

Visual Communication: Past, Present, and Future

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Abstract:

The advent of digital technologies brings a whole new dimension to human-to-human communication. From postal delivery system to telegraph, from telegraph to telephone, from telephone to television, technologies change the way we communicate with each other. Whether one-to-one or one-to-many, the information medium has changed from text to voice, from voice to images. The demand in bandwidth grows with the enrichment of information content. Issues in technology, policy and economics make visual communication nowhere near the ubiquitousness voice communication - telephone. Are we anywhere near that goal? What are the key technological, political and economical issues that we have to overcome to make that happen? This project examines past attempts of picturephone and videotex services, and try to shed some light into a future visual communication system.

Introduction

Seated at his home edu-tainment workstation, Mike Multimedia is researching a report on high-speed rail transportation. In a window on the display he calls up a full-motion color video sequence of a French Train a Grand Vitesse, which he had recorded earlier on a digital laserdisc from a high-definition TV network broadcast. The scenes lack the specific detail he's interested in, so he accesses the international databank in Chicago that stores high-speed rail digital video, and requests additional color sequences. They appear immediately in a second window of the display, but as he is reviewing them, the phone rings and an image of his wife appears in a third window. Her face is flushed, and she is obviously upset. "Honey, I've had an accident with the car, but I'm not hurt," she says, "but I'm afraid we're going to need a new right front fender." Mike answers, "Don't worry about it, as long as you're O.K." Mike, his train of thought broken, is tempted to look in on a football game in a fourth window. After a few minutes, he switches to a full-screen display, and then guiltily goes back to his report. The phone rings again and a fax

message from a source appears in another window, containing information to include in the report. - *IEEE Spectrum, March 1992*

This short description of a futurist's vision of our future is excerpted from IEEE Spectrum, March 1992, in an article titled "Digital Video" by Ronald K. Jorgen. Stories like this were thought to be imaginary a decade ago. They could be found only in science fiction books. Not so these days. They are appearing everywhere, including prestigious technical journals. We have seen many of these applications implemented individually on a trial basis. Some of them are available as commercial products with subpar quality. Much improvement is to be done on later products. The question is not whether we will have these products, but when we will have them at a commodity price. The digital revolution will certainly change every aspect of our lives. Its impact on social, economical, or political issues will be great that some experts say it's greater than the industrial revolution.

Jorgen's excerpt depicts part of the future information age - a future where digital technology dictates technologies in information gathering, storage and retrieval, processing, dissemination, transmission, reception, and presentation. Traditionally, these technologies were hatched in various fields including, but not limited to, consumer electronics, communication, and computer industries. Now they are converging together. In Jorgen's article, the work horse behind all the applications is a machine which he calls a home edu-tainment workstation. Some people mockingly use the term "teleputer" - a combination of television and computer, for the same idea. Indeed, the concept of a television and a computer being two different identities should cease to exist. In fact, not even teleputer is adequate to describe the products an edu-tainment workstation can replace. It can provide the functionalities of a television, VCR, camera, camcorder, CD player, laserdisc, telephone, facsimile machine, computer, and many other consumer and communication electronics. Of particular interest is the fact that all the applications contain visual information: the playback of a recording on a re-writable laserdisc, the viewing of high-definition TV broadcast on a network, the viewing of a database inquiry service involving video¹, the videophone, and the graphics facsimile. The network broadcast high-definition TV is a one-way communication channel, which is not the focus of this report.

¹The industry jargon is video-on-demand.

The re-writable laserdisc will be important to information storage, but is not discussed here either. The video-on-demand service can well be integrated into a videophone² or a facsimile's functionality³. A video-on-demand system can present text and graphics information coded as rasterize pixels array. The focus of this paper is on the future of a two-way interactive visual communication system.

Visual communication is a much broader concept than just an interpersonal switched visual telecommunication systems like videophone service. It also encompasses visual teleconferencing for groups of people, and information retrieval involving images. Videophone and the information retrieval over phone line are not new ideas. Videophone, or picturephone as it was called, was introduced in 1970 in the U.S. Interactive information service involving text and graphics⁴, termed videotex⁵, was introduced in 1979 in UK. Yet, two-way visual communication is not as omnipresent as voice communication by telephone, or as text communication by postal service today. Picturephone failed to create a niche market - video teleconferencing for business travelers, its inventors had hoped for. It cost AT&T over 500 million dollars[1]. Videotex failed to create a mass market its service providers thought it would⁶. It was a market failure in many countries, particularly in the U.S. Was videophone a solution looking for a problem? Was videotex a concept looking for a market? Will digital technology, in particular computer technology, bring new lives back to these ideas?

This paper examines the failure of picturephone and videotex services, and discusses issues encountered in their respective technology, economics, and marketplace. A status check with the current technology and a proposal to deployment of a two-way interactive visual communication will also be presented.

²In this case, the communication bandwidth requirement will be asymmetrical. That is, high bandwidth for the incoming data stream and low bandwidth for the outgoing stream.

³If we demand the fax pages being sent at video rate, it indeed can display live video.

⁴Or animated graphics.

⁵This term is used by CCITT.

⁶With the exception of France, where government financed the deployment.

Videophone

History

As early as 1927, Bell Labs conducted an experimental face-to-face telephone conversation between Herbert Hoover (then Secretary of Commerce) in Washington DC. and AT&T President Walter Gifford in New York City using a television signal[2]. Mr. Gifford foresaw the use of television as an adjunct to telephone calls for face-to-face telecommunication in the future[3]. A series of trials and experiments led to the development of Mod II system, which saw its commercial deployment through local exchange service in Pittsburgh in 1970. Chicago had its picturephone service since 1971. Over 100 subscribers were listed in 1973. Four years later, only nine customers retained their picturephone service.

Technology

Mod II was a desktop customer premise equipment (CPE) with a black and white camera, monitor, and graphics visor. The video contained 250 active lines out of 267 line at 30 frames per second and a bandwidth of 1 MHz. The viewing screen was 5 1/2 inches high and 5 inches wide⁷. A speakerphone or a regular handset was used to the voice channel. It was not clear what Mod II's market identity was. It was designed for video conferencing, which, in turn, was to improve collaborative working over distance; yet it lacked the features for that application. It had a graphics visor but no hardcopy or storage capability. Workers often needed to exchange documents for filing or reference. There was another drawback. Mod II did not provide the capability for handling multiple video conferencing calls on the same screen. There was no provision for switching among multiple speakers in the same conversation. As a result, conference participants had to gather in front of a picturephone and took turn to show their faces. The unit was small enough to be on a desktop, but it was best suited for a two-person video conversation.

Mod II worked over existing local loops with some modification. Two additional twisted pairs were used to accommodate the extra bandwidth needed for video: one pair for incoming video, and one pair for outgoing video. Active equalizers

⁷The nearly square screen was designed to show human faces. A picture of Mod II system can be found in Pierce's book[4], p236.

were added every mile to compensate attenuation of the high frequency video signals. Long distance switched picturephone service was never deployed, although a digital encoding scheme at a rate of 6.312 mbps was proposed.

Economics

The cost of extra twisted pairs to the customers' premises and through the trunk lines was eventually to be paid by the subscribers. One local picturephone call would displace two voice-only calls. One long-distance picturephone call would displace 100 long-distance voice-only calls. Judging from this fact, the long-distance would be very expensive.

The initial offering of local-exchange picturephone service in 1970 cost \$169 for installation and \$169 a month thereafter, with no additional charge for the first 30 minutes usage each month and 25 cents per minute thereafter. A year later, same service was offered in Chicago with no installation charge and the monthly charge dropped to \$75 with no additional charge for the first 30 minutes each month and 15 cents per minute thereafter. The average monthly rate for U.S. local single-party service with unlimited calling, including taxes but excluding telephone instruments, was \$5 in 1970⁸. Converted to 1988 constant dollars, it is equivalent to a monthly charge of \$676 in Pittsburgh and \$300 in Chicago⁹. The cost was too high compared to regular voice service, whose average monthly rate was \$5 for local single-party service with unlimited calling, taxes included.

Marketplace

Residential

Although the picturephone initially targeted business customers, it was intended to evolve into a switched telecommunication service for universal use as an ultimate substitute for voice-only telephone service[5]. Market response to picturephone service was very disappointing to picturephone enthusiasts. Lack of applications was cited by most trial users. Indeed, residential use of strict face-to-face communication had limited appeal. Consumers' adaptation to a new technology usually starts with a subset of applications the technology can offer. I conducted an informal survey on my

⁸This number is derived from Pierce's book[4], p6.

⁹Data is extropolated from Pierce's book[4], p6.

friends. Most of them would make use of the video feature only for calls to their close friends or family members unless face-to-face conversation over the phone becomes a social etiquette. Based on this result, the number of picturephone calls a person makes every day is a small fraction of the total number of voice calls, even assuming no extra charge to such calls. Cynics see videophone as a vehicle for phone sex, which it may well become. Phone sex industry may just become the niche market of videophone. To the mass market, usefulness and cost of a new technology are clearly the most dominant factors. The Mod II system failed to address either. It was said to be a solution looking for a problem.

Business

AT&T's picturephone was designed as a desk-top unit targeted for use by business customers. Julius P. Molnar, an executive vice president of Bell Labs, considered the major impact of the telephone and jet aircraft on communications and predicted that before the turn of the century Picturephone will displace today's means of communication; similar to what telephone did to postal service[5]. Some researchers had predicted that teleconferencing could take the place of from 20 to 85 percent of all meetings involving travel. Contrary to this prediction, teleconferencing services met with low acceptance.

A Michael Noll hypothesized that users' behavior, not technology or cost, ultimately determined the usage[2]. Users need to have the right kind of meetings, usually recurring, on-premises committee meeting intended mostly for coordination and information-exchange purposes, to justify its use. The room video conferencing paradigm of the time and high cost of connection time demanded full preparedness of equipment, personnel, agenda, and conference materials. A study conducted by John R. Pierce showed that only 4 percent of all meetings involving groups of people are good candidates for teleconferencing.¹⁰

The shift from room conferencing to desktop conferencing paradigm reduces the cost of preparing a room conferencing. With the system installed on a desktop computer, participants to a video conference can sit in his office and

¹⁰See Pierce's[4]P.236.

be called upon for a conference anytime without an advanced notice. This would encourage the usage in a casual setting. Exchange of text, graphics, or images can be easily accomplished with a computer equipped with a camera or a scanner.

Standards

Before 1984 AT&T's divestiture, there was no competition in the telecommunication industry. Neither was there standards issues within the U.S. Whatever AT&T did became a *de facto* standard. The lack of an international standard actually inhibited the use of picturephone services overseas. Switched telephone networks in other countries would have to install the same extra twisted pairs and use the same digital encoding for trunk lines for international videophone calls. Without a standard, many of the equipment vendors built non-compatible hardware and links islands of their consumers through dedicated trunk lines. The cost of initial capital investment to equipment and subsequent upgrade or maintenance is very high. Customers did not have a third-party to choose their hardware and service. It was difficult to justify such an investment since high cost of video conferencing defeated its intended saving of expensive traveling.

Policy

There was no government regulation against picturephone service. However, there was no government policy of supporting a universal videophone service either. No public policy was made to build a universal videophone network or to increase the installed customer base, a classic chicken-and-egg problem. As a stand-alone single-function unit, it could not achieve the economic scale of a mass market to sustain its service without public funds until it became profitable. The cost of researching, developing, and providing such a service came from AT&T and could only be compensated from the marketplace. And that proved to be too costly for the mass market.

Summary

On the technology front, optical technology was not available at that time. Image compression algorithms were not as good as today. The cost of bandwidth per Mhz was significant with twisted pairs and cable trunk lines. Circuit switching required a continuous physical connection between the two

ends of a phone line. The technology at that time could not deliver a cost effective picturephone service.

Picturephone failed in the residential marketplace partly because there was no demand, but it alone did not translate to market failure. Picturephone as a stand-alone commodity item may never sell in mass market. It simply has limited uses for its cost. The same thing can be said to the picturephone service. It has to be bundled-in with other value-added services, such as on-line service.

Picturephone hardware should be packaged in a larger system with a different product identity to enter the mass market. That product is the personal “communicator”¹¹.

Picturephone failed in the business marketplace because of technology, economics, and standards issues. There was demand for that purpose as later demonstrated by the recent success of video conferencing vendors like PictureTel and Siemens. Mod II was not the right product for that need. In fact, its identity was ever clear among its designers and marketing personnel. Its capability was technologically limited and it's only good for a two-person communication system, but it targeted the business conferences where multiple conference participants were commonplace.

Lack of a standard for long-distance and international calls further hampered its use in business marketplace where picture was intended to overcome distance barrier.

Videotex

History

Videotex¹² refers to various computer-based interactive systems that electronically deliver screen text, numbers, and graphics via the telephone or two-way cable for display on a adapted television set or a video monitor. The first system was developed on a Hewlett-Packard computer, and demonstrated

¹¹We have already seen telephone built in a personal computer.

¹²The term videotex is a generic suggested originally by the CCITT (International Telephone and Telegraph Consultative Committee).

in 1973¹³ in Britain. At that time the system was named “Viewdata” to the new television-based information system. Britain led the world by introducing its videotex service, known as “Prestel”, in 1979. Other countries throughout the world followed in the subsequent years[6,7]. Most public videotex services met with low acceptance rate with the exception of France. The French PTT deployed a videotex service with its telephone service and gave away free videotex terminals. It has over 4 million videotex terminals today, but the usage per subscriber is low in comparison to the number of accesses of an on-line service in the US. Other countries saw limited success from predominantly business customers. In the US, two prominent systems, Viewtron and Gateway, failed and folded in the marketplace. Instead, on-line services¹⁴ survived and boomed due to the popularity of personal computers and, most recently, the Internet. A sample of the major services throughout the world and the number of subscribers’ terminals in 1982 is shown in the following table.

Table 1: Major videotex services and the number of subscribers in 1982

Country	System Operator	Service Name	terminals
Austria	ITT/Austrian PTT	Bildschirmtext	300
Britain	British Telecom	Prestel	12000
Denmark	ITT/Demark PTT	Teledatal	260
France	French PTT	Teletel	250000
W. Germany	PTT	Bildschirmtext	5000
Holland	PTT	Viditel	2000
Finland	Sanoma	Telset	260
Sweden	PTT	DataVision	30
Switzerland	PTT	Videotex	150
USA	Knight-Ridder	Viewtron	260
	OCLC	Channel 2000	200
	Times Mirror	Telidon	200
Canada	PTT	Telidon	6000
Japan	PTT	Captain	1000

¹³The idea of videotex was attributed to Sam Fedida, then working at what was at that time the British Post Office Research Center in the early 1970s.

¹⁴Here I made a distinction between an on-line service and a videotex service in their origins.

Technology

Videotex technology brought integration of computer, telephone and television technologies. Videotex technology can be classified as a two-way asymmetrical graphics communication involving coded text and graphics. On one end of the communication link is the system operator's computer which gathers, processes, stores, and retrieves information. On the other end is the subscriber's terminal which decodes and displays the information.

The CPE of a videotex service was an adapted television or a video monitor. The CPE had a keypad and a modem. Subscribers typed in their requests with the keypad and sent requests through a modem. System operators' computers then processed the requests and sent back coded information over the phone lines. Early videotex services were centralized operations. System operators maintained large amount of information in their own databases. They also provided the necessary CPE to the customer. In many countries, the PTT was the system operator, the information provider and the common carrier[6,7]. The carrier for videotex was either a public switched telephone network or a private cable network. Data were digitally encoded and transmitted over existing networks.

Economics

Videotex did not require extra wires through local loops or trunk lines¹⁵. Cost was largely associated with CPE and databases¹⁶. Early videotex systems required dedicated terminal equipment, such as UK's Prestel, France's Minitel, Canada's Telidon and U.S.'s Viewtron and Gateway. Information providers' databases needed constant updates and maintenance. System providers had to maintain and update their computer systems as well as to market and promote the service, and to pay for telecommunications. Customers paid for their terminal equipment, connection time, use of databases, and, in the case of Viewtron, telecommunications fees.

For example, Knight-Ridder introduced its Viewtron videotex service in 1983. It had color, quality graphics, and hundreds of thousands of frames of news, information and entertainment accessed through its own databases or through

¹⁵With the except of high quality graphics and short access time. One example is the Viewtron system.

¹⁶Interestingly, customers pay for content for a videotex service in addition to charge of conduit for a videophone service.

gateways to other information providers' databases. Subscribers had to purchase AT&T's Sceptre videotex terminal at \$900 initially, later discounted to \$600, as the only way to access the system. Common carrier Southern Bell installed a Local Area Data Transport (LADT) network and charged Viewtron subscribers \$1 per hour in addition to \$21 of basic videotex service charged by Knight-Ridder. In 1985, Knight-Ridder changed its pricing strategy. It charged \$25 per month for rental of terminal equipment and first 5 hours of service, and \$1 per additional hour. Phone charge was extra by usage. Knight-Ridder could not make it a profitable business and shut down its Viewtron service in 1986. Times Mirror also offered a videotex service, called Gateway, in 1984. It charged \$30 per month for terminal rental and 10 hours of service, and \$3 per additional hour. It too could not attract enough customers and shut down its operation in 1986.

In other countries, videotex was not a profitable business either. Prestel did not make money until its sixth year. More detail on the pricing and economics of other systems can be found in Mayne's book[7].

Marketplace

Contrary to picturephone, videotex was conceived for the residential marketplace. Videotex system operators had hoped for an economic scale of a mass market to drive down the cost of CPE and their cost of operation. Demand for videotex service existed, but system operators failed to recognize that their entry point was a niche market - business customers and PC owners. To those, electronic messaging and mail services were important - another oversight in early systems. At the time of videotex's introduction in the early 1980s, mainframe computers and minicomputers already populated the workplace. IBM had introduced its popular System/360-370 for fifteen years. DEC's PDP series had existed over a decade. Microprocessor technology had seen its use in microcomputer systems. The APPLE II computer was already popular among early adopters. Later, IBM introduced its popular PC series in 1981. The computer revolution swept the business community. The general mass market lagged behind educated young professionals in adapting to new technologies, and the professionals were interested in better productivity in the workplace, where computer terminals were abundant.

Viewtron and Gateway belatedly wooed PC owners randomly scattered around the nation - a grasp for any branch on the cliffside as they came tumbling down. But it was too late. They tried to shift from the single-function videotex terminal to the PC population but could not alter their marketing patterns in time¹⁷. It require a different pricing structure, a willingness to accept the fact that PC owners were more interested in communications than just static page accessing. Also, a service based on a single monthly rate for the basket of videotex services had to be unbundled.

It was no coincidence that on-line services succeeded. CompuServe and Dow Jones News/Retrieval (DJNR) were considered plain-vanilla, text-only on-line electronic databases accessed through phone lines to personal computers and desktop terminals. The supported a variety of terminal equipment, mostly computer based, and never got themselves into the equipment vendor business.

CompuServe started in 1969 as a time-sharing service for business needing remote access to mainframe computers. In 1979, it began its information service to use the great computing power unused after business hours. It offered new services for PC users when Personal computer became popular. CompuServe attracted customers nationally who were well-educated “characteristic Yuppie types”. DJNR began in 1974 as a business and financial service over dedicated phone lines. It was accessed by personal computers, time-sharing terminals, communicating word processors, and teletypewriters. By 1979, the service was expanded to reach companies outside the financial industry and PC owners using dialup phone access. DJNR charged \$54 per hour prime time to \$12 per hour in non-prime time, plus one-time membership fees and monthly charges[8]. Despitethe pricing was beyond the reach of general market, both did well in the marketplace.

Standards

Videotex development was hampered by competing standards that left manufacturers wary of producing hardware that might soon become obsolete. It also made it difficult for service providers to design databases when faced with different electronic text coding and access procedures. CCITT adopted the

¹⁷ Does this ring a bell to how WANG, DEC, and IBM got themselves in troubles? It was in about the same time these companies started sliding down.

standards of Britain, France, and Canada by 1980. The effect was a political compromise with no real standards. National pride superseded technical efforts to create a single coding scheme. United States and Canada backed NAPLPS (North American Presentation Level Protocol Syntax), while Japan backed its CAPTAIN and European countries pushed the CEPT (Commission of European Post and Telegraph) standard.

On the database technology side, there was no standard in access, storage, or user interface. Proprietary access and storage algorithms increase the cost of system integration, which system operators incur. A standard user interface will promote its acceptance and is particularly important to mass market.

Policy

Though many of the system operators were the PTTs of their countries, only France deployed a nationwide service. Unlike voice-only or picturephone service, the initial installed customer base was not as important. It is important only to person-to-person communication. Electronic messaging, BBS, mails were thus important services for that end, which the initial systems failed to address.

Summary

Videotex had mass market potential as demonstrated by the recent success of on-line services. The idea of residential videotex service was ahead of its time given the readiness of technology and marketplace at the time. On-line service providers didn't target the mass market from the outset. They created a niche market consisting business customers and early PC adopters, and later rode the PC tidal wave into the mass market. Viewtron and Gateway failed to recognize that the computer revolution was sweeping the industry, and that their initial market entry should have been the business community and the PC owners. They designed a system to work as a single-function stand-alone terminal equipment. The fact that potential subscribers, business customer and PC owners, had easy access to a computer terminal on which they worked, communicated, and entertained, among other things, was ignored.

Current Technology

Videophone and video conferencing came to the forefront again in late 1980s. This time armed with digital technology and international standards. VLSI technology has made great leap in the last decade. The cost of memory and IC chips has gone down dramatically. Image compression techniques have improved to a point that a 30:1 compression ratio for video with good quality is commonplace. And an algorithm has been adopted by CCITT as an international standard[9]. Digital modulation-demodulation techniques with error-correcting codes can pack more bits into the same bandwidth. Packet switching technique eliminates the need of a continuous connection and allows flexible routing of data and efficient use of physical wires. CCITT contributing members finally reached an accord on how to provide services for integrated service digital network (ISDN) worldwide. Realizing its potential mass market status, vendors have been racing to come up with a cost effective solution. Technology seems ready and vendors are poised to launch an all-out assault on the market.

Videophone

AT&T introduced its video telephone over regular telephone lines in 1992 at a price of \$1500 per unit¹⁸. The videophone has a 3.3 inch by 2.5 inch color LCD display. A camera lens is mounted above the screen. It allows self view, audio-only, among other features. Equipped with a modem, it sends a bit stream at 19.2 kbps, of which audio takes up 6.8 kbps and video 10 kbps.

The new videophone does not see much market acceptance either. At 19.2 kbps, the image quality is simply not good enough and the frame rate is too slow. The cost is equivalent to a personal computer, but its only use is person-to-person communication. To that end, the installed customer base is not large enough to initiate a snowball effect. The demand was not there for the Mod II system and the demand for the digital videophone is not here either. For technology to drive an almost non-existing market, the product must be very inexpensive.

Videophone as a stand-alone product still seems to be a product looking for a market.

¹⁸MCI later introduced a set for \$750.

Video Conferencing

Video conferencing equipment has much better success in the marketplace. PictureTel, Siemens, AT&T, Intel all make video conferencing equipment. The success is clearly due to the international standards adopted by CCITT. The market was there when videophone was introduced in 1970. But the product was not the right one and was inoperable over international boundaries. A personal computer or a workstations is on every desktop in the workplace today and is used as a platform for work, communications, entertainment, etc.. The paradigm of video conferencing has shifted from room to desktop. Control is done on the software level rather than the hardware level. The center of focus of standardization is thus shifting towards software interface.

Videotex

Computers have replaced the videotex terminals and the original public videotex service has ceased to grow. Instead, it has been transformed into or replaced by on-line services. On-line services adapted many of the characteristics associated with videotex to widen their base of users to the more general consumer market. For example, today more than 2.7 million personal computer users in 120 countries use their modems to tap into nearly 2,500 databases CompuServe offer on-line.

In the for-profit on-line service sector, the access of information is through a modem over a telephone network. Subscribers can access other networks through gateways provided by the system operators. System operators charge a flat monthly rate for a basic service, which usually includes access to public network and some databases. The following table is a sample of the for-profit on-line service providers in the US and the services/databases they provide.

Table 2: Popular on-line service providers in the US

Company	Services Provided	Monthly Rate
America On-line	EMail, WWW, FTP, Gopher/WAIS, USENET, live chat, news/stocks/consumer info (USA Today, ABC, Kodak, Time, etc.)	\$9.95
Compu-Serve	EMail, USENET, FTP, Telnet, IRC, forums, news/stock/consumer info (MedLine, CNN, AP, Reuters, IP, US News & World Report, etc.)	\$8.95
DELPHI	EMail, WWW, Gopher/WAIS, FTP, USENET, IRC, news/stocks/consumer info (AP, Reuters, IP, Dialog Research, etc.)	\$10.00
PRODIGY	EMail, WWW, FTP, USENET, forums, news/stocks/consumer info (PCFN, Quote Check, Consumer Report, etc.)	\$8.79

In the non-profit service sector, information service providers, mostly non-profit institutions, offer free information or free shareware of any kind over public networks. The most popular public network is the Internet. Subscribers can tap into the Internet by connecting to a near-by node on the Internet and follow the same protocol of the network for data transfer. The Internet community consists of people who have access to a computer on the net usually through work, education, and gateway. On-line services have benefited from the popularity of the Internet. Since many people subscribe to an on-line service just to get access to the Internet, in this way the Internet has penetrated into homes and acquired its mass market status. The Internet becomes popular because it offers a network over which many services are offered free of charge.

On-line services and the Internet are popular because they don't require special single-function CPE to work on. The concept of dissociating CPE hardware, software, network, and service has become the model of open systems. Behind this concept is the concept of interface standards. TCP/IP protocol becomes a *de facto* standard for access to the Internet. Any CPE following that standard can be a node of the Internet no matter who makes the CPE.

Standard is just as important for application software, which often encounters a variety of hardware platforms. Mosaic and Netscape are the *de facto* Internet

browsers. HTML (HyperText Markup Language) has become the standard linking databases of different types. For visual data, there are a few standards concerning the storage of such data. JPEG[10] (Joint Photographic Experts Group) is Adopted by ISO and is supported by most applications processing still images. MPEG[11] (Moving Picture Experts Group) is the standard for motion video. Standardization has spurred the growth of hardware and software applications of JPEG and MPEG and made the prices competitive in the marketplace.

Conclusion

I believe in the future optical fibers will unite the homes in different countries, and a man in one part of the world may communicate by word of mouth and sight of eyes with a different place. - *Modified after Alexander Graham Bell*

The assumption that a stand-alone, single-function picturephone terminal would dominate future interpersonal telecommunication failed to test in the real-world marketplace. The problems of the Mod II system in the residential market were that it had limited application and it was too costly. The idea of videophone at that time was ahead of what technology could offer - an cost effective solution in terms of CPE and telephone network. Some people derived a conclusion that very few people wanted videophone services therefore it would never sell. I am dubious. Many people buy a computer to do word processing or to play games. They buy color monitors even though, for word processing, a monochrome will suffice. The same thing can be said to other add-on modules in a computer: sound cards, modems, CD-ROM drive. Another good example is the add-on options of a car. The marginal cost of a feature when bundled in a package is so low compared to a stand-alone single-function unit. The low cost justifies occasional use of that feature. In particular, many operations, such as Huffman coding, DCT, motion estimation and compensation, etc., in the CCITT H.261 compression algorithm are also used in JPEG or MPEG. When people come to expect on-line or video-on-demand services¹⁹, engineering shrewdness can use some of the hardware to further reduce the cost. The vehicle for penetration of videophone into mass market would be a computer with videophone capability. The mass market potential

¹⁹Today on-line subscribers use JPEG for storage and transmission of images.

is not here yet, since videophone hardware and ISDN service are still too expensive.

However, to business users, the CPE hardware and ISDN service for video conferencing are ripe for the market. The telephone network is not quite up to the required bandwidth. To business users, graphics is more important than video. As one expert puts it: "What's driving the market for desktop video systems is not the video per se, but rather users' pent-up desire for document sharing and the ability to do collaborative work. As it happens, desktop video technology and two-way document-sharing capabilities are emerging simultaneously, but the majority of market players admit that video is the least important piece of the equation at this stage in the product's evolution." For that end, narrow-band ISDN offers a reasonable solution.

The presupposition that a stand-alone single-function videotex terminal would dominate future information services was upended by the PC's arrival. Computers replaced videotex terminals and on-line service superseded videotex service in the marketplace. The popularity of tapping onto the Internet is pushing the speed of modems to a limit. Ultimately, it will push for a faster telephone network. The content of on-line service will migrate from graphics and images to video. The video-on-demand capability will be integrated under a grand architecture to support multiple applications involving video. It carry the videophone into mass market. On-line services will be the killer application for personal computers.

Videophone technology will ride the tidal wave of personal computers and on-line information services into offices first, then into homes. Someday, staying on-line would mean "staying competitive"; literacy would mean "computer literacy"; telephone implies "videophone"; only when communication is synonymous with "visual communication".

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