

Ubiquitous Networking: Towards a New Paradigm

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The computing paradigm is changing from the client-server systems that replaced mainframes at the end of the 1980s to network computing based on open systems and the Internet. Nor will change stop there. The most advanced computing paradigm visible on the horizon is one incorporating even clothes and the human body. We shall call this “exotic computing.”

Between the two lies “ubiquitous networking,” where mobile telephones, home-based information appliances, car navigation systems and videogame machines will be linked by broadband wired and wireless networks. This is a market that Japanese companies should seek to dominate. In order to achieve this, companies operating in different sectors will have to seize the initiative by establishing the technical standards for this network while content providers will have to take the lead in devising innovative business content.

I “Ubiquitous Networking”

1 Evolution of the Computing Paradigm

Although for Japan the 1990s were a “lost decade” in which Japanese companies were preoccupied with cleaning up the mess after the asset boom of the 1980s turned to bust, for the world as a whole they can perhaps best be described as “the first decade of the Internet age.” This description seems especially apt in view of the monumental impact of Internet technology not only on the world of computing and communications, but also on economics, business, society and politics.

The end of the 1990s was also the beginning of a new millennium. Japanese companies are reported to be some two to three years behind and have some catching up to do with US companies, which have established a formidable lead in this field. Japanese companies are now also beginning to devote the resources they will need to achieve this goal. But over and above this, the fact that we have entered a new millennium causes us to ask whether we should be content with this state of affairs or whether we should be seeking to achieve something original.

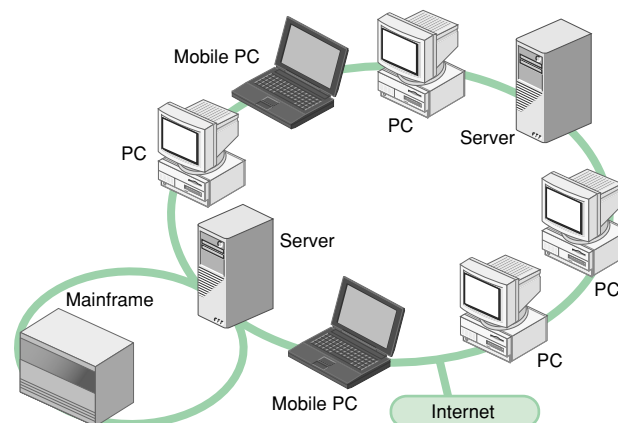
Information technology is constantly evolving. As it does so, it is heavily influenced by the dominant technology of the period. The industry’s formative years were dominated by mainframe computers and only came to an end in the late 1980s and early 1990s, when mainframes were replaced by client-server systems that achieved significant cost savings by using a combination of workstations and personal computers.

Since then, the computing paradigm has undergone a further transformation with the arrival of the World Wide Web and Internet technology. The first commercial applications appeared in 1991, and use has spread rapidly since the 1993 release of Mosaic—the first widely used browser. This current computing paradigm is referred to as “network computing” because it consists of a network of personal computers and servers linked using a protocol called TCP/IP. (See Figure 1.) It is spreading rapidly around the world and permeating all aspects of society and daily life. We can expect this to continue, albeit with a certain time lag.

Does network computing therefore mark the final stage in the evolution of the computing paradigm? Although some people believe that the Internet will last forever, the very speed at which it has developed makes the duration of previous technological innovations pale in comparison—something that should make us question the assumption that the transition to the next paradigm has already been completed.

Leading research centers are constantly extending the frontiers of information technology. The Media Lab at the Massachusetts Institute of Technology, for example, is doing research and development on devices such as paper computers (consisting of particle-sized electronic

Figure 1. Network Computing



components scattered on sheets of paper) and wearable computers (which we don’t just like clothes) as well as techniques such as “interbody signaling” (where the human body itself becomes a live communications network).

Another example is the “Internet car” project currently under way at Keio University’s Shonan-Fujisawa campus and led by Jun Murai. The concept is to transform the motor vehicle into an information-gathering medium. For example, if a car’s wipers come on, it is assumed that it has started to rain. Similarly, if its wheels begin to turn more slowly when the car is being driven on a highway, it is assumed that a traffic jam is ahead. These signals are then combined with information from a GPS (Global Positioning System) satellite.

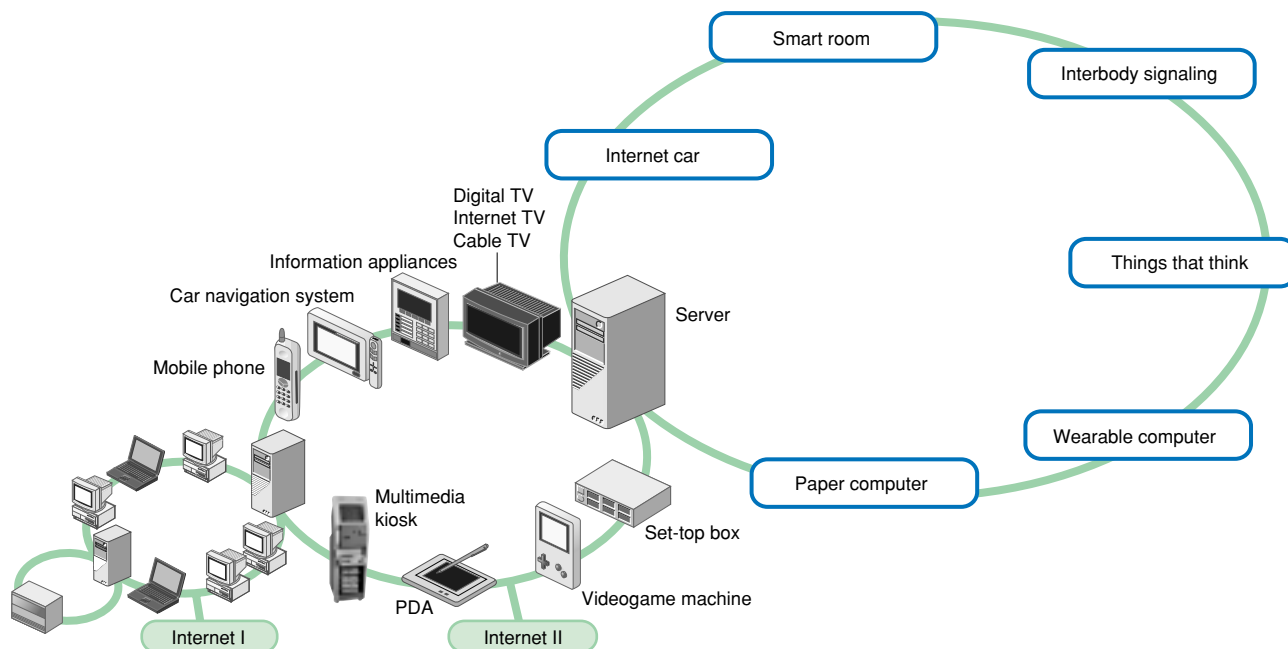
Another example from MIT’s Media Lab is the concept of “things that think”—a far cry from our current image of computers, which has been formed largely by devices such as personal computers and PDAs (personal digital assistants). Even though paper computers and wearable computers are still some way off and it is difficult to imagine them in daily use, they do exist as a concept and research on them is well under way. We shall refer to this computing paradigm as “exotic computing.” (See Figure 2.)

2 Ubiquitous Networking

Although the evolution of computers is currently at the stage where development is focused on improving network computing, exotic computing lies further down the same road. However, it is difficult to imagine that a world where virtually everything is computerized can evolve directly from the current state of development.

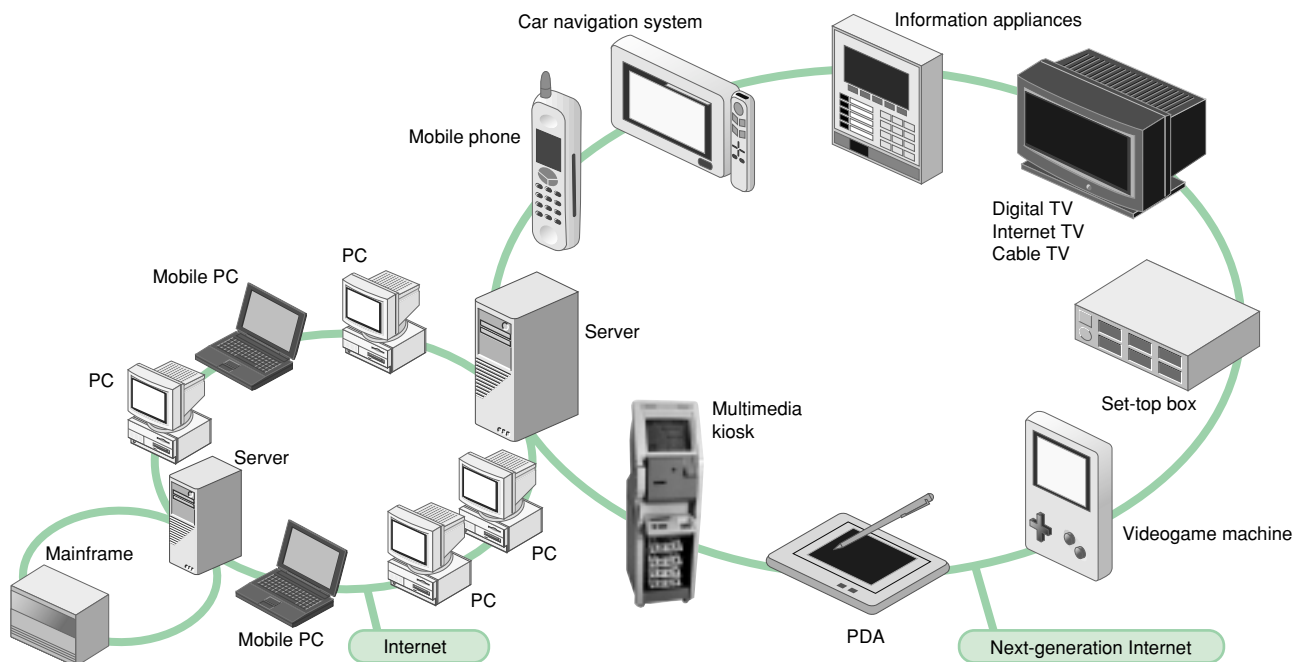
Between the two there must lie an intermediate paradigm—what we shall refer to as “ubiquitous computing.” This will rely not on devices such as paper computers and wearable computers, which currently exist only on the drawing board, but on devices which already exist—not desktop or portable computers, but devices such as mobile telephones, multimedia kiosks, videogame machines, set-top boxes, digital TV sets, car navigation systems, and information appliances. (See Figure 3.)

Figure 2. Exotic Computing



Notes: PDA means personal digital assistant; smart room means a room where the activities of those present are supported by cameras, microphones and sensors located in the room.

Figure 3. Ubiquitous Computing



All these devices will be linked to a network that will include wireless communications and broadcasting and offer greater bandwidth than the public telephone lines and trunk lines on which the Internet currently depends. This network will enable users to enjoy video and music—either downloaded from the network or created by users themselves and uploaded to the network—free of the irritation caused by the limitations of existing technology. This is the computing paradigm that we call ubiquitous computing.

The term ubiquitous—now well established in computing circles in both the United States and Japan and

frequently used by W3C and other international bodies responsible for validating computing and communications standards—has recently come into more general use in Japan and has appeared, for example, in reports published by the Japan Electronic Industry Development Association.

Once this technology is developed, users will be able to experience high-quality digital media anywhere and express themselves much more fully than allowed by the color images mainly composed of still pictures that currently characterize the Internet. The market that this broadband network will create is referred to as either the

ubiquitous networking market or the ubiquitous network market.

NRI is interested in this market for a number of reasons. First, ubiquitous networking will produce a demand for new devices and content—areas in which Japanese companies excel. They have a competitive edge in the kind of technically sophisticated devices that would be used in ubiquitous networking—for example, videogame machines, information appliances, car navigation systems, and digital TV sets—and still enjoy a lead over their US rivals as producers of content for mobile telephones and multimedia kiosks.

The second reason for our interest in this market is the fact that Japanese companies have some catching up to do in the field of network computing, especially as it relates to the Internet and e-commerce. However, US companies are so far ahead in this field that Japanese companies hoping to make the most of their own know-how and create a new industry would probably stand a better chance of catching up with and overtaking their US rivals in the field of ubiquitous computing than in that of network computing.

The third reason for our interest is the fact that this will be a market not just for particular devices but for a whole new computing paradigm with a virtuous cycle where demand for new devices creates demand for new content, which in turn creates further demand for new devices—a situation which could well be described as “emergent evolution.”

Therefore, although Japanese companies should make the most of whatever opportunities present themselves in the field of network computing, their strategy should be to try to switch their paradigm to one of ubiquitous computing as soon as possible.

3 Japanese Companies and Ubiquitous Networking

In order to turn such an approach to their competitive advantage, Japanese companies will have to achieve two things. First, they will have to play an active role in developing protocols for ubiquitous networking. When the technical standards for the Internet were being established on the basis of technological know-how acquired by the US military during the 1960s, Japanese companies were left largely on the sidelines and only began to try to catch up once the *de facto* standards had already been established.

When it comes to establishing ubiquitous networking, Japanese companies will have to ensure that they are able to devise business models at the same time as they develop technical standards. Otherwise, there will be a lag between the two, and major opportunities will be missed.

In the past, each industry—be it mobile telephones, in-car equipment, or videogame machines—has tended to develop its own standards, and cooperation between them will not be easy. However, the fact that most of the

leading manufacturers are Japanese represents a golden opportunity for them to get together and develop a standard protocol. If they fail to take the initiative in this way, they risk becoming merely suppliers of commodity items.

The second thing that Japanese companies will have to do is to develop suitable content at the same time. Most of the added value from ubiquitous networking will come from either the content itself or the business models in which the content is incorporated. The kind of content best suited to ubiquitous networking will involve much larger file sizes than the still color images, video clips, and soundbites currently found on the Internet and will require more bandwidth. Japanese companies will have to develop and accumulate such content if they are to successfully switch their paradigm to one of ubiquitous computing.

II The Technology for Ubiquitous Networking

1 Ubiquitous Computing

Ubiquitous computing owes its origins to work carried out at the Xerox Palo Alto Research Center (PARC) in the early 1990s on developing user-friendly computers. The idea was that users would be no more conscious of how these computers worked than they would be, say, of the letters of the alphabet.

There are three stages in the use of computers, and the aim is to make the transition from the first two stages (mainframes and personal computers), where this is not possible, to the third stage (ubiquitous computing), where it is. The three stages are as follows:

- (1) Mainframes: one computer, many people;
- (2) Personal computers: one person, one computer; and
- (3) Ubiquitous computing: one person, many computers.

As these terms refer to the ways in which computers are used, PDAs belong to the second category (personal computers) as each user uses only one device. The term ubiquitous computing, on the other hand, refers to the fact that users do not need to be aware of how their computers work in order to be able to use them effortlessly.

Office workers do not need to have their own Post-its or lined A-4 paper. They can help themselves whenever they need them. Similarly useful are notepads that they can throw away when they are finished with them. Nobody needs to think how to write on such stationery. If computers are to be used equally effortlessly, they need to present their users with no greater a challenge than that presented by writing on a Post-it or a sheet of lined A-4 paper.

Researchers at PARC developed three prototype ubiquitous computing devices:

- (1) Tabs: inch-sized computers that function like Post-its and notepads;

Figure 4. One of the Tabs Developed at PARC

Source: Xerox Palo Alto Research Center (PARC)

- (2) Pads: foot-sized computers that can be used like notebooks; and
- (3) Boards: yard-sized computers that can be used like blackboards.

The aim was to produce low-cost computers that could be used just like Post-its or notebooks by linking them to a network in such a way that data processed on one device could be accessed from the others. Figure 4 is a photograph of one of the pads that was developed.

While the concept of ubiquitous computing itself presented no major problems, PARC's researchers had their work cut out trying to put it into practice using the technology available at the time. Of the various technical problems they faced, the following were the three biggest obstacles:

(1) High-capacity wireless network

With 300 people using 100 devices each with a capacity of 256Kbps, the wireless network needs to have a bandwidth of 7.5Gbps.

(2) Portability

Networks using protocols such as TCP/IP are intended for personal computers that are only used at a single location. For example, they do not currently allow a machine's network address to be changed while it is being used.

(3) Window migration

Window systems are designed for use with one computer at a time and do not allow a user to open the same window on more than one computer.

2 The Ubiquitous Network Market

Although the tab, pad and board prototypes developed at PARC have remained just models, ubiquitous computing established itself as a concept for the post-PC era. While this era is different from ubiquitous computing, it is moving in the same basic direction of trying to achieve ubiquity.

In the age of the Internet, interest naturally tends to focus on personal computers and the Internet, but there have been major advances in hardware, software and network technology. As a result, many fields are heading in the direction of ubiquitous networking. Some of the most important developments have been in the following four fields:

- (1) Information appliances
- (2) Mobile telephones
- (3) ITS (intelligent transport systems)
- (4) Videogame machines

The following section gives an overview of the impact of information technology (and, more specifically, of ubiquitous networking) on fields other than personal computing.

3 Information Appliances

First, information appliances, which are also referred to as home-based digital devices, home-based network devices or home-based Internet devices. Although the same technology is involved, each term emphasizes a particular aspect.

These devices enable users to do such things as download information on an artist (whose CD they are listening to) from the Internet and display it on a television screen or—even though it is often claimed that no one would ever want to do so—choose the day's meals from the Internet using a refrigerator fitted with a browser-capable LCD panel and immediately order any missing ingredients. These smart appliances in each smart house are linked to their own network.

There are currently three different types of home networks under development:

(1) Information networks

These are generally PC-based and designed to provide access to the Internet and network printers.

(2) A/V networks

These are designed to link digital recording equipment such as set-top boxes (for receiving digital broadcasts), TV sets and DVD players.

(3) Control networks

These are based on the power supply network.

Developments in each of these areas are proceeding independently: information networks use TCP/IP protocols; A/V networks use the IEEE1392 standard; while control networks tend to use any of a number of different systems each devised by the company concerned. Although each of these network types is important in its own right, even more important is how they can be interlinked, and a number of developments are under way.

4 Mobile Telephones

Next, mobile telephones. Japan already has more than 50 million mobile phones in existence, and demand is showing no signs of abating. There has been particularly strong

demand for systems (such as NTT DoCoMo's "iMode" service) that can connect to the Internet. Sales soared after the product was launched in February 1999, with 1 million handsets being sold during the first six months and 2 million handsets during the first eight months.

There have been many different types of PDAs—including devices that use Microsoft's Windows CE as their operating system and Sharp's Zaurus—each with its own special features. However, mobile telephones have all the makings of becoming the "killer" PDA—no doubt because features such as network connectivity, size (70–80cm³), weight (70–80g) and standby time (200–300hrs) are what users want. People can carry them around conveniently without having to worry all the time about whether the batteries will run down.

As users of mobile telephones with Internet connectivity can be billed for content along with call time, this becomes an attractive business scheme for the considerable number of content providers that are already in business. Future growth is likely to come mainly from music and images.

However, the fact that any advances in mobile telephony cannot be allowed to compromise the very features that make mobile telephones so attractive to users means that a number of technical hurdles will have to be overcome. For example, improvements such as faster transmission speeds (currently mainly 9.6–28.8Kbps), color instead of monochrome displays (with a resulting reduction in battery life), and greater memory (music and images require 20–30 times more storage capacity than is currently possible) will all have to be achieved while retaining the existing shape.

5 ITS (Intelligent Transport Systems)

Turning next to motor vehicles, we see that automobiles themselves are an amalgamation of computers and networks. However, current developments in intelligent transport and networking focus on transport systems as a whole rather than on individual vehicles. Such systems are referred to as "intelligent transport systems (ITS)."

Individual vehicles comprise three different networks: an information network that links such things as the car navigation system and the CD player; a control network that links the engine, transmission and brakes; and a body network that links components such as the headlamps and power windows. While various wiring systems link all of these networks, so many wires are involved that moves are under way to replace them all by a single POF (plastic optical fiber) cable.

ITS are used on roads and at toll collection points to make transport systems more intelligent. The system currently in use—known as VICS (vehicle information communications system) that mainly provides information about traffic congestion—is intended to make traffic flow more smoothly by feeding information to each vehicle's navigation system.

This year an ETC (electronic toll collection) system is due to be deployed. This will automate the process of collecting road tolls by using a wireless network to check the identity of drivers and deduct the toll from their accounts without interrupting the flow of traffic. Research is being carried out with a view to designing a variety of working systems that will be able to improve road safety and reduce journey times for emergency vehicles.

6 Videogame Machines

Last is the matter of videogame machines. PlayStation 2 (PS2) is due to be launched on March 4, and demand is rumored to be such that the first batch of shipments is expected to be sold out on the first day. In addition to the advances that have been made in individual game systems, there have also been major developments in game networks.

One of the advances that have been made in individual game systems is in processing power. The PS2's microprocessor is rumored to be even faster than Intel's latest Pentium III series. Particularly noteworthy is the number of floating-point operations per second—a key factor for videogames. Rumored to be capable of 6.2 gigaflops (billion floating-point operations per second), the new chip will be some three times faster than a Pentium III 600-Mhz chip.

Another advance has been the development of graphic chips, which has enabled game enthusiasts to enjoy at home the kind of realism they could previously only experience in amusement arcades. The fact that videogame machines demand more performance from microprocessors than do personal computers means that they have recently come to play an important role in the development of such chips.

Another feature of videogame machines is Internet connectivity. Sega's Dreamcast, for example, was designed on this basis to enable everyone to play together regardless of their actual location. Many different Internet games are available and are expected to become increasingly popular as line charges and ISP subscription fees continue to fall.

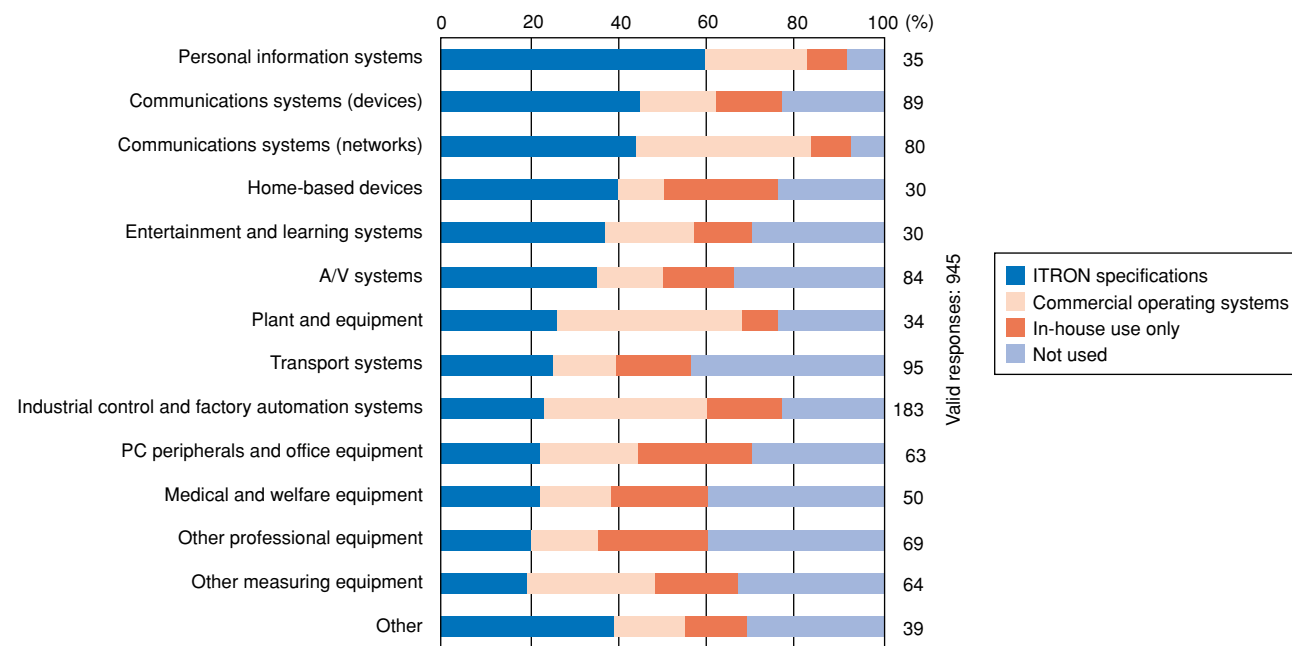
7 The "Ubiquitous Island"

As we have seen, the post-PC era has already arrived in many different fields. As we suggested in Section I ("Ubiquitous Networking"), the following will need to take place if these developments are to gather momentum:

- (1) Japanese companies will have to take an active part in developing protocols for ubiquitous networking.
- (2) They will also have to develop suitable content.

When a protocol is being developed, openness and speed are vital. Experience suggests that attempts to develop protocols end in failure if the process is dominated by the body responsible for their validation and are more

Figure 5. Diffusion Rate of ITRON Specifications (Embedded Operating Systems by Application)



Note: ITRON means industrial TRON.
 Source: 1999nen Anketo Shukei Kekka [Results of 1999 Survey], TRON Association.

likely to be successful if *de facto* standards are allowed to develop as a result of open competition. Protocols need to be open and as many companies as possible need to be encouraged to take part in their development if the final product is to be up to the high standards required.

Japanese companies also need to play an active part in the development of such protocols. During the era of network computing, they had little opportunity to participate in the development of *de facto* standards—in spite of all their ability to produce imaginative ideas. For example, although the TRON (The Real-time Operating System Nucleus) project led by Ken Sakamura of the University of Tokyo, has managed to produce some outstanding proposals for hardware, operating systems and middleware and has achieved a major success in the field of embedded systems (ITRON), it has so far failed to produce any *de facto* standards in the field of business (BTRON). (See Figure 5.)

As has already been mentioned, Japanese companies have an outstanding track record in two important areas of ubiquitous networking: mobile telephony and information appliances. In order to make the most of this record and contribute all they can to the development of ubiquitous networking, they need to adopt open systems and ensure that as many people as possible are involved.

The development of content, on the other hand, requires both a conventional and an original approach. For example, a number of companies are already providing

content for NTT DoCoMo’s iMode service. They owe their success to their originality. In view of the fact that young people are among the biggest users of mobile telephones, anyone trying to develop suitable content for them will have to take account of their needs.

At the same time, however, a conventional approach is also required if business schemes are to be devised from network systems and combined with new content. By billing users for content along with call time, NTT DoCoMo’s iMode service ensures that both content providers and users get a fair deal.

Provided Japanese companies play an active part in developing protocols and content for ubiquitous networking, Japan may one day become known as the “ubiquitous island” in just the same way as Silicon Valley received its name in the era of network computing.

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