Featured Topic: Evolution of Information and Communication Technology and Our Roles in It

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1. Introduction

Since the spread of the internet from the beginning of the 1990s, we can obtain information from across the world almost with no delay. Data traffic has been increasing year after year (Fig. 1).

Initially, voice and text information was sent over the internet, then pictures and video were added, and recently, various data has been transmitted, which are necessary for autonomous driving, artificial intelligence (AI), the metaverse, and other technologies that change our lifestyles. In addition, the subject of communication has been expanding from human to things, and a large volume of data is being exchanged all the time.

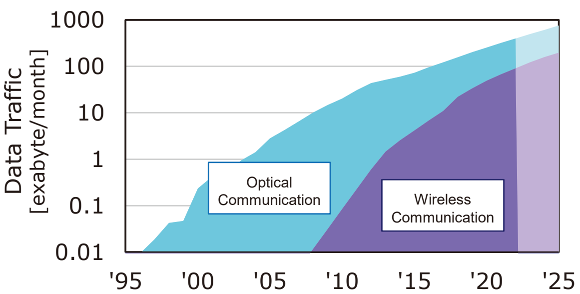


Fig. 1. Trend and forecast of global data traffic (Cisco VNI, Ericsson Mobility Report & Sumitomo Electric Device Innovations estimate)

2. History and Development of Telecommunication Technologies

There are two types of communication: wired and wireless communication.

Optical communication, a type of wired communication, has contributed to the evolution of information and communication technologies. Since the first quartz glass optical fibers were prototyped in 1970, optical fiber cables have been widely installed. In optical communication, analog signals, such as voice for example, are converted into digital electrical signals of zero and one. They are converted into optical signals and transmitted through optical fibers. At the receiving end, the optical signals are converted into electrical signals which are finally demodulated into analog (e.g. voice) signals and information is transmitted.

On the other hand, the first-generation commercial wireless communication service was launched in Japan in 1979 by Nippon Telegraph and Telephone Corporation and elsewhere in the world around the same time. In wireless communication, after analog signals are converted to digital signals, they are superimposed on a high-frequency wave (microwave or millimeter wave) for transmission through space. Radio signals are converted to electrical signals and into analog signals at the receiving end.

Since then, various technologies have been developed to increase the data transmission capacity in both optical and wireless communication.

In optical communication, to increase data transmission capacity, the first approach is to increase the operating speed of optical elements. Another method is wavelength multiplexing technology in a single fiber and multilevel modulation technology utilizing the phase and polarization of light. Recently, multicore fiber, a single fiber with multiple cores, has also been developed (Fig. 2).

While optical signals travel down optical fibers, they degrade in waveform and attenuate in intensity. Since high-speed modulated optical signals and multilevel signals are

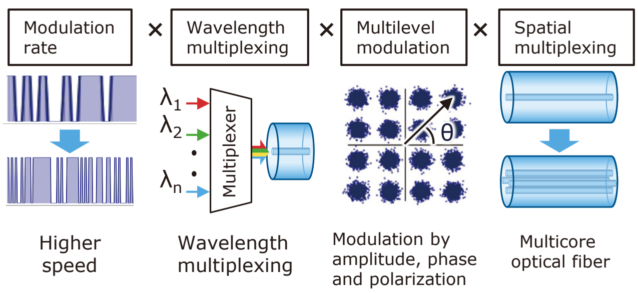


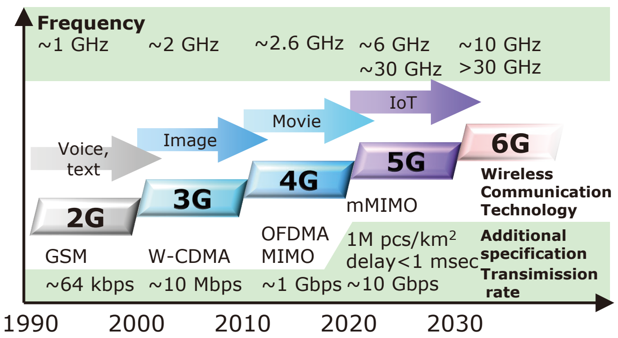
Fig. 2. Technologies to increase capacity of optical communication

significantly affected by waveform degradation, reducing the losses in optical fibers and optical connectors is important to transmit highly modulated signals at high speed as accurately as possible.

The most economical combination is selected and implemented in the communication systems, which depend on transmission distance considering the progress of the latest compound semiconductor devices, Si ICs to drive and control them, and the improved characteristics of optical components.

In wireless communication, second-generation mobile communication technology enabled 10 Mbps transmission. New generation technologies have emerged approximately every 10 years through more effective use of frequencies using higher frequency and advanced signal modulation. Current fifth-generation (5G) technology enables a maximum transmission speed of 10 Gbps (Fig. 3).

The 5G technology is designed with IoT (the Internet of Things, with everything being connected over the internet) in mind. Our smartphone is used as a small-sized information and communication processor rather than for voice telephony equipment. Various applications and services are emerging to be installed on them.



GSM: Global System for Mobile Communications
CDMA: Code Division Multiple Access
OFDMA: Orthogonal Frequency Division Multiple Access
MIMO: Multi Input Multi Output
mMIMO: massive MIMO

Fig. 3. Evolution of wireless communication technology

Transmission distance and ease of connection differ by radio frequency. Radio waves are also used for radar and other sensing applications as well as microwave heating and microwave power transmission. Therefore, it is important to increase the data transmission capacity of the radio frequency resources assigned to wireless communication. Since interference between signals is becoming a critical issue along with improving frequency utilization efficiency by advanced modulation technology, decreasing distortion will be more important to suppress the interference.

3. Future of Information and Telecommunication Society

Figure 4 shows a possible information and communication society in 2030.

Sixth-generation (6G) mobile communication technology has been already proposed. 6G is not just a wireless technology, but is likely to represent entire information and communication technology. The communication area will expand not only over the ground, but also to the sea, sky, and space. 6G will support a data rate of 100 Gbps, a latency of 0.1 msec or less, and a simultaneous connectivity of 10 million devices/km^2 or more. Automated factories, autonomous driving, AI, digital twin, the metaverse and other applications that use the 6G technology will be popular without causing users to be aware of data communications in their daily life.

A substantial increase in data traffic capacity is essential to realize the 6G society, while progress towards this goal will cause the serious problem of increasing power consumption.

It is estimated that if the power consumption of network equipment is not reduced dramatically under an extension of current technologies, the overall power consumption of information network in 2030 will be five times the current level, or 2,400 TWh/year.[1] In view of carbon neutrality, reducing energy consumption is inevitable. For this reason, it has been studied for not only the reducing power consumption of equipment and the replace-

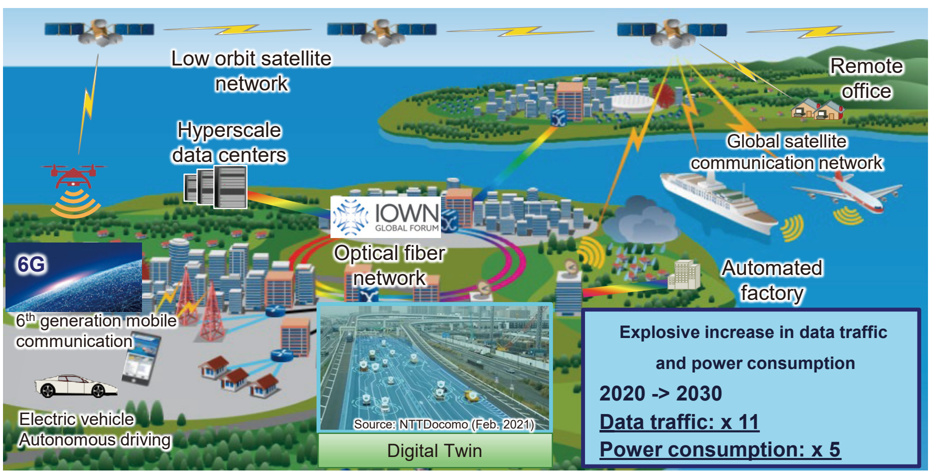


Fig. 4. Information and communication society in 2030

ment of metal wire with optical fiber (e.g. communication between and within servers less than a few meters), but also the All-Photonics Network initiative (IOWN), which eliminates electrical-to-optical conversion and uses only optical signals for transmission.

The key technology in the replacement of electrical wire with optical wire is silicon photonics. This technology make it possible to fabricate optical functional elements such as miniaturized optical waveguides and couplers on silicon substrate by using the advanced microfabrication technologies developed for Si ICs.

In the future, technologies that integrate silicon photonics with compound semiconductors and silicon photonics with optical fibers and connectors will be necessary.

4. The Role of Sumitomo Electric Industries

Sumitomo Electric Industries, Ltd. is one of the few companies in the world that are involved in a wide range of activities from R&D to product manufacturing, from materials such as optical fiber preform and compound semiconductor substrates, to optical and electric devices, optical communication equipment such as optical connectors and fiber fusion splicers, optical fibers and cables, and communication systems integrating these devices. Horizontally and vertically integrating and converging the technologies that support the information and communication infrastructure allow us to propose and provide large-capacity, low-power-consumption solutions optimum for the entire system. We have a major role to play in creating a better, sustainable society.

Sixteen papers have been submitted from our laboratories, divisions and affiliated companies on this issue. I hope that these papers will help the Sumitomo Electric Group to contribute to the evolution of a Safer and more Comfortable society that is also Green and environmentally friendly.

Reference

(1) JST-LCS Proposal paper (February 2021)