Ubiquitous e-Japan: Industry and Technology Foresight in the Information and Communications Field

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I would like to discuss several topics in the area of information and communications, from the viewpoint of industry. I am going to begin with an introduction on the current status of the economy and industry. Next, among other technologies in the information and communications field, semiconductor electronics, broadband and mobile communications, and the Internet are going to be discussed. Then, I would like to take a brief look at ubiquitous networking, an environment where communications technologies, computers and home appliances are integrated into a single system and connected via a network.

1. Current status of the economy and industry in Japan

Although it has been stated again and again that Japan is in the state of recession, the nation's GDP accounted for 15.4% of the world's total GDP in 2000. This is, in fact, a remarkable figure given that Japan's population is half the size of the U.S. and it has a relatively small land area. Japan, which has a GDP that is 2.5 times larger than the world's third-largest GDP of Germany and is equivalent to the combined total GDP of the countries ranking third, fourth and fifth, remains without doubt an economic power. The Japanese people should be proud of this.

A look at year-by-year changes, however, reveals a different perspective. Japan's GDP had been on a steady rise until 1990, when it became saturated at approximately 500 trillion yen, marking a turning point into the following years. The changes became obvious in 1995, and led to the nation's recent experience of a negative GDP growth for the first time. This is a development that has clouded the mind of the Japanese people.

Changes in the structure of Japanese industry have been clearly seen. While Japan has been trying to strengthen its manufacturing sector, the sector produces no more than 20% of the country's GDP compared to the service industries' contribution of about 60%. The contribution of the manufacturing industry in Japan is probably smaller than that in the U.S. This fact, which is vital to estimating the future of Japan, is misunderstood by many.

2. Technological development in the information and communications field

(1) Semiconductor electronics

The semiconductor industry, which had once attracted a great deal of attention as the driving force of industry, apparently peaked out in value terms in 1995. The year 2000 was an unusual year for the industry, with a growth of 30%-plus followed by a decline of 30%-plus in the next year. The industry's average growth rate during the 20 to 25 years through 1995 stands at about 15%, while the comparative figure for the extended period through 2002 drops to 10%. This indicates that the semiconductor industry has been reaching maturity since 1995.

On the other hand, ceaseless technological advancement continues. Looking at DRAMs, which are currently available with a 256-Mb density and a 0.13-micron pitch, 0.09-micron-pitch products are expected to appear on the market by the middle of this year. As this technology area follows Moore's Law, pitches are forecasted to reduce down to 20 nanometers. Despite arguments that such forecast figures will eventually level out, not only have they not done so yet, but they are even being realized earlier than expected. Regrettably, however, 256-Mb memory sells for less than three dollars each these days, driving most of the DRAM manufacturers into the red. There is a strange belief about semiconductors that their prices converge to a dollar value equal to π divided by two. Supposing this is true, the further technology advances, the more money manufacturers could lose. This would create an unhealthy cycle for the industry.

Frequencies have also been increasing steadily. From a technical perspective, Si MOS, Silicon-Germanium hetero-bipolar and GaAs hetero-bipolar technologies are becoming the mainstream. In high frequency bands, frequencies between 2.4 and 5 GHz for example, silicon bipolar technology is no longer needed as Si MOS can supersede everything else. Even higher frequencies are forecasted to be covered by Si MOS. At the experimental level, Si MOS devices that allow for 200 GHz have already been developed.

With respect to applications, wireless/wired LAN systems have already begun using 5 GHz, although further efforts must be made in the future to seek for applications at millimeter waves. Whereas millimeter waves have not materialized in semiconductor devices, extensions toward this direction are expected.

In the progress of high-speed computers, there was clearly a period of rapid growth. This can be attributed not only to the development of devices but also to parallel processing architectures. The transformation of the architecture facilitates advances in software as well as hardware. There are, however, limitations as a matter of course. As many others have already predicted, this technology area has finally reached a stage that must be considered close to the limitations. Since development through detailed processing has hit a ceiling, it should be about time to find a breakthrough in piling up atoms on a material.

It is certain that semiconductors still have plenty of room for technical development, but the semiconductor industry is experiencing some changes. This sector may lose its power to drive the overall industry and become just an ordinary segment of it. Although nanotechnology can possibly lead to a breakthrough, not all nanotechnologies are to be valued these days. While it was not until recently that nanotechnologies came to be a focus of attention, they actually have a considerably long history as a research subject, going back as much as about 20 years. The careful choice of the right theme is essential.

(2) Broadband and mobile communications

Broadband at 10 Gbps and 40 Gbps is already in use for backbones. In inner cities, metro lines connected via 10-Gbps Ethernet, which are known as WAN, have become commercialized. With an access line of 600 Mbps combined with FTTB, a technology meant for extending fiber-optic cables to office buildings, gigabit Internet connections will become commercially feasible.

Regarding ADSL, a technology that is growing fast especially in Japan, while communications speeds up to 12 Mbps are common and in practical use, 16-Mbps services have already been launched. Thanks to a significant reduction in price, the number of subscribers to ADSL has soared and reached eight million households in Japan. South Korea has the largest number of ADSL subscribers in the world. The U.S., which fared well at an early stage, has been quickly falling behind others recently. In Europe, ADSL has yet to become widespread. The technology that Japan is particularly concentrating on is FTTH, which involves running fiber-optic lines up to homes to enable 100-Mbps transmissions. The age when even subscribers can enjoy 100-Mbps transmission speed is coming.

As an example of technology for this, how wavelength division multiplexing has developed is explained here. This is a technique that allows a single-mode fiber to carry many narrow rays of light on different wavelengths. While, in 1995 to 1997, no more than 16 wavelengths were carried in a single fiber, the number increased to 176 to 700 by 2000. This has given each fiber the capacity to transport tremendous traffic of 1.76 to 6.8 terabits per second. Expected in the foreseeable future are semiconductors with extremely short wavelengths, followed by commercialization of the technology to control them, thereby resulting in the accommodation of as many as 1000 wavelengths to realize communications at 10 Tbps.

All these innovations originate from the invention of the erbium-doped fiber amplifier in Britain, which provided a technique to allow optical signals to be carried without being converted into electrical signals. To expand the wavelengths, optical fibers doped with different elements are being tested. Furthermore, using Raman amplification will enable the commercialization of fiber amplifiers having a very wide bandwidth.

Data traffic surged shortly after 2000. Voice traffic, on the other hand, has not shown a significant increase. Optical lines including those for backbones, whose capacity far exceeds the demands, have already been installed. This is one of the reasons behind the IT bubble, which occurred mainly in the U.S. Many telecom companies went bankrupt because of too much investment. Although Japan has not gone this far, it is said that only 2 to 3% of the existing fiber-optic cables are in use, leaving over 90% in a state known as dark fiber. To promote the release and use of dark fiber is crucial to reinvigorating the economy.

An increased amount of information and traffic resulted in an increased influx of data. Accordingly, technologies to store them are making rapid progress. The storage space of hard disk drives is increasing faster than Moore's Law. While a storage capacity of about 18 petabytes is demanded now, businesses are, with expectations of further increases in size, working toward hard disks with finer pitch and the use of magneto-optic. Since accumulating all the information in the world would amount to a tremendous size, storage and recording technologies present large business opportunities.

The next topic is mobile communications. The industry now provides third generation systems such as wideband CDMA (W-CDMA), CDMA 2000, and even one that allows for over 100-Kbps of data flow. In Europe, a dual-mode system that supports both CDMA and GSM is being implemented. Because of technical difficulties and high costs, W-CDMA, which was developed by NTT DoCoMo, is experiencing a somewhat slow growth in demand. The technology, however, will soon see rapid progress.

On the other hand, wireless LAN systems that provide data rates roughly between 1 Mbps and 10 Mbps using the IEEE standard bandwidths of 2.4 GHz and 5 GHz are now being commercialized. Such wireless networks are expected to be set up in public places such as commercial buildings and railway stations. Moreover, the fourth generation, for which the specifications have not been defined, is steadily progressing, aiming at about 100 Mbps. However, as of now, no semiconductor device is commercially available to provide speeds of several tens of GHz.

In summary, current broadband technologies are ahead of demand. In a few years, however, they will go into actual use. In addition, wireless technologies are showing signs of explosive growth. Depending on the types of content they will be carrying, networks, whether wired or wireless, that can transfer data at 100 Mbps will permit people to use a variety of devices without the awareness of being connected.

(3) Internet

Although slow to grow at the beginning, the diffusion rate of the Internet in Japan now stands at approximately 40% and is expected to increase to 80% in five years. In terms of technical development, the initial technologies, namely, dial-up connections and ISDN, were considerably slow at 64 Kbps. Their usage was very limited because downloading a movie, for example, took as long as 125 hours. Even connections via CATV and ADSL, which are now available at 8 Mbps, take one hour to download a movie. In contrast, FTTH allows its subscribers to download a movie in five minutes and a music CD in six seconds. Thus, FTTH is most likely to become prevalent in the future. To achieve widespread use, cost, including for the infrastructure, is the key element. A comparison of the purposes for using the Internet now with that of two years ago indicates that there is a significant increase in the downloading of images and music.

What I would like to stress about ubiquitous networking is that the Internet via IPv6 will increase the number of available addresses to the 128th power of 2, IPv6 is actively promoted in Japan and is also prevalent in China and other countries. The implementation of the protocol is expected to bring about essential changes in the world of communications and connectivity, as it will enable the assignment of addresses to all kinds of devices from a refrigerator to a washing machine. Microchips embedded in various appliances will enable them to communicate with each other and will merge products that are now called home appliances, as well as other machines such as cars, into the concept of digital equipment. This will lead to the convergence of the computer, communication and consumers.

According to a forecast by the Ministry of Public Management, Home Affairs, Posts and Telecommunications, the market will grow to a scale of 80 trillion yen by 2010. Technological challenges before that are the issues of microchip computers and RFID (Radio Frequency Identification) in the area of devices, security in the network domain, and, with respect to content service, systems for content distribution, intellectual property rights and privacy.

3. Summary

The information revolution has reached its second phase. The critical issues here, even in terms of infrastructure and terminals, are software and content. The digitization of terrestrial TV broadcasting, which has already begun, will not gain popularity unless it successfully provides interesting content through its?several hundreds of channels. Toward the future, the digital content sector is likely to become a powerful driving force in the industry. Large-scale funding by the government in this field might not cause complaints from the U.S. and Europe, since it would be considered cultural promotions. Economic development through cultural promotions will be the last phase of "ubiquitous e-Japan."

As a last note, I would like to thank the NISTEP staff for preparing the presentation slides.