be established and released for every call. Initial public frame relay services will likely require "permanent virtual circuits" rather than call-by-call setup, however.)

Frame relay equipment products will include:

- Frame relay switches
- T-1 multiplexers
- Frame relay PADs and Concentrators
- Bridges and routers
- Front end processors

MARKET PROJECTIONS

US projections suggest that public Frame Relay services will reach an annual figure of $500 Million by 1994. "Frame relay is coming on stronger and sooner than expected....Frame relay and cell relay services look like strong winners." (*McQuillan, January 1992*).

No specific projections for the Frame Relay *equipment* market were encountered in the literature search.

CONSULTANT'S VIEW

Frame Relay has significant potential through the rest of the decade, in Canada as well as elsewhere.

The Saskatchewan Government is currently evaluating the use of frame relay to establish a WAN in its province-wide backbone network. This suggests that private network markets for frame relay products and services will evolve in Canada as well as the US and other countries.

Frame Relay's longer term potential depends on how quickly it is overtaken by ATM, which can provide higher bandwidths and multimedia capability. The two will likely co-exist for some time. Relative prices (tariffed or otherwise) of services and hardware for the two technologies will be an important factor determining user choices in the future.

c) SMDS (Switched Multi-Megabit Data Service)

SMDS is a high-speed packet-switched data service based on connectionless switching. (Data packets, or cells, contain their own source and destination addresses, as in a Local Area Network.)

SMDS is the first manifestation of a range of cell-based network technologies which includes ATM and Broadband ISDN. It grew out of the IEEE 802.6 working group's work on Metropolitan Area Networks, and is a subset of the 802.6 protocol.

Its name is self-explanatory. It is envisaged as a data-only service (no voice or video), operating at multi-megabit speeds.

Bellcore has specified two speeds at which SMDS can be provided: 1.544 Mbps (T-1 rate) and 44.736 Mbps (T-3 rate). Its purpose is primarily LAN connectivity over the public network.

Some functions which SMDS will support include:

- Local LAN interconnection (campus and Metropolitan area applications)
- LAN interconnection over the public network, nationwide if desired.

"While SMDS isn't exactly the same thing as a 5000 km Ethernet, it's getting close," says one writer. (*Goldstein, May 1991.*)

MARKET PROJECTIONS

SMDS is likely to grow rapidly in the mid-to later part of the decade in the US.

"Articles in the trade press and conference talks by corporate representatives have portrayed MCI and AT&T offering interexchange SMDS service imminently, with Sprint coming into the picture somewhat later. As of early September, however, no such service is yet running. Intercarrier facilities and billing operations need to be set up, and the carriers are taking a significant amount of time to do this." (Mollenauer, October 1992.)

In Canada, none of the telephone companies or other providers have announced plans to offer SMDS. Northern Telecom, who provision most Canadian carriers, says that it considers ATM to be the next stage in evolution after Frame Relay, and sees less user need for SMDS as part of the transition, at least in the Canadian market. Northern says it could provision SDMS interfaces on its planned ATM products, but so far has no plans to do so.

CONSULTANT'S VIEW

SMDS is primarily a *service*, provided by carriers, not a *product*. Its hype in the US market reflects two factors:

- In the US telecommunications environment, carriers can provide services, but not provide customer premises equipment. So they can't sell MAN hardware to customers, but they can provide a MAN-speed service.
- Public network packet switching (X.25) never really caught on in the US; it is still scarce and relatively expensive. So US carriers are targeting Frame Relay for "low-speed" data services (up to T-1) and SMDS for higher speeds.

The question of whether Canadian carriers will see customer demand for a higher-speed data service, intermediate between Frame Relay and ATM, is unknown. If ATM-based services arrive relatively quickly (in the last half of the decade) and are perceived as affordable for high-speed transmission, SMDS-speed data requirements may be "skipped over". On the other hand, Canadian businesses are keenly alert to how their US-based competitors use technology; if high-speed data networks give rise to important business advantages in the US, Canadian customers will demand access to similar services.

d) ATM (Asynchronous Transfer Mode)

Alternate terms for ATM are "cell switching" and "cell relay." ATM, together with the SONET infrastructure, will really be the embodiment of "Broadband ISDN". ATM is envisaged as carrying voice, data, and image traffic (including video).

ATM standards are not yet complete. The ATM Forum, with membership including most of the major prospective ATM vendors, expects to have key standards complete by the end of 1993.

Applications for ATM include:

- medical applications: transmission of charts, X-rays, CAT scans, patient histories, photographs, EKG records.
- teaching: distance learning, resource sharing.
- engineering: CAD/CAM, architectural drawings, simulations, supercomputer graphics, geological data.
- scientific: weather forecasts, particle physics
- public safety: forecasting storm tracks for hurricanes

Some ATM products, and services supported by ATM, include:

- ATM Local Area Networks, providing multimedia connections between workstations (in-house or in a Metropolitan Area).
- ATM switches, providing LAN interconnection over the wide area network.
- Switched HDTV, including video on demand and interactive multi-media retrieval.
- Videoconferencing and multimedia conferencing.

MARKET PROJECTIONS

On October 1992, Kanata-based Newbridge Networks announced an agreement with MPR Teltech (of Burnaby, BC) to combine the ATM development programs of both companies under the Newbridge umbrella. This, says Newbridge, will accelerate the delivery schedule for Newbridge's ATM switch, exhibited at INTEROP in San Francisco in late October, now announced for December 1992 delivery. Newbridge's ATM switch (called the *36150 MainStreet AtmNet*) can be configured from 620 Mbps to 10 Gbps. Individual users can connect to the switch at up to 155 Mbps (OC- 3 SONET rate) and the switch itself can access wide area fiber otpic links at speeds up to 620 Mbps (OC-12). Newbridge says it "will enter commercial service with two major North American service providers in the first quarter of 1993." (*Newbridge press release, October 21, 1992*)

Some observers expect a significant market for private ATM LANs or ATM hubs for LAN interconnection. Providers in this market include Adaptive, ForeSystems,

Synoptics, Ungermann-Bass, MPR (now a strategic partner with Newbridge) and others. Devices connecting into these ATM products will include client computers, servers and routers. Private ATM backbone networks will likely be hybrids (private local switches connecting to wide-area public ATM services), with early users introducing ATM by 1994 and further evolution throughout the decade. (See *McQuillan, July 1992*)

Northern Telecom, another leading contender for provision of ATM products, says the market may be slower to accept and deploy ATM than current media hype would suggest. Northern's view of the market for ATM and related Broadband services is:

- to 1995: early applications for high bandwidth will be driven by high end niche requirements, such as military and space applications.
- 1995 - 1998 or 2000: market acceptance of the technology, though most will still be niche applications. The SONET infrastructure will still be being installed. (SONET networks will be largely in place in the public network, at least in North America, by the year 2000, in Northern's view.)
- 2000 and beyond: ATM switching and access comes into widespread usage.

Northern Telecom sources say the company plans an ATM product launch in 1993. Details on the product are not available, though sources say its switching fabric will operate at up to 10 Gbps, and that it will allow carriers to provide a parallel broadband overlay network (operating together with the switched narrowband network).

CONSULTANT'S VIEW

Northern Telecom's projections for evolution of the ATM market seem fairly reasonable. However, Northern will have significant competition in this market – from niche providers like Newbridge, as well as network giants like AT&T.

The real driver for ATM in the switched telephone network will be multimedia applications. To the degree that these applications grow, the high-bandwidth capability of ATM will be virtually required. (In fact, the growth of multimedia will be limited by the rate of deployment of ATM.)

Private and hybrid ATM networks, including ATM LANs, will appear in the US, though Canadian applications will likely be fewer. The key market for ATM switching products will be network providers and telephone companies, both in North America and internationally.

The promise of ATM is to provide true "bandwidth on demand", removing the bandwidth bottleneck which currently limits the range of user applications which can be conceived. ATM is virtually certain to be a component of network services by the end of the decade, though use of applications using ATM capabilities will likely not be widespread until into the new century. (Many applications will only

evolve after the capabilities of high-bandwidth multimedia connectivity become apparent to business users.)

D.CONCLUSIONS

By the end of the decade, the following scenario will be technically feasible:

- Businesses and other organizations will be able to connect LANS, at LAN speeds, across the continent (or overseas) over the switched public network. Applications may be data-only, or (increasingly) will be multimedia.
- "Bandwidth on demand" – up to 10 Gigabits – will be available for needs such as multimedia videoconferencing, over local or wide area calls.
- The "public network" will consist of multiple, interoperable wireless and wirebased networks with seamless signalling capability between them.
- Individuals who wish to may have "personal numbers" associated with them rather than with specific locations. The network will be able to locate them and route calls accordingly. "Personal agent" software will simplify the user's interface with the network, allowing calls to be flexibly screened or routed.
- Multi-purpose pocket phones will allow a person to place and receive calls from cellular, public cordless, and private cordless systems. They will also allow the user to be alerted to urgent messages (voice, fax, or other e-mail) and have these routed based on the users' preference.
- Increasing numbers of business faxes will be sent to and from PCs, routed by LAN servers and PBXs (or over a wireless network server), rather than between single-function fax machines. Fax images will be editable, and will include color if desired. They can be part of multimedia files, connected to videofiles and voice-annotated text or data files if desired.
- Businesses, government, and other organizations will be able to offer their customers the ability to place orders or complaints, or retrieve information, by "talking to a computer" (in natural language) any time day or night. The computer will act on instructions from the caller, alerting a live agent only when required, and can send confirmations out to the caller's preferred messaging system. (English-language capability will likely be first, but other languages will follow. In fact, translation services could be one of the offerings, with voice or text output.)
- Telecommuters and residential subscribers will have access to a variety of high-bandwidth services from their homes. These could be offered by the phone company, by cable companies, or by wireless service providers. Services may include interactive video, distance learning, multimedia database access, and entertainment services.

These are just some of the examples of what will be possible. Technology that used to exist in the realm of science fiction is rapidly becoming a reality.

Early users of these technologies will be deploying them by the end of the de-

cade.Large-scale deployment of all these technologies will likely take at least into the first decade of the next century. There may well be a 15-20 year span from early use to widespread commonplace use. (And by then — new technologies will be on the horizon that we haven't dreamt of yet!)

Predicting uses for technology can never be based on pure demand-pull or supply-push models. Users cannot demand services which are technically out of reach — or ones which are within reach, but of which users are unaware or do not understand. On the other hand, the simple existence of a technical capability does not ensure that it will meet a user need and thus become commercially significant.

The challenge facing the DOC in its R&D strategy is to marry the two: to determine which user needs can be met — in ways which users have likely not yet conceived — by the complex of promising technologies on the horizon.

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