

**A Development Scenario for
Ubiquitous Networks: Viewed
from the Evolution of IT Paradigms**

Hiroyuki NAKAMURA

Nomura Research Institute

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Ubiquitous networks represent the next-generation IT paradigm, which is characterized by the ability of various portable devices and information appliances to be used anytime and anywhere. Through shifts of technology that are best described by the expressions “embedded in the real world” and “from ownership to applications,” ubiquitous networks continue to evolve from “ownership-focused ubiquity,” where users depend on the mobile environments they own, to “application-focused ubiquity” in which the universal availability of devices enables users to concentrate on applications.

Various changes are occurring in the process of this evolution. These include: (1) the decentralization of control through unbundling; (2) the establishment of wireless networks intended for data transmissions; (3) the separation of terminals and user identification devices; (4) the conversion to ubiquitous thin clients, and (5) the full-scale utilization of service providers. Moreover, in an age of application-focused ubiquity it is anticipated that each unbundled layer will achieve a format that provides a mechanism to appropriately collect profits.

I Where are the ubiquitous networks?

The story is told of an observation group visiting a research laboratory. “We’ve come to see the Internet,” the tour leader told a researcher. “Where is it?” Momentarily stumped for an answer, the researcher finally pointed to a stack of routers piled up on a nearby rack. “There it is,” he said. This is a story that could plausibly be told when the Internet began to attract attention in the first half of 1990s.

Since last year Nomura Research Institute has been advocating ubiquitous networks as the next-generation IT paradigm to follow Web computing. As “ubiquitous” means existing everywhere simultaneously, the paradigm of ubiquitous networks essentially means applications that can be used anytime and anywhere through the universal availability of devices such as mobile telecommunications equipment and information appliances. It is even expected to provide a context in which Japan, which fell behind in the diffusion of the Internet, can achieve world leadership.

When it comes to thinking about whether it’s possible to go somewhere to see these ubiquitous networks, many people might find themselves in the same situation as that observation group described above. When we refer to ubiquitous networks, what kinds of thing are we talking about? Where are these things and who is making them? Do we find our answers simply in the evolution of mobile environments as represented by the next-generation IMT-2000 cellular telephone?

In the following report we will attempt to take a look at how ubiquitous networks can be realized from a technological point of view, and based on the principles behind the evolution of the IT paradigm and the various other paradigms advanced in the past.

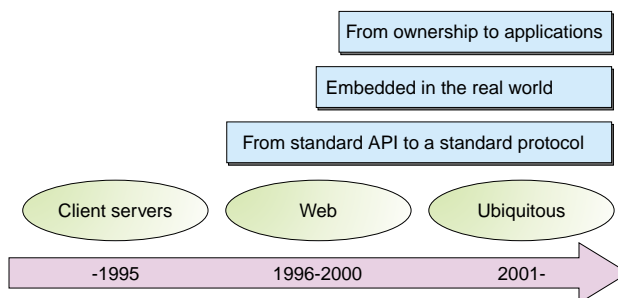
II Evolution of the IT paradigm and the principles behind it

Ubiquitous networks are an extension of the immense changes in the IT paradigm that have continued through mainframes, client servers and Web computing. Three principles—from standard API to a standard protocol, embedded in the real world, and from ownership to applications—are considered to form the background of this evolution (Figure 1).

1 From standard API to a standard protocol

API (application programming interface) refers to the routines used when directing certain software and hardware functions, while a protocol sets out the rules for communications procedures on a network. The shift from standard API to a standard protocol means a shift in the

Figure 1. Evolution of the IT paradigm and the principles behind it



Notes: API = Application programming interface; IT = Information technology.

main role of IT from hardware and software to a network.

Before the spread of the Internet, the best approach for each vendor to expand its market share was to promote the use of the company’s in-house API as a standard. In the world of the Internet where various types of equipment and operating systems are interconnected, however, the standardization of the protocol itself is the most important consideration.

The importance of this principle in shifting from a standard API to a standard protocol is once again being recognized in the era of ubiquitous networks when various devices such as cellular telephones, information appliances, and on-board terminals in cars and other vehicles are increasingly interconnected. Yet countless people are frustrated almost daily because they cannot move a telephone list from their cellular phone to another device or use a video remote control with another appliance. The reason for this annoyance is that all of these devices are still designed around the logic of a standard API.

In addition to anytime and anywhere, a further requirement for ubiquitous networks is the concept of “everything.” Therefore, the key to designing the details of ubiquitous networks is to standardize the protocol between each and every device to make certain they can be seamlessly interconnected.

2 Embedded in the real world

Full-scale efforts to move to computing embedded in the real world began around 1999. While e-commerce is the largest application in the Web-computing age, it is now thought that skillfully blending on-line transactions with actual outlets in the real world will lead to a more successful e-commerce business model than merely concluding all transactions purely online. Often called “click and mortar” merchandising (a clever play on the well-established “brick and mortar” reference to a physical outlet), this approach is attracting increased attention in Japan as well, especially by businesses such as convenience stores that have their own elaborate store networks.

This shift towards computers embedded in the real world will become even stronger in the future. This is true not only for e-commerce targeted at consumers, such as purchasing digital content (informational content) at kiosk terminals in shops and paying at cash registers by using a cellular telephone. It is also true for e-commerce aimed at businesses, such as sending orders directly from the field. The IT paradigm is also being pressed for a response to this development.

3 From ownership to applications

A remarkable aspect particularly in terms of the business utilization of IT is what is called the ownership to applications transition. Those responsible for IT at many companies are intrigued by the idea of ASP (application service providers) that offer a fee-based usage of an application over a network, without the need to purchase the application itself.

In an IT environment that changes at an almost bewildering speed, the concept of system ownership is dogged by various risks, such as the additional investment required as a system becomes outdated faster than expected. By changing to a system in which the company uses an application provided by an ASP, it's possible for the company to convert IT costs into a variable expense.

The term xSP (external service provider) is often applied to all such entities, including ASPs, ISPs (Internet service providers) and MSPs (managed service providers). With the exception of ISPs, however, they have attracted more discussion than clients—no doubt because the technologies and services offered are still immature. Yet this does not mean that the xSP concept itself is invalid.

The same approach also applies to the consumer IT environment as well, as most people cannot afford to buy the latest version with each new leap in information

appliance technology and software. The use of incentives (sales subsidies) to sell cellular telephones cheaply and recover costs from part of the calling charges is one form of the transition from ownership to applications.

III The paradigms surrounding ubiquitous networks

The following section overviews the new paradigms that have been put forward by research institutions, vendors and others during the 1990s.

1 Ubiquitous computing

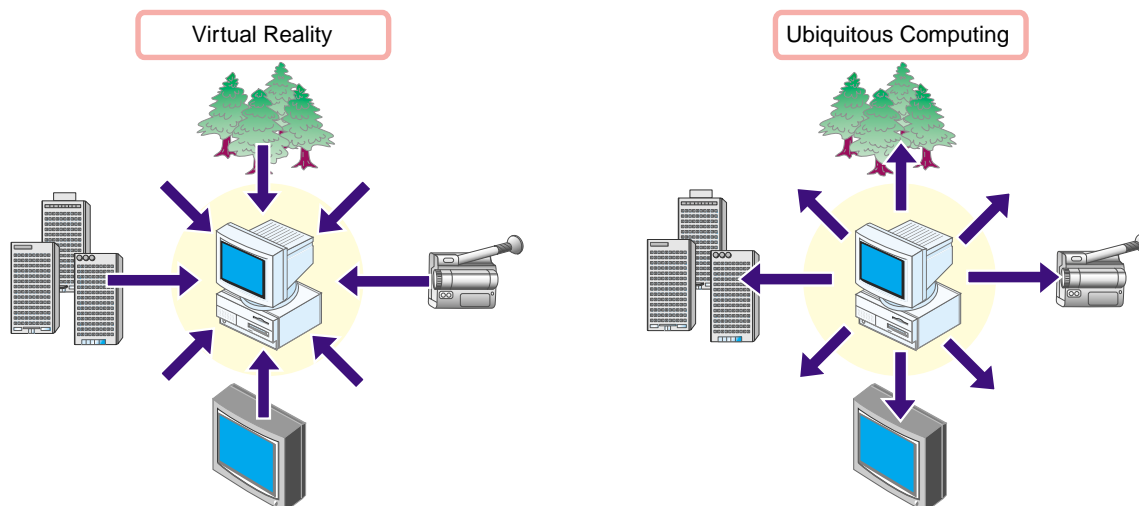
The concept of ubiquitous computing was first advocated in the United States by Mark Weiser at the Xerox Palo Alto Research Center around 1990. At that time the concept of virtual reality was attracting attention as a way to “virtually” reproduce the real world inside a computer. In contrast, ubiquitous computing takes the orientation of using computers to skillfully support human activities in the real world (Figure 2). This is a shift that follows the idea of embedded in the real world, one of the principles described in the preceding chapter.

Since about 1998, IBM has been using the word “pervasive” in advocating what they have called “pervasive computing,” which means nearly the same thing as ubiquitous computing.

2 Nomadic (non-mobile ubiquitous) computing

There are many people who think that ubiquitous is nothing but another word for mobile in the sense that the network can be accessed anytime and anywhere. However, the mere extension of mobility alone does not result in ubiquitous computing.

Figure 2. Virtual Reality and Ubiquitous Computing



Source: Mark Weiser, Xerox PARC.

Actually, I confess to being a mobile user in my own way—even though I do find it a bit cumbersome to lug around a notebook computer, PDA, cellular telephone equipped with an Internet function and a card-type PHS (personal handy-phone system). From this perspective, I eagerly look forward to the emergence of a nomadic (non-mobile ubiquitous) environment (Figure 3).

Such a nomadic environment is one where you don't need to carry various devices with you. Rather, the places you go such as companies, schools, homes, business trip destinations, hotels and rental offices are all equipped with information devices available for your use. This means creating an environment where users can access the same data regardless of their location, and where applications such as screen-based desktop environments can be used just like at one's home or office.

Such a permeable network environment (i.e., one passes through and leaves the network behind) has been realized in the UNIX world for more than ten years as the X Window system. The spread of a similar environment is also expected in personal computers and information appliances.

3 Augmented reality

It was previously noted that the ubiquitous computing paradigm differs from virtual reality in that the orientation is to support activities in the real world. This approach includes what is called "augmented reality," wherein reality is enhanced through the use of sensors planted ahead of time in various locations or carried by users to provide support by detecting information such as the user's position and/or direction of movement. Vehicle navigation systems that utilize the global positioning system (GPS) and the dissemination of traffic congestion information using beacons or other devices buried under the roadway are examples of such initial uses.

At AT&T's laboratory in Cambridge, England, experiments are being conducted in which persons carry sen-

sors and their actions in a room are reproduced on computers. This research is focusing on "sentient computing," which is basically an element of augmented reality.

4 Wearable computing

The paradigm of "wearable computing" was advanced by researchers at the Massachusetts Institute of Technology around 1996. This paradigm, which uses computers and sensors attached to a user's body, is one form of the evolution of mobile computing using device miniaturization and contains elements of augmented reality through its use of sensors.

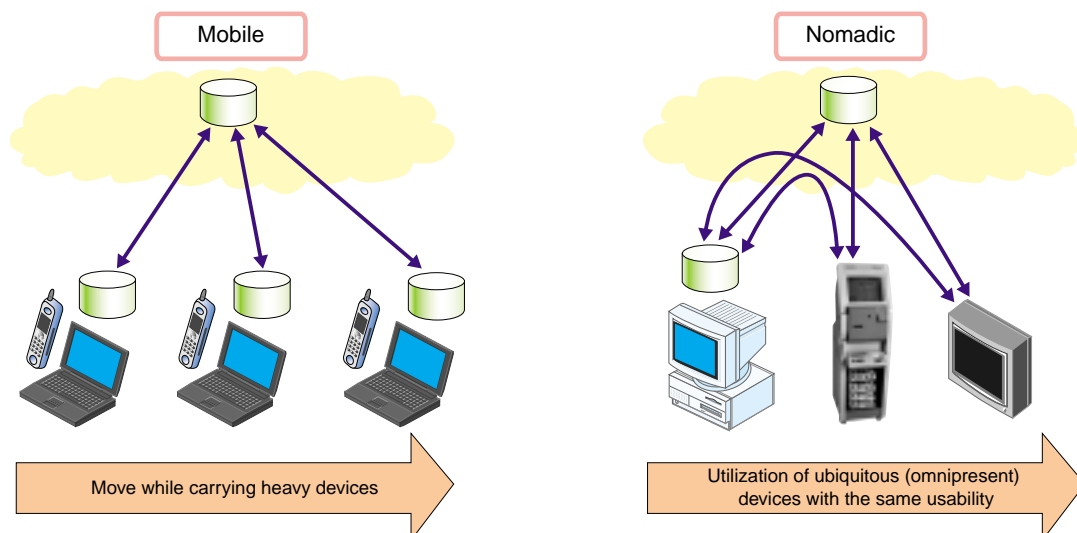
5 Position of each paradigm

Figure 4 shows the relationship of each of these paradigms by using several of the principles described in the preceding chapter to plot their alignment along an "ownership and application" axis and an "embedded in the real world" axis. Ubiquitous computing is the broadest paradigm and includes mobile computing, which is continuing to spread and has a strong orientation towards ownership as evidenced by the fact that individuals carry their own devices. In contrast, nomadic computing that uses networks with terminals set up in various places is a paradigm with a stronger inclination towards applications. Finally, augmented reality that uses sensors to support activities in the real world is a paradigm where the real world orientation is strongest.

IV Evolution of the IT paradigm towards ubiquitous networks

Let us now take into consideration the characteristics of these paradigm clusters to think about how the IT paradigm will evolve over the next ten years in an era of ubiquitous networks.

Figure 3. Nomadic Computing



A Development Scenario for Ubiquitous Networks: Viewed from the Evolution of IT Paradigms

1 From ownership-focused ubiquity to application-focused ubiquity

To begin with, I believe the first big trend will be a shift from ownership-focused ubiquity to application-focused ubiquity. Ownership-focused ubiquity refers to one form of usage that follows a line extending from the mobile networks used so widely at present. Even in the case of increasing speeds under IMT-2000, this posits no change in the current environment in which each user owns a mobile device and secures access to proprietary networks through a contract with a cellular telephone carrier.

In contrast, application-focused ubiquity is a format using the same operating environment but with devices set up beforehand in various locations, and network access is established on an ad hoc basis at each location. This shift from ownership to application was touched upon in Section II. Although the transition from ownership to application did move forward during the Web computing age, it may be asserted that the strong element of ownership in the mobile environment essentially represents technological retrogression. Accordingly, it

is my view that the most noteworthy trend over the next decade will be the progress from ownership-focused (mobile) ubiquity to an era of application-focused ubiquity.

2 Dominant players in an era of ubiquitous networks

Let us now turn to describing the changes that will occur among the dominant players in accordance with the evolution of the IT paradigm. As shown in Figure 5, when we look back over the past transitions in the IT paradigm we can see that the dominant player in each respective age secured its position by bundling (integrating) the high-ranking layers while keeping a firm hold on the lowest layer. And as each new paradigm emerged to unseat its predecessor, unbundling (dissolution) occurred because of technical necessity and the dominant player also changed as a result.

At the time of the transition from mainframes to client servers, hardware and OS unbundling changed the dominant player from IBM, which had a firm grip on hardware, to Microsoft, which provided the OS. Later, during the period of transition to Web computing, OS and applications were unbundled by the diffusion of the Web that does not rely on an OS, and domination started shifting to companies such as Oracle that have a strong grip on database applications.

Now that we are in the era of ownership-focused ubiquity (mobility), we might say that NTT DoCoMo with its grip on the wireless system network is a dominant player. Indeed, it would not be incorrect to say that NTT DoCoMo's i-mode is the first example of success in the sale of online digital contents. Because the network and contents have been unbundled on the Internet, providers are finding it necessary to collect a fee for each of these respective services individually. Although a variety of charging systems have been proposed, none has yet to achieve widespread use for reasons such as the lack of universal applicability and/or high intermediary commissions. The unique feature of i-mode is the point that the

Figure 4. Arrangement of the Paradigms Related to Ubiquitous Computing

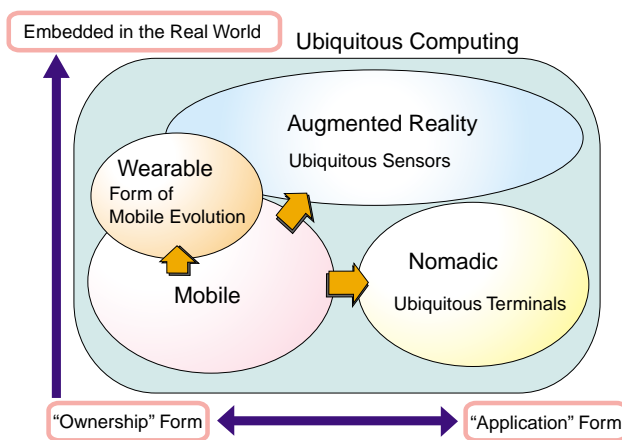
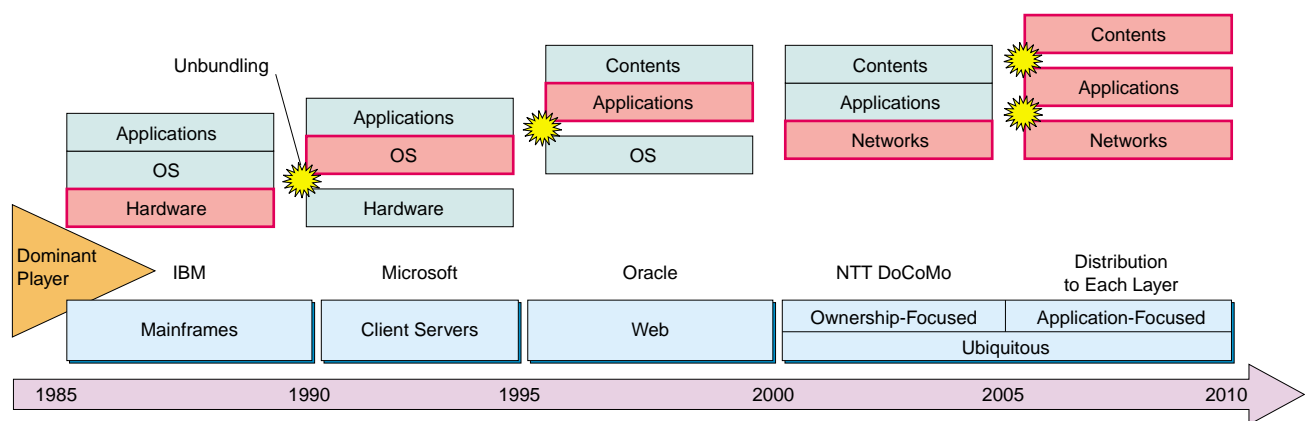


Figure 5. Change in Dominance Through Unbundling



Note: OS = Operating system (basic software).

application and contents have been bundled on a proprietary wireless system network, and the charge for the contents is billed to the user by being added to the communications fee.

From a technical viewpoint, it is logical to assume that a second unbundling of networks, applications and contents will accompany the evolution of the paradigm towards application-focused ubiquity. Thus in an era of application-focused ubiquity the dominant players will be distributed to each network, application and content layer. The premise for this change, however, is a significant evolution in the fee assessment system on the basis of open networks. This aspect will be described later.

3 The awaited wireless network for data communications

Figure 6 is a diagram that forecasts what kinds of changes will occur in each layer, taking into consideration the transition from ownership-focused ubiquity to application-focused ubiquity. The details of these changes are explained sequentially as follows.

First, in terms of a network infrastructure it is clear that a wireless system is important for a ubiquitous network that can be used anytime and anywhere. In Japan, however, such a network infrastructure depends particularly on the data communications services that cellular telephone and PHS carriers provide.

As the present level of service was constructed on a circuit-switching infrastructure that was premised on voice telephone calls, however, the biggest drawbacks are its metered-rate system, high-priced communications charges and transmission speeds of 64kbps (kilobits/second) or less. While speeds can be raised from 384kbps to a level of about 2 Mbps by using IMT-2000 in the future, the essential problem—i.e., an architecture originally designed for voice telephony—will not change.

For the era of ubiquitous networks, wireless networks that are based on a data communications paradigm will be both necessary and indispensable. This means that the IP (Internet protocol) will become the basic protocol as a matter of course. While it is sometimes asserted that the ubiquitous networks by which various devices are connected will become networks that are distinct from the Internet, this would seem doubtful. After all, the Internet has grown by the internetworking function with which networks are connected to networks, so it is only natural to assume that ubiquitous networks will be realized by extending the Internet to various environments.

If wireless IP networks with adequate spectrum are to be created, it will probably be through putting voice on top of IP in the future in the form of VoIP (voice-over IP). (See the upper half of Figure 7.) There are a number of business entities in the United States offering wireless ISP services that provide wireless networks for specialized data transmissions. For example, Ricochet offered by Metricom, Inc. provides a unique service in which wireless modems set up in locations such as street light poles transmit data in packet-relay formats. Users send and receive data using small wireless modems about the size of a pencil case that are attached to notebook computers. Metricom has developed this service in several major cities across the US. While the basic data transmission speed is 28.8kbps, services at a speed of 128kbps have been started in some cities. This service is offered at a fixed fee of approximately \$75 per month.

Wayport, another US company, is utilizing wireless LAN systems that can transmit data at speeds up to a maximum of 11Mbps (in accordance with the IEEE802.11b standard established by the US Institute of Electrical and Electronic Engineers) to provide wireless data transmission services in locations such as airports and hotels. Users of this service are provided with

Figure 6. From Ownership-Focused Ubiquity to Application-Focused Ubiquity

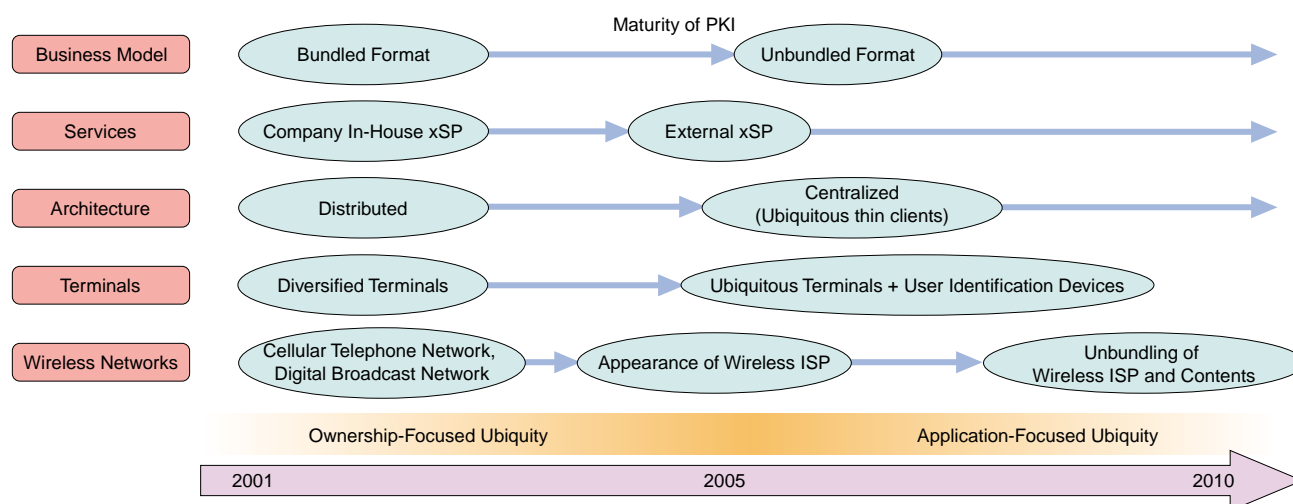
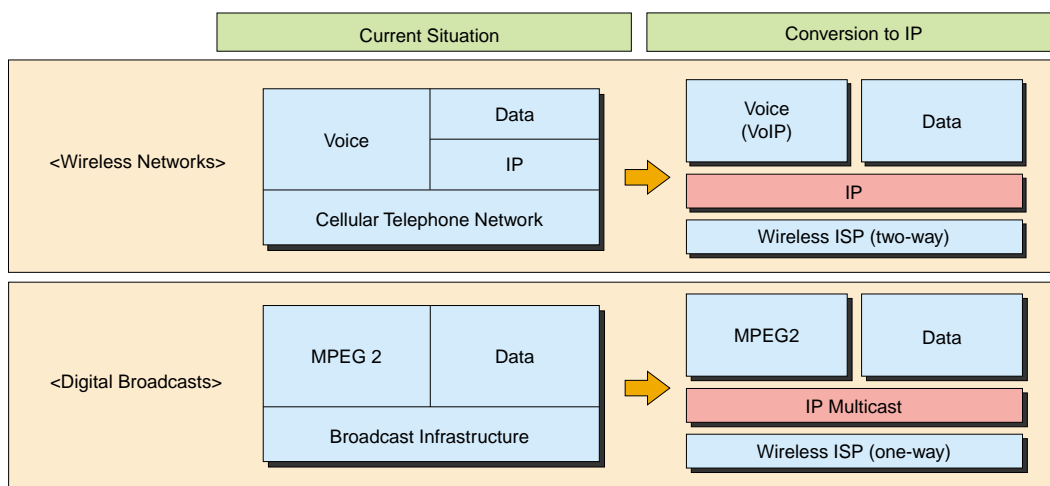


Figure 7. Conversion of Wireless Networks and Broadcasts to IP

Notes: IP = Internet protocol; MPEG2 = International standards for motion picture compression established by the Moving Picture Experts Group; VoIP = Voice over IP.

a wireless LAN card that conforms to the standard generally used in offices and homes.

The charge is \$35 for 10 usage sessions (each session can last an entire day). Users can take advantage of a high-speed wireless Internet environment with speeds up to the maximum of 11Mbps whenever they wish, without regard to connection time. This would appear to be a service mainly designed for airports and hotels, where the goal is to accommodate the many long-distance business travelers in the US. But if the same kind of service were also provided in locations such as railway stations, restaurants and coffee shops in Japan, the demand would probably be high. In fact, an effort has been started by NTT East Corporation to offer a similar service in Japan. While still in the experimental stage, this so-called “bi-portable” service was initiated in Tokyo’s Shibuya district in January 2001 and will provide high-speed wireless access at 36Mbps in the 5-GHz band.

Although wireless LAN service in the 2.4-GHz and 5-GHz bands in Japan also involves unique problems relating to interference with the existing weather radar network, the early spread of wireless networks for data transmissions will be an indispensable element for the realization of ubiquitous networks.

4 Beyond the fusion of broadcast and telecommunications

The start of digital broadcasting is often seen as the first step in the fusion of telecommunications and broadcasting. At present, however, the digitization of broadcasting—i.e., the conversion of motion picture content to MPEG2—has just begun and the basic structure of broadcasting networks remains the same as in the past (MPEG2 is an international standard for moving image compression). Data broadcasts, moreover, are also transmitted via their own unique procedures.

The argument has also been made that broadcast networks will become unnecessary once it becomes possible to utilize broadband transmissions to transmit motion picture content over a data transmission network. However, it is also possible that by using an infrastructure with the same multicasting capabilities as wireless systems, the broadcasting functions of delivering the same content to large numbers of people will become a separate niche for data transmission.

To fuse broadcasting networks with data transmission networks—essentially with the Internet in a real sense—will involve nothing less than adopting IP (more accurately, IP multicasting with simultaneous content transmission) as part of the broadcasting infrastructure. In other words, it is widely believed that making the basic parts of broadcast networks into one-way wireless ISPs is an ideal format for fusing broadcasting and telecommunications (see bottom half of Figure 7).

To return to the argument about unbundling mentioned earlier, today’s broadcasting stations assume a business model that adopts the bundling of broadcast network infrastructure and programming contents. From a technical point of view, however, unbundling this package into a one-sided wireless ISP and production companies for programming contents would be entirely possible.

Earlier I described the technical environment surrounding the wireless network of cellular telephones and broadcast networks. Wireless ISPs that specialize in data transmissions are likely to appear within a few years, making high-speed network access possible for a fixed fee. The next transformation—namely, whether voice telephony for cellular telephones and programming contents for broadcasting will be unbundled from the wireless ISP infrastructure—is difficult to predict. Despite the fact that it would be a highly logical transition from the technical standpoint, its feasibility depends entirely upon transmission and broadcasting policies.

5 Separation of ubiquitous terminals and user identification devices

Next let us give some thought to changes in the terminal environment. In an era of application-focused ubiquity it will become possible to use the devices we commonly carry about in the age of ownership-focused ubiquity (mobility) by using terminals set up in various locations as described under the nomadic environment. To give terminals everywhere the same feel when people use them and make it possible for users to freely utilize them as they would their own terminals, it will be necessary that all terminals be based on an open standard. A user's personal data will be input via some identification device that users carry with them, such as a smart card or tag. The UIM (User Identity Module) designed for IMT-2000 terminals adopts this format.

When the *l*-mode plan was announced by NTT regional companies in October 2000 as a fixed telephone version of *i*-mode, it attracted little interest as it chiefly involved email and Web functions on fixed telephones for home use. On the other hand, the aspect of creating ubiquitous terminals by using a smart telephone card to distinguish among users so they can use a pay phone at their destinations to read their own mail was remarkably well received. (As of February 2001, approval is still pending because of provisions in the NTT Law, and the timeframe for starting this service remains unclear.)

Moreover, it's widely believed that the spread of ubiquitous terminals will lead to the disappearance of mobile devices, as they are only a halfway solution at best. Instead, they will be replaced by fixed terminals offering superior user interfaces and wearable terminals that excel in portability.

The use of IPv6 (IP version 6), the next generation version of IP, is appropriate as the key protocol for networks that connect these various types of terminals. However, the shift to IPv6 is considered to be more positive for terminal vendors than for users such as telecommunications businesses, as constructing an Internet using expanded address space and an open, flat IPv6 base will make it more difficult for telecom firms to use the network's unique characteristics to structure a bundled-type business model. As a result, terminal vendors are likely to recover their positions of leadership.

6 System architecture will move to ubiquitous thin clients

One major trend that is expected in system architecture is a shift from an environment that distributes applications and data among mobile devices to ubiquitous thin clients (architecture where terminals provide only simple processing such as data displays, with processing and data loads centralized in servers). Thin clients are a technology that precisely captures the shift from ownership

to applications by providing centralized hardware and software control that enables users to take full advantage of applications.

While the enthusiasm for thin clients started around 1998, there hasn't been a great deal of progress in their actual introduction. Among the various reasons for this, the lack of adequate network spectrum can be cited as the main factor. For example, a spectrum of about 20kbps per terminal is necessary to deploy the representative Metaframe thin client environment produced by Citrix Systems. Simultaneously applying such a system on a scale of several thousand employees would require a spectrum in the several dozen Mbps class.

Even without the conversion of access circuits to broader bandwidths and lower costs through the introduction of ADSL (asymmetric digital subscriber lines), fiber optic circuits, 10 gigabit Ethernets, etc., high-speed network environments will become a reality in an era of ubiquitous networks. This will make it easy for thin clients to fully demonstrate their original capabilities.

Moreover, the conversion to thin clients will be a major trend in the mobile environment as well. Figure 8 shows the results of a questionnaire asking corporate users about their intentions and concerns with respect to introducing a mobile environment for in-house email. Although many firms plan to shift to mobile email within the next two years, the chief concern was "information leaks because of inadequate employee control over terminals."

Although it is possible to ensure the security of communication routes by using personal security codes, this provides no defense against terminal loss and theft. This concern can be eliminated, however, if the thin client environment can be used in a way that confines valuable data to the server side only and does not leave data behind on the terminal.

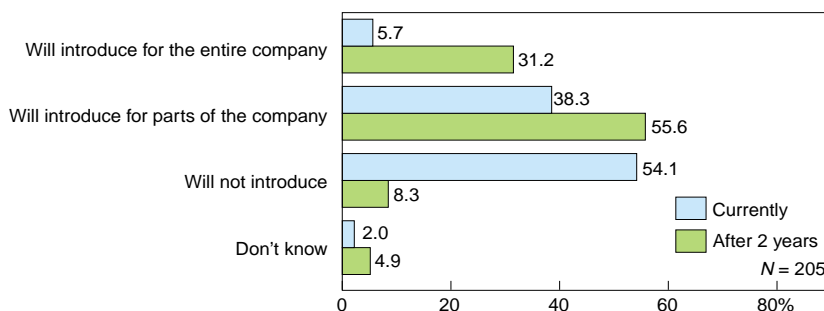
7 Will the use of external xSPs really grow?

Let us next consider the question of whether firms will really use xSPs (external service providers) in a manner that will change information systems from ownership to applications. For small and medium-sized firms there is comparatively little resistance to using outside xSPs, as such companies never find it easy to accumulate human resources and computer system assets in-house. As a result, outside services can be introduced much more quickly.

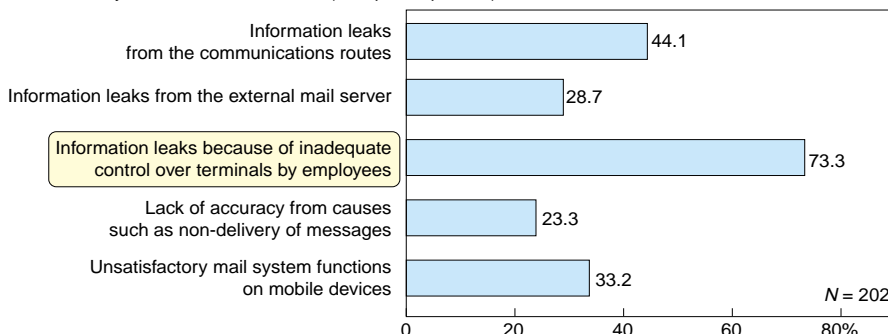
In contrast, the resistance to using external services is strong at large companies because of fears that control will be lost or concerns about customizing services to fit the company's own environment. For this reason it is thought that companies will initially take steps to turn their own information system divisions into in-house xSPs by centralizing and controlling hardware and applications and requiring user divisions to utilize the in-house services. But once external xSP services have

Figure 8. Intentions and Concerns of Corporate Users Regarding Mobile Computing

Have you introduced an environment that enables employees to use a mail service utilizing cellular telephones (i-mode, EZWeb, etc.) away from the office so they can read their in-house e-mail?



What are your causes for concern? (Multiple responses)



Source: Nomura Research Institute, *Corporate System Survey*, November 2000.

matured and resistance to using them starts to fade, large companies as well can be expected to shift towards the use of external service providers.

8 Deployment of the PKI environment necessary for unbundling

To move ahead with unbundling in a way that enables fees to be charged for each layer, further developments in PKI (public key infrastructure) will be required. Presently companies such as financial institutions are using PKI tools for some of the services they offer consumers, but these systems are remarkably inconvenient. Even when no technical problems are encountered, such services score poorly with users, as they are hard to use, employ special terminology and compel consumers to follow complex operations. With improvements in PKI usability (convenience) and the start of efforts to create the foundations for a generalized PKI, however, it will become possible for the player's at each layer to appropriately collect their respective fees through unbundling.

V The opposition between technical inevitability and business models

I have attempted in this paper to outline the specific changes each respective layer will follow within the

larger trend of moving from ownership-focused ubiquity (nearly synonymous with mobility) to application-focused ubiquity. This is chiefly an argument from the perspective of technical necessity. Particularly with regard to the shift towards unbundling, many players will probably emerge who oppose such a change in terms of a business model even if such a transition seems appropriate from a technological perspective. Moreover, the fact that i-mode is seen as a successful example of the vertical bundling of network and contents probably exerts an impact as well.

However, it will be difficult to maintain any business model that defies technical necessity over the long-term. If open ubiquitous networks can be created by the appearance of technical solutions such as wireless ISPs, it is only a matter of course for players at each respective layer to recover their own added value from network users. Indeed, the question really gets down to whether this format isn't desirable for the healthy development of ubiquitous networks in the long run.

Hiroyuki NAKAMURA is a chief researcher in NRI's Information Technology Research Department. His specialty is technology paradigm theory.

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