Overview of Communication Network Evolution

ABSTRACT: The shifts in social paradigm can trigger diversified communication services. Therefore, technical “seeds” must be fostered to meet these needs. This entails building an infrastructure for communication networks and technologies for user systems. We can observe significant developments in (a) transmission systems, in which the characteristics of technological “seeds” in optical transmission and wireless transmission meet these requirements, (b) switching systems, which are moving towards ATM (asynchronous transfer mode) technology, and (c) storage systems, which handle multimedia above transmission and switching systems. Furthermore, it is expected that the communication network infrastructure will evolve towards greater reliability and contain more intelligent functions by modification of the management system.

INTRODUCTION
TODAY, the environment of communication network is changing dramatically. The explosive growth of new communication services such as the Internet, the rapid and widespread proliferation of mobile communications, and the global alliance of communication carriers, following communication deregulation in many countries, suggest that we are entering an advanced information age of true substance.

The impetus for such big changes comes from society’s needs. Whether these changes are actually accomplished depends on the provisioning of technical “seeds” to meet these demands. The implementation of infrastructure technologies which support the basis of communication networks, such as transmission and switching, has been promoted to match the changes in social needs at good cost-performance, based on the evolution of semiconductor devices, computers and software technology.

On the basis of a comparison between the progress of communication networks and its relation to society’s evolution, this article describes the direction in which this massive ongoing change is heading, and gives an overview of the future.

DIVERSIFIED COMMUNICATION SERVICES
The paradigm shifts observed in modern society represent major changes in the social framework, such as shifts from “centralized to distributed,” from “local to global,” from “shared-use to personal-use,” and from “monopoly to competition.” These changes are very important for social progress, while solving many current challenges, such as the aging of society, environmental problems, and globalization.

The concept of paradigm shifts is also applicable to corporate strategies in this information-intensive age. The re-engineering of these changes is currently being discussed.1) One major topic in this discussion is the strategic and effective use of computers and telecommunications in a new social environment.

Today, communication services are being diversified at a rate which has not been experienced before. They are also undergoing drastic changes, ongoing against the backdrop of certain social paradigm shifts.

A typical example of this is the rapid proliferation of mobile communications in Japan. The rate of increase in subscriptions for pagers, mobile phones and PHS (personal handyphone system) achieved...
average figures of 45% annually during the period between 1994 and 1997. The number of pager subscribers reached 8.3 million, while the number of mobile and PHS subscribers reached 35.7 million by December 1997. It is expected that the number of subscribers to mobile telephone services will come close to the total number of current wire-based telephones (62 million) by the year 2000 (Fig. 1).\(^{(2),(3),(4)}\)

It is expected that the number of subscribers to mobile telephone services in Japan will come close to the total number of current wire-based telephones (62 million) by the year 2000. WLL will continue to expand in the global market.

The astonishing explosion in the number of users connecting to the Internet is not an exception. While the number of hosts connected to the Internet in July 1995 reached 6.6 million, by January 1998 this figure had increased to a staggering 29.7 million, a rate of increase unprecedented in history.\(^{(5)}\) It is assumed that this phenomenon is a result of the combination of many factors, and is closely related to the two paradigm shifts, from “local to global” and “centralized to distributed.”

The formation of mega-carriers at the global level, typified by the alliance among communication carriers mainly in Europe and America, and the movement to provide low-priced communication services, can be seen from the same perspective. While deregulation brings about an active, competitive environment and works as a trigger for making latent needs manifest, it also acts as a driving force for accelerating the development of technical “seeds.”

The keywords associated with social needs are “personal,” “multimedia,” “global,” and “low-cost.” It is expected that services which fulfill these needs will appear in a variety of forms.

**EVOLUTION OF COMMUNICATION NETWORKS**

Technological changes in infrastructure for communication networks and communication terminals for human-to-machine interfacing are indispensable for diversified communication services. This section gives an overview of the progress of the infrastructure technology which constitutes the network.

Management of the network functions and the three technological aspects, housed within it, transmission, switching and storage, are all requested from the infrastructure. So far, there has been a huge technological change at each alternation of generation. Even at present, a technological change is afoot for needs becoming manifest by the social paradigm shifts.

**Transmission Systems**

(1) Transmission is classified into backbone transmission, to interconnect switches, and subscriber
access, to connect users to a switch. The most significant technological innovation in backbone transmission is optical transmission. The prime factor attributed to the shift from conventional wireless communications, such as microwave transmission, to optical transmission is the excellent cost-performance associated with optical systems. This is a good example of the case in which the technical “seeds” match the social needs for a larger capacity of backbone transmission systems.

The capacity of backbone transmission systems shows a trend of increase of one order higher approximately every eight years. Today, 10-Gbit/s systems are available for practical use (Fig. 2). Previously, only the need for the information transfer that would utilize such a huge capacity was discussed. However, these trends indicate that any increase in capacity will always be consumed by new and improved services. In other words, latent needs for communication services will always exist in a variety of ways, and will become manifest in correlation with other technologies and the paradigm shift of social structure.

On the other hand, the area of subscriber access is closely related to the switching system, so both must be coordinated to meet these needs. The current goals of this subscriber access are to achieve a higher speed and greater diversification (Fig. 3).

The Internet is regarded as the driving force for higher speeds. The use of ISDN (integrated services digital network) to access the Internet more quickly is gaining precedence over analog modems, because ISDN can support a greater amount of data (up to 128 kbit/s) using existing telephone lines. However, new access technology will be necessary to implement higher access speeds to meet the future requirements expected for multimedia applications.

To address this challenge, two technologies are being developed: FTTH (Fiber to the Home) which provides fiber-optic cables to each home, and FTTC (Fiber to the Curb) which provides fiber-optic cables to a local multiplexing hub and then uses existing telephone lines to distribute the information to each home. The “seeds” which allow high-speed information delivery in optical transmissions are evolving towards the implementation of broadband ISDN, even in the field of subscriber access.

Another change in the field of subscriber access is the diversification of access measures, in particular, radio access, which will play an important role in the future progress of communication networks. In the history of communications, radio has been used as the standard technology for backbone transmission. Upon entering the era of large-capacity transmission, radio access, to connect users to a switch. The most significant technological innovation in backbone transmission is optical transmission. The prime factor attributed to the shift from conventional wireless communications, such as microwave transmission, to optical transmission is the excellent cost-performance associated with optical systems. This is a good example of the case in which the technical “seeds” match the social needs for a larger capacity of backbone transmission systems.

The capacity of backbone transmission systems shows a trend of increase of one order higher approximately every eight years. Today, 10-Gbit/s systems are available for practical use (Fig. 2). Previously, only the need for the information transfer that would utilize such a huge capacity was discussed. However, these trends indicate that any increase in capacity will always be consumed by new and improved services. In other words, latent needs for communication services will always exist in a variety of ways, and will become manifest in correlation with other technologies and the paradigm shift of social structure.

On the other hand, the area of subscriber access is closely related to the switching system, so both must be coordinated to meet these needs. The current goals of this subscriber access are to achieve a higher speed and greater diversification (Fig. 3).

The Internet is regarded as the driving force for higher speeds. The use of ISDN (integrated services digital network) to access the Internet more quickly is gaining precedence over analog modems, because ISDN can support a greater amount of data (up to 128 kbit/s) using existing telephone lines. However, new access technology will be necessary to implement higher access speeds to meet the future requirements expected for multimedia applications.

To address this challenge, two technologies are being developed: FTTH (Fiber to the Home) which provides fiber-optic cables to each home, and FTTC (Fiber to the Curb) which provides fiber-optic cables to a local multiplexing hub and then uses existing telephone lines to distribute the information to each home. The “seeds” which allow high-speed information delivery in optical transmissions are evolving towards the implementation of broadband ISDN, even in the field of subscriber access.

Another change in the field of subscriber access is the diversification of access measures, in particular, radio access, which will play an important role in the future progress of communication networks. In the history of communications, radio has been used as the standard technology for backbone transmission. Upon entering the era of large-capacity transmission, radio
conceded its position to optical transmission technology. However, the seeds of radio technology, which have been closely linked with the paradigm shift of “personal,” have recently found favor in the field of mobile communication, in a way different from backbone transmission.

Communication through personal computers (PCs) via mobile telephone terminals is already in widespread use, as are PHS-based data communication services, which began operating in Japan in April 1997. It is expected that the establishment of e-mail as a regular means of communication, together with the use of hand-held PCs, will boost the demand for a reliable high-speed data service in mobile communication systems. Mobile communication is expected to progress from the conventional telephone-oriented system to a system which supports multimedia communications. New technologies, such as broadband CDMA, which have already received much attention, will address the challenge of high-speed multimedia communication via radio technology. Research and development of such technologies is actively underway.\(^{(7)}\)

**Switching System**

(1) One of the major technological innovations previously developed in switching was digital electronic exchange, the basic concepts of which are reflected even in today’s exchanges.

What is noteworthy in this evolution of digital technology is the provisioning of the ISDN service. ISDN was introduced in various countries around 1988 as the international-standard infrastructure technology to support the entirety of communication services, including voice, data and video. There was already a concept of multimedia communications at that time, and ISDN was expected to be a service which would spread into every home. However, the initial users were mainly corporations. This means that although there were latent needs for multimedia communication at home, the environment was insufficient to make them manifest.
Today, however, the widespread increase in the number of users accessing the Internet, and the increasing demand for high-speed data communication, owing to the dramatic decrease in the price of personal computers, are two of the factors which are accelerating the proliferation of ISDN into the home.

(2) Around the time when the international standard for ISDN was being established, the research and development of broadband ISDN was actively being promoted for use as the infrastructure for a fully-fledged, multimedia communication era. During this time, many other technologies emerged. One of the technical “seeds” which has the potential to drastically change the communication infrastructure is ATM (asynchronous transfer mode). This method of transferring and processing all information in short packets or “cells” was a revolutionary idea for the coming multimedia era.

Today, ATM technology is being introduced into the infrastructure of communication networks in a variety of ways. It will be especially effective as the backbone technology for high-speed data transfer, such as in frame-relay networks. These networks extensively use an architecture which realizes a good cost-performance by adopting ATM technology for the internal processing of the switch, while using frame-relay networks in the user interface. With regards to the Internet, a significant improvement in the processing capacity of IP (Internet protocol) is being demanded to handle increasing traffic. It is expected that ATM technology will be able to cope with this increase.

In the future, ATM technology will be used to support the demands of multimedia communication, which will surely evolve in the network infrastructure toward the ultimate goal anticipated in the beginning of its development.

Storage Systems

While the demands of the communication service are becoming more diversified, so the information storage systems are evolving too. The voice message service, best represented by the answering machine, is perhaps the most familiar communication service which uses information storage.

Voice mail services are becoming an essential item for users of cellular and PHS telephones. In addition, voice mail is also being introduced as a new service for telephones and pager systems.

High-efficiency voice encoding and large-capacity file technologies are two basic technological “seeds” which are deemed necessary to implement such a service. Voice encoding evolved into the technology which can be seen today, triggered by (a) the need to use digital leased lines economically in corporate networks, and (b) the need to accommodate more subscribers within a limited band frequency.

The evolution of the high-efficiency voice encoding
technology was supported by the advanced voice analysis and encoding algorithm, and digital signal processing (DSP) technology. It is expected that the further development of both of these technologies will result in the embodiment and widespread use of new services, such as voice recognition and media conversion.

The development of large-capacity, low-cost magnetic and optical disks will become increasingly more important in the future to meet the demands of new services, which are required for the realization of a fully-fledged multimedia environment in telecommunications.

Web servers are also advancing rapidly to encompass multimedia applications such as sound and video. The server, which has evolved as the data storage or I/O device in computer systems, is expected to serve as a key storage subsystem in communication networks in the future, primarily in new Internet services.

Management System

The communication network is an important infrastructure which supports social activities. The news about the national-level discussion ongoing to improve the reliability of the communication network during disaster after the Hanshin-Awaji earthquake in Japan in 1995 is still fresh in our memory. Each of the transmission, switching and storage subsystems which constitute the communication network requires a management function to monitor the operating state and take actions if failures occur. The integrated management of the entire network is performed by the upper management system, or TMN (Telecommunications Management Network). The TMN handles a vast amount of the management information obtained from these subsystems (Fig. 4).

The evolution of the digital, computer and software technologies in the communication network continuously enhances the functions of the network management system. It is expected that new services, closely associated with economic activities, such as electronic commerce and electronic money, will be introduced and expanded globally throughout the communication network in the future. In this respect, network security and reliability are becoming a critical issue.

CONCLUSIONS

We have discussed the current situation, as well as the direction of future evolution, of the communication network infrastructure from the viewpoint of social paradigm shifts.

Hitachi will contribute to the realization of a highly information-oriented affluent society in the 21st century by providing a variety of devices to quickly meet the diversified communication service needs. Hitachi will also contribute to the realization of a seamless network through the use of software and the provision of a total solution which responds to the needs of each user.

REFERENCES
(1) D. Tapscott et al., translated by Nomura Research Institute, Paradigm Shift—The New Promise of Information Technology (1994).
(2) Society of Telecommunications Carriers, Society News (19 March 1997).
(3) Telecommunications Technology Council, Report from the Committee on the Efficient Frequency Use in Mobile Phones, etc. (February 1997).
(4) Ric Telecom, Telecommunication, No. 152 (March 1997).