From Digital Economy to "Digital GreenEarth"
IT to Bring Low-Carbon Society to Japan in 2050

By Yasuhiko ARAKAWA

1. Introduction

Information technology (IT) has advanced rapidly for the last several decades and has been widely accepted by society. As a result, it has served as the prime mover for bringing about innovative changes in society. IT has become indispensable technology, for example in the process of economic and financial globalization, spurring a variety of changes in economic activities not only in Japan but in the rest of the world.

In the meantime, the importance of energy and environmental issues is being recognized. Realizing a low-carbon society where carbon dioxide emissions are minimized is one of the main social goals. Cutting-edge scientific technology is now destined to squarely tackle a common challenge for the entire human race: global warming. In addition, the global economic trend of inflation fanned by natural resources and deflation induced by industrial products is viewed as a major factor behind growing calls for a low-carbon society. Industrial development in emerging economies has led to a plunge in prices of industrial products relative to those of resources. The age of high-flying resource prices has set in. Soaring prices of raw materials directly strike the industrial sector. But the sector finds it hard to pass on higher material costs in product prices. To tide over the plight, it is important to spur resource-saving technological innovation and, with the impediment of higher resource prices as a turning point, achieve higher product performance and greater energy conservation by fully utilizing high technology.

Today, we are going into a situation where we see the undercurrent changing in industrial structure as well as in establishing goals for science and technology. IT will undoubtedly continue to help boost economic activities as it has done as the driving force of a digital economy. The IT sector, however, currently faces the question of to what extent it can contribute to ensuring global security of the human race and thus achieving a sustainable society. This report proposes that IT be fully used to attain a "Digital GreenEarth" as one of its main tasks. First, this report outlines recent developments in IT and then discusses what should be done to achieve a low-carbon society in Japan by 2050. Specifically, it discusses the significance of roles to be played by IT in not only promoting a digital economy but also realizing a Digital GreenEarth. In particular, it proposes the concept of virtual mobility and suggests the direction of technological development. The proposals are meant to help develop a green society by curbing energy consumption by society as a whole and achieving a sustainable society while boosting social convenience. While the Digital GreenEarth is a term newly coined by this writer and used for the first time in this report, virtual mobility is the concept proposed by the Japan Electronics and Information Technology Association (JEITA) in March 2008.

2. Current State & IT Trends

Discussed first in this report are developments of IT, which has supported our digital economy. Semiconductor integrated circuits (ICs) are increasingly being miniaturized and diversified. The size of IC chips has been miniaturized exponentially – as known under Moore's Law – at a pace of 0.7 times in a couple of years currently. The rapid integration has led to a sharp rise in data-processing and memory capacities. Such a trend is projected to continue at least until 2015. ICs are being used as main components of information communications equipment, thereby helping to raise performances and functions of personal computers, mobile telephones and digital devices. They are also contributing to making these devices more compact and reducing their power consumption. With the development of semiconductor micro/nano-scale processing technology, the diversification of microchips is advancing, resulting in their wider application to electric power-control devices, sensors, actuators and biochips.

The development of information networks has also brought about significant innovation in economic and industrial activities. Mobile phones and the Internet have spread rapidly in the last decade and have established themselves as part of social infrastructure in a short period of time. The hookup with the Internet via fiber-optic cables is spreading fast, enabling households and offices to access high-speed data communications networks. As a result, economies around the globe make responses quickly. This in turn has promoted globalization of economies and at the same time made the world economy fragile – a phenomenon that can be seen as merits and demerits of the digital economy.

In the field of displays, transition has progressed steadily from conventional cathode-ray tubes (CRTs) to flat panels such as liquid crystal display (LCD) and plasma display panels. Today, flat panels are being widely used as displays for PCs and home televisions. Aided in part by the digitalization of terrestrial TV broadcasting, displays are becoming larger, with their image definition becoming higher. Flat display panels are also being used for mobile phones, car navigation systems and many other electronic gadgets. An era of ultra-wide, ultra-thin and high virtual-reality feelings has set in.

The age of broadcast-communications integration is coming soon. Higher speed and larger capacity will be achieved in the next-generation electronic communications network (NGN), enabling interactive, high-speed data communications between households as well as between business offices. Specifically, it will become possible to send high-definition TV (HDTV) video images to a large number of households simultaneously via networks. The boundary between broadcast and communications will become blurred, opening the way for greater integration between broadcast and communications.

3. Challenges for IT Development & Concept of Digital GreenEarth

The 1997 Kyoto Protocol agreement requires Japan to achieve the goal of cutting carbon dioxide emissions by 6% by 2012 from the 1990 level. Japan also proposed that such emissions in the world be halved by 2050 under the "Cool Earth 50" initiative. IT has greatly contributed to developing a digital economy and social convenience. Such development, however, brings about a substantial increase in information volume and power consumption in a network society. The total volume of network information is projected to surge 200 times by 2025 from the 2006 level. We need to curb power consumption by IT equipment involved in networks as much as possible on the strength of technological innovation.

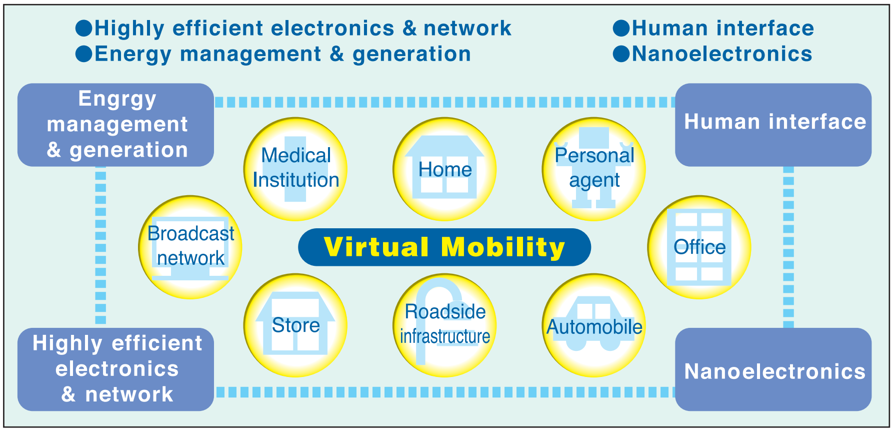
At the same time, it is extremely important to proactively contribute to cutting emissions of greenhouse gases by society as a whole by utilizing IT. The basic concept of the "Digital GreenEarth" is meant to achieve this goal.

4. IT Development for Digital GreenEarth: Call for Virtual Mobility

With the aim of developing IT toward a Digital GreenEarth, this report discusses virtual mobility – the basic concept that constitutes the core of data communications equipment technology aimed at achieving a low-carbon society in Japan by 2050. Virtual mobility means an exchange of information via electronic communications networks. It is defined as conducting social and economic activities without physically moving persons, goods and money between places.

Virtual mobility has been used to give people alienated from society due to a lack of traffic means opportunities to participate in society by way of the Internet and other means. From a broader and positive viewpoint, however, this report suggests that virtual mobility be redefined as a new concept aimed at providing not only alienated people but also those who have full traffic means and thus can move freely between places with highly efficient, power-saving means of communication with each other via electronic communications networks.

Chart 1 Digital GreenEarth brought about by virtual mobility technology



Source : Compiled by auther

CO_2 emissions by Japan's transportation sector in fiscal 2004 (through March 2005) amounted to 2.54 million tons, up 20.6% from fiscal 1990, accounting for 19.6% of the country's overall CO_2 emissions. If the concept of virtual mobility takes root in Japanese society, movements of persons, goods and money would be curbed, raising expectations of lower energy consumption by the transportation sector.

Replacing human moves with information traffic will spur electronic conferences and working at home, thereby leading to lower energy consumption and saving time required for moves. Paper media such as newspapers, magazines and books as well as plastics media such as CDs and DVDs – all movers of information by way of goods – will be replaced by information traffic via electronic communications networks. This results in a cut in consumption of paper and plastics. Similarly, electronic money will be used more widely, leading to the spread of electronic account settlements without using cash.

The limited movements of persons, goods and money are also expected to cause the secondary effect of reducing the number of traffic accidents. Achieving high efficiency on the back of remote medical care such as remote diagnosis will contribute to improving medical and welfare services which are becoming increasingly poor due to the graying society. The spread of working at home and remote education will result in a longer, happier time at home.

The progress of virtual mobility is also predicted to spur changes in industrial structure. If information traffic proves to bring greater benefits to society than moves of goods, capital infusion will focus on information traffic, leading to rejuvenated intellectual production. As business deals can be done easily on a global scale, regional disparity in production will be eliminated, sparking expectations of even domestic economic development. The limited moves of goods also suggest the direction of a low-energy consumption economy, based on local production for local consumption. Use of a network of dispersed power sources based on the region-wide optimum scheduling technology in such areas helps cut CO_2 emissions and build up lifeline infrastructure that can withstand disasters.

In virtual mobility, it is important that a cut in energy consumption arising from the curbing of physical moves far exceeds an increase in energy consumption stemming from a rise in information volume for the achievement of virtual mobility, resulting in reduction in overall energy consumption.

5. Technological Tasks in Development of Virtual Mobility Technology

As shown in *Chart 1,* it is necessary to conduct development in three main tech-

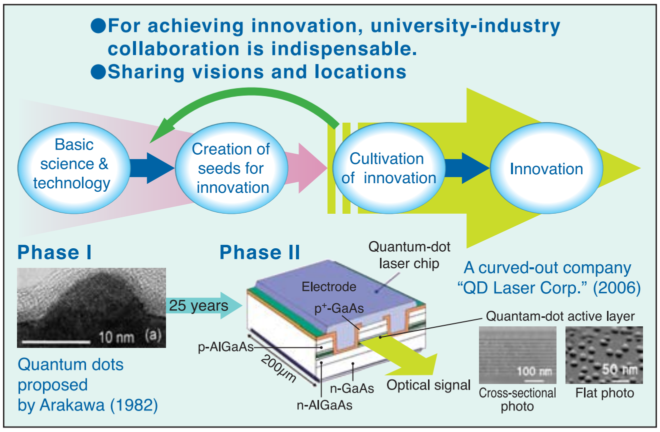
Chart 2 Virtual mobility technology

Highly efficient electronics & network	Energy management & generation
High-performance & low-power CMOS-LSI	Highly efficient air conditioner management
Integrated energy management of equipment & devices	Dispersed power management systems
Highly efficient power supply systems	Highly efficient power generation
Highly efficient photonic network	Solar cell technology

Human interface	Nanoelectronics
Interface for human communication	Nano-CMOS materials
Display technology for high-level reality	Silicon photonics
Security technology	Highly efficient power devices
Network technology	Innovative quantum devices
Advanced sensor technology	

Source : *Compiled by auther*

Chart 3 Achieving innovation by university-industry collaboration



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nology fields – boosting efficiency and saving power consumption in network infrastructure and servers, energy management, and human interface –to create a sustainable society on the back of virtual mobility technology. To achieve these goals, another field – nanoelectronics – is considered to be an area of innovative basic technology. *(Chart 1)*

(1) Boosting Efficiency & Lowering Power Use in Network Infrastructure/Servers

In a society brought about by virtual mobility, various pieces of information are transferred to networks from sensing devices stationed around us while various pieces of information, including high-definition video images, are distributed from servers. A large volume of information traffic is feared to sharply increase power consumption by networks, servers and storage equipment. To break the limit to a reduction in power consumption by IT network infrastructure and peripheral equipment (the barrier to the creation of a virtual mobility society), it is important to improve the performance of complementary metal oxide large-scale integrated (CMOS-LSI) circuits and cut their power consumption. It is also important to raise the efficiency of power systems for servers as well as of photonic networks.

(2) Energy Management

The advancement of IT technology, combined with the improvement of network infrastructure, generates the need for energy management technology for the integration of equipment and systems. Highly efficient power source technology for lighting equipment is a key concept, along with technology to boost the efficiency of air-conditioning equipment, technology to boost the performance and efficiency of power sources and power-control systems for hybrid vehicles, technology to cut CO_2 emissions from power generation/transmission, solar battery technology, and dispersed power source technology.

(3) Human Interface

To achieve virtual mobility, it is necessary to create an ubiquitous environment where users can access and obtain desired services and content anytime and anywhere via networks linking a wide array of peripherals and equipment. Moreover, it is necessary to develop technologies so as to attain secure, comfortable and highly efficient virtual mobility by improving environment sensing and monitoring technologies aimed at enabling us to work in harmony with the surrounding environment. For that purpose, improvement in the performance of perception/expression interface technology aimed at smoothing communications is required, together with that of display technology to realize abundant communications and high virtual reality, security technology for enabling safe communications and sensors that support the human interface.

(4) Innovative Basic Nanoelectronics Technology

To drastically cut power consumption, further technological innovation is necessary on top of the existing silicon LSI technology. Among challenges considered important for the purpose are the development of a new material based on nano-level CMOS, silicon photonics and highly energy-efficient compound semiconductor elements, and the innovative improvement of efficiency by use of quantum devices. *(Chart 2)*

6. Importance of University-Industry Collaboration

This report proposed the concept of a Digital GreenEarth in a shift from a digital economy from the viewpoint of IT's contribution to the protection of the global environment. As a core area of the proposed Digital GreenEarth, virtual mobility was also suggested.

A society of low energy and resource consumption can be achieved by developing key technologies that are necessary for the spread of virtual mobility under that concept. It is important to bring about discrete technological innovation in each technology required for realizing a Digital GreenEarth.

It is deemed essential to promote university-industry cooperation. *Chart 3* shows expected important roles of university-industry collaboration toward achieving innovation starting with the exploration of science and technology seeds. As an example of such cooperation, it also shows the fact that quantum dot circuitry proposed by this writer 25 years ago is being put on the market as a quantum dot semiconductor laser. JS

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