YOKOGAWA'S BUSINESS STRATEGIES TOWARD UBIQUITOUS COMPUTING

NAGASHIMA Akira [*1]

As we enter the 21st century, the term "ubiquitous" is becoming just that—ubiquitous. The emerging benefits of "ubiquitous computing" have the potential of fundamentally altering the way we live and work. To summarize the major benefits, a ubiquitous computing environment will enable us to utilize information 1) from anywhere 2) without conscious effort 3) with a sense of super-realism 4) from the user's point of view, and 5) with the utmost flexibility and adaptability. These benefits will usher in a new era for measurement and automation as well. That is why we have declared the "Yokogawa ubiquitous initiative," whereby we have accelerated our R&D activities to help promote the real-life applications of ubiquitous computing technologies. To name a few of these activities that combine the fruits of our decades long R&D investments, we are playing a leading role in such emerging areas as IPv6 networks, advanced network security solutions, high-speed broadband network modules, widely distributed autonomous field instrumentation networks, and net sensing systems.

INTRODUCTION

"Ubiquitous computing" is a concept that is fast becoming a buzzword in the world of the 21st century. This paper outlines the potential Yokogawa sees in ubiquitous computing environments and shows how we have been addressing ourselves to sharing the task of their realization. Specifically, the first half of the paper explains the benefits that ubiquitous computing will bring about and what is required, followed by the second half which introduces the varied activities Yokogawa has been conducting to satisfy those requirements.

SEVEN SCENARIOS OF UBIQUITOUS COMPUTING

Figure 1 shows the seven scenarios of how ubiquitous computing will benefit the world:

*1 Director, Chief Technology Officer
Executive Vice President of
Corporate Research and Development Headquarters

Households

First scenario: Networked home appliances such as TVs and refrigerators provide timely access to information and can be controlled remotely.

Second scenario: Your bed, toilet and other items around the house automatically collect and record data that can be used to diagnose your health, etc.

Cities

Third scenario: At the supermarket, your shopping cart advises you on purchases, such as the day's bargains and necessary items according to your dinner menu, and automatically performs checkout when you pass through a gate. This enables supermarkets to automatically keep track of your shopping preferences and habits.

Fourth scenario: Experience the freedom and peace of mind of staying in touch with your home and workplace, as well as public agencies, wherever you may be.

Factories

Fifth scenario: The network enables you to operate your plant from any location around the globe. This makes it possible to make the most of professional expertise, experience, and knowledge which will be in increasing demand.

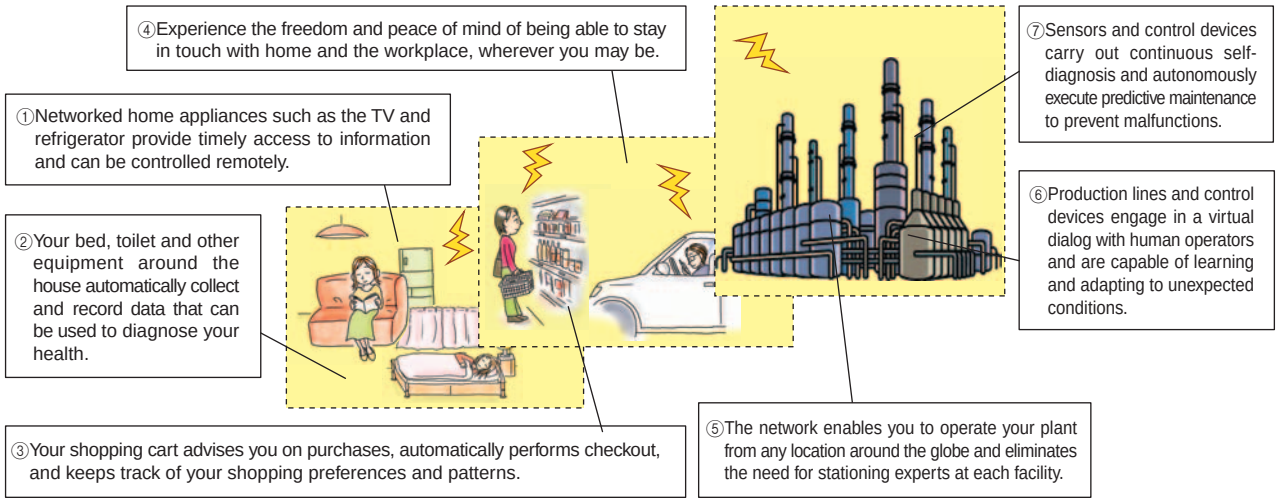

Figure 1 Ubiquitous Computing Environment

Sixth scenario: Production lines and control devices engage in a virtual dialog with human operators by e-mail and are capable of upgrading themselves by adapting to such unexpected conditions as malfunctions and product changeovers.

Seventh scenario: Sensors and control devices on production lines carry out continuous self-diagnosis and autonomously execute predictive maintenance to prevent malfunctions by notifying the operators or independently correcting problems.

BENEFITS OF UBIQUITOUS COMPUTING

Based on the aforementioned seven scenarios, the major benefits of ubiquitous computing can be summarized as enabling us to utilize information in the following ways:

From anywhere

Ubiquitous computing removes location dependency. This is embodied in the remote control of networked home appliances in the first scenario; information accessibility of mobile terminals in the fourth scenario; and the remote operation of factories by experts in the fifth scenario.

Without conscious effort

Ubiquitous computing technology performs a variety of tasks without the beneficiary's being aware of it. This corresponds to the refrigerator in the first scenario, monitoring its contents and their best-before dates; the bed and toilet in the second scenario which measures and records body temperatures, pulse counts, and sugar and protein levels automatically, as well as contacts doctors as necessary; the shopping cart in the third scenario, accumulating customers' shopping habits for the store to improve the product selection and layout; and the sensors and devices in the seventh scenario, carrying out preventative maintenance through regular self-diagnoses, which is a factory version of the second scenario.

With a sense of super-realism

Ubiquitous computing does not block access to any information, and work can be done remotely as if doing it on-site. This is embodied in the shopping cart in the third scenario, giving us tips on bargain items in such a way as to make us inclined to buy them when the cart is in the proximity of those particular products' shelves; and in the fourth and fifth scenarios which give us a superb sense of realism as if we were operating the factory on-site, even if it is by way of mobile terminals.

From the user's point of view

Ubiquitous computing technology implements functions from the user's point of view, rather than from that of the information and operations providers. This corresponds to the home appliances in the first scenario that can be effectively operated by nonprofessionals; the shopping cart in the third scenario, advising customers according to their characters and preferences; and the control devices in the sixth scenario, which understand and speak the operator's language.

With utmost flexibility and adaptability

Change is inherent in ubiquitous computing environments. This is embodied in the concept of the first scenario when, for example, a new VCR is connected to a network, and it immediately starts working with the existing devices and all the functions can be easily used; and in the individual devices in the sixth scenario which automatically adjust themselves to new environments, such as when a device may have failed or been added, and their operations have thereby changed.

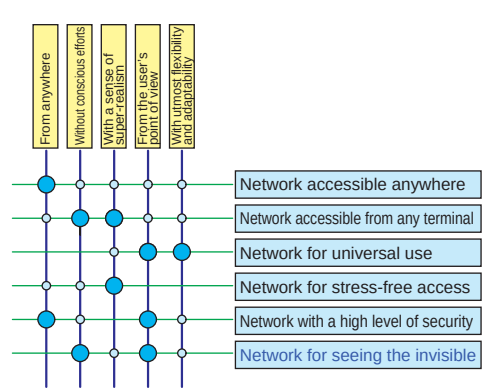

Figure 2 Relationship between Ubiquitous Computing Benefits and Requirements

REQUIREMENTS FOR UBIQUITOUS COMPUTING

This section deals with the requirements for making the benefits of ubiquitous computing a reality. We have selected six requirements after consulting the basic concepts of a report compiled by the Study Group on Future Prospects of Ubiquitous Network Technology of the Ministry of Public Management, Home Affairs, Posts and Telecommunications. Figure 2 shows the relationship between the benefits and requirements.

Network accessible anywhere

Ubiquitous computing can only be realized on premises that can be connected to a network anywhere as necessary, and IPv6 holds the key to its success. The IPv6 is a set of network protocols that is ideal for the ubiquitous technology era, with its capability of controlling a huge address space for configuring a global open network and of implementing security in that open network, as well as its built-in plug and play system which facilitates dynamic connection to a network and the configuration thereof.

The support of mobile and wireless technologies is also essential. This is because field information environments including factories require supplemental networks in addition to IPv6, and thus fieldbus technology must be supported for connecting diversified sensors that are distributed throughout the field, preferably on a wireless basis.

Network accessible from any terminal

To effectively capitalize on ubiquitous computing, communications between persons or between persons and computers only will no longer be sufficient. It will be desirable for every constituent of society to be networked and to speak a common language. For instance, information home appliances and control devices can perform more efficiently through a network by processing the information that they acquired and combining it with other equipment's functions.

When something not expected is connected to a network and information that has nothing to do with its initially intended functions starts to be collected, far-reaching effects can result. In other words, collecting and accumulating items of information that seem useless individually can reveal completely unforeseen facts, which is why ubiquitous computing is intriguing and even formidable.

However, when promoting a network accessible from any terminal, we must pay particular attention to several issues, including the granularity of the network devices. Namely, conventional special network devices are for the most part large-sized with complicated built-in functions, and their granularity may not be appropriate for use with ubiquitous computing. In these cases, their functions need to be divided into smaller units and distributed on a network.

Network accessible for universal use

Ubiquitous computing comprises a flexible, expanding environment that can handle requirement changes and deterioration caused by partial failures by re-configuring its services and applications dynamically. To realize this, individual devices that are scattered on a network must not only operate autonomously but also work together in real time, in order to maximize the computing system as a whole. The system is also required to respond to minor malfunctions that some distributed networked devices may develop, while at the same time conducting product changeovers simultaneously as they occur, and independently re-configuring the system accordingly.

To rephrase the above from a different viewpoint, network contents that are used to write services and applications must be independent of their operating environments or platforms. More specifically, it is essential that the identical contents are able to run on a broad range of platforms. In addition, it is preferable that the contents can be transported onto a new platform regardless of their original ones so as to be utilized stably over an extended period of time.

Network for stress-free access

Realism plays a significant role in ubiquitous computing, wherein multimedia information including images and voice is mobilized in various aspects. Demand for quicker network response is also intensifying. Larger capacity networks are requisite to keep up with ADSL and other high-speed Internet connections which are rapidly becoming popular. Currently as many as over 50 percent of households in Japan already have access to the Internet, and 63.28 million people use cell phones as of April 2003. ADSL services are subscribed to by 7.48 million households, and CATV has been adopted by 2.14 million, with 350 thousand households connected by FTTH.

Network with high level of security

Although ubiquitous computing can only be achieved in an open network environment, it also places special emphasis on reliability and security, on which various information is dependent. This ranges from personal data which must be strictly confidential, to information that controls our lifelines which can greatly affect social activities.

It is becoming a common consensus that a ubiquitous computing environment cannot be created by simply mobilizing information in a limited area, and that it can be built only in a more open network that is not protected by firewalls or other measures. Realizing these conditions necessitates every networked device to be properly authenticated and to protect its own security. Network monitoring devices that record and monitor on-line transactions are also required, including surveillance cameras installed on the street.

If the network's reliability cannot be guaranteed to an absolute degree, it is advisable to guarantee it on a best efforts basis. Such a network environment must be equipped with the capability to localize the damages by dispersing the functions of the network devices, and to provide alternative mechanisms through the device's autonomous actions, as well as a duplex system that enables devices according to their assigned priorities to be used for exceptional purposes in case of emergencies.

Network for seeing the invisible

A ubiquitous computing environment is anticipated to extract some useful, desired data from a group of hitherto un-compiled information, and to process this information and deliver it to users in an easy-to-understand format. To this end, a mechanism must be developed that compiles new knowledge from a mass of information which is seemingly meaningless. Such a mechanism would enable the forecasting of customers' behavioral habits and

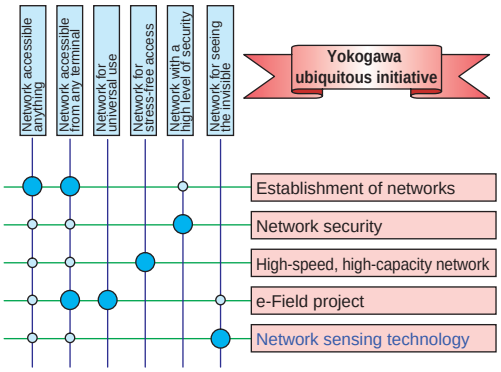

Figure 3 Yokogawa Strategies for Ubiquitous Computing Requirements

potential device deterioration using peripheral contents that accompany compulsory information, and generate qualitative changes in information while items of information that are not very useful in themselves are being collected in huge amounts.

Another aspect of fulfilling this requirement is that ubiquitous computing could enable information to be collected that has previously been considered impossible, such as the detection of intruders by using senses equivalent to the five senses, detecting the potential occurrence of fire, and unevenness in color. By using modeling and simulation techniques, the ultimately most important information regarding actual applications can also be estimated in real time. Moreover, completely new sensing technologies can turn the invisible into the visible. These nanotechnology-based sensing techniques include bioinstrumentation and gas measurement.

YOKOGAWA'S BUSINESS STRATEGIES

Positioning ubiquitous computing as one of its future mainstays, Yokogawa has declared the "Yokogawa ubiquitous initiative" and has been concentrating its resources on promoting the relevant strategies under the leadership of the Corporate Research and Development Headquarters. Figure 3 shows the relationship between the ubiquitous computing requirements and our corresponding strategies. Over and above these strategies which will be introduced later in this document, Yokogawa has been operating a diversified range of existing businesses, such as the production of semiconductor test systems, control/information systems for production lines, and development support tools.

Establishment of Networks

Yokogawa has long recognized the importance of IPv6 and has been contributing to its development work, chiefly in the security and testing systems segments, by participating in the WIDE (Widely Integrated Distributed Environment) project. We are also expediting the active use of IPv6 in the industry.

WIDE project activities

Yokogawa became a member of the WIDE project in 1992, a project organized by a private research organization and which is operated by Keio University in collaboration with the industry. Yokogawa has been participating actively in some of the working groups and sub-projects. These include the KAME project in which Yokogawa as the core member developed the IPsec security protocols for the standard IPv6 stack; followed by the TAHI project in which we took charge of technology development and administration, therein developing a tool for testing conformance with specifications, as well as virtually hosting an interconnectivity testing event. Yokogawa is also participating in the USAGI project which is designed to implement the IPv6 protocols on Linux platforms.

Release of IPv6-compatible, leading-edge products

Yokogawa developed and released the following products:

- TTB :A series of protocol translators that seamlessly connect IPv6 and IPv4.
- LMat :The world's first network management software to support IPv6.

Fieldbus

The fieldbus network is best tailored to the needs of the plant instrumentation market, and thus anticipated to perform an important part in establishing a ubiquitous computing environment by complementing the Internet. As a leading supplier in the process instrumentation field, Yokogawa has always adopted a positive approach to the extensive efforts by the Fieldbus Foundation since the foundation was established. Namely, Yokogawa took part in composing the standard specifications, and was a chief staff member for the preparation of the physical layer and application layer specifications. It also developed and released the standard chip for the Foundation Fieldbus, as well as took a leadership position in interoperability testing. In line with these efforts, Yokogawa has released more fieldbus-enabled products.

Network Security

Achieving a higher degree of network security is the most fundamental objective for Yokogawa which has inherently regarded reliability as critical. We are conducting research and development activities as outlined below, with the aim of implementing advanced security on networks that are more open thanks to the IPv6 technology.

PAFFI: Packet Footmark FInder

This unique piece of equipment functions on networks in exactly the same way as a monitor camera does on the street. The PAFFI is installed at a network point, and records and accumulates the characteristic information of packets that pass that point, so that paths of problematic packets can be traced. Although this product is still in the prototype stage, it has already attracted a great deal of attention from progressive-minded users.

SIOS: Security Intelligence Operation Studio

The SIOS creates a database of network vulnerability descriptions and the corresponding countermeasures, and provides network supervisors with the information in Japanese in real time. It has already been commercialized and is being well-received among users, including some major enterprises.

SecureTicket: Integrated security software for Web servers

The SecureTicket provides Web servers with security measures—user authentication, malicious access prevention, and information encryption. So far more than 800 systems have been shipped and are currently in use.

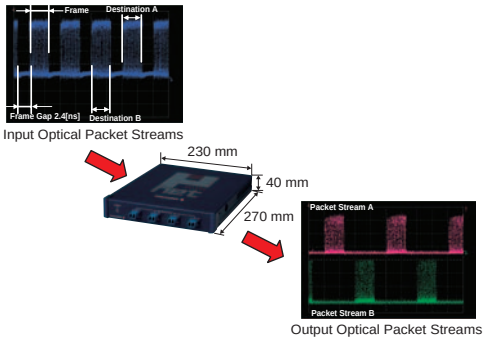

Figure 4 40-Gbps Optical Packet Switch

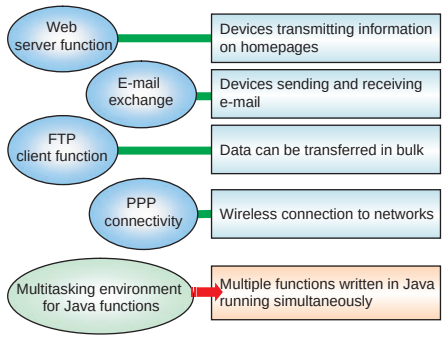

Figure 5 Overview of DUONUS Functions

High-speed, High-capacity Network

Being aware that the 21st century will become the age of high-speed, high-capacity networking, Yokogawa has been intensively devoting its energies since 1983 to the research and development of compound semiconductors on which the ultrafast optics and electronics technologies are founded. Such strategies have been embodied in our commercialized 40-Gbps communication modules, which have a wide range of applications from transmitters to receivers. These modules have been incorporated in Yokogawa's and Ando's communications measuring instruments, and have been evaluated as exceptional by manufacturers of infrastructural network equipment inside and outside Japan. This has created a market for the steady supply of 40-Gbps and 10-Gbps modules over an extended period of time. Based on these 40-Gbps modules, we will enhance our strategies to develop and supply next-generation optical network equipment.

Merger with Ando Electric

Yokogawa has acquired and merged with Ando Electric in order to expeditiously strengthen its measurement technology for optical and digital communications, and to thus form a solid business base for the relevant industries. This unification has produced a profound multiplier effect through integrating the two companies' specialties, thereby augmenting the product lineup for optical and digital communications measurement and facilitating prompt responses to market needs.

Next-generation Optical Network Equipment

Gaining momentum from the aforementioned results of the development and release of 40-Gbps modules, Yokogawa has begun developing next-generation optical network equipment taking advantage of its more sophisticated systematization technology. This equipment is targeted not for infrastructural networks, but for LANs or other types of networks which handle a large amount of data locally, including broadcasting stations. Figure 4 shows a prototype of a 40-Gbps optical packet switch.

Mobile broadcasting

In 2004, nationwide multimedia broadcasting for private users mainly through mobile terminals, or "ubiquitous personal broadcasting", will come into full swing. For this new service, Yokogawa has developed and provided a gap filler which resolves faulty reception in locations where signals from broadcasting satellites tend to be interrupted. The gap filler enables users in Japan to benefit from mobile broadcasting anywhere they may be. Yokogawa is also actively engaged in the remote control and maintenance of relay stations.

e-Field Project

Yokogawa has launched and been vigorously promoting the e-Field project which is aimed at fulfilling the realization of ubiquitous computing in the field. The following are the four goals of the e-Field project:

(1) Easily connecting field and control devices and attaining a satisfactory level of security in a ubiquitous network environment
(2) Devising a mechanism which enables field and control devices to autonomously send messages to networks
(3) Enabling qualitative changes of information and building a robust system by distributing field and control devices on a network
(4) Surpassing static systems to devise a mechanism with which changes, deterioration, and expansion can be dealt with dynamically

To achieve these goals, Yokogawa has been proceeding with the following strategies:

Autonomous field devices

Yokogawa disclosed the concept of DUONUS in February 1997, a field device that transmits information autonomously over the Internet. More than 2000 DUONUS units have already been supplied to the market since February 1998. The DUONUS has successfully created the aimed-for mechanism—namely, devices are capable of setting up homepages on the Internet and

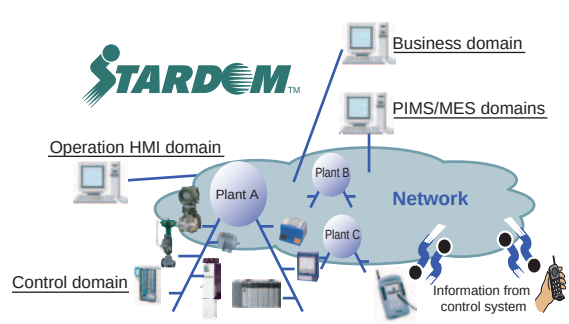

Figure 6 STARDOM System

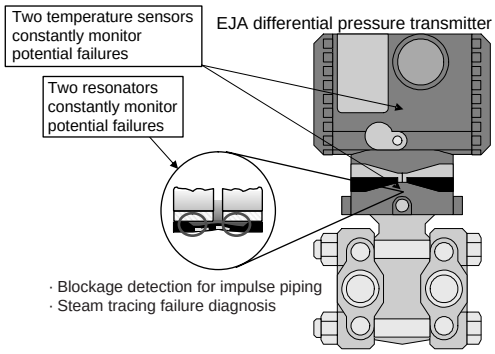

Figure 7 EJA's Predictive Maintenance

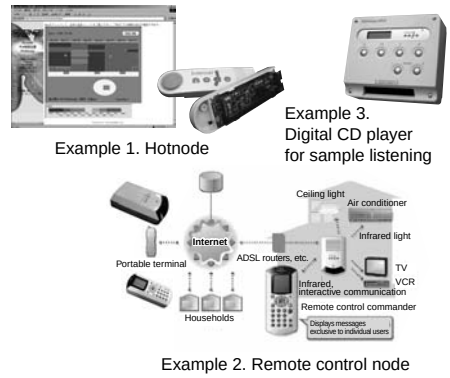

Figure 8 Micronode Applications

can exchange e-mail, while Java objects are activated by event occurrences and executed in a multitasking fashion. Figure 5 shows an overview of the DUONUS functions.

Ubiquitous computing with STARDOM

STARDOM is a network-based control system that amalgamates the world's standard control language, IEC 61131, and the DUONUS functions. Figure 6 shows a conceptual drawing of STARDOM, which is an ideal control system for ubiquitous computing with its outstanding features such as autonomous controllers, Web-based HMI, and a wide and varied content packed with application-specific expertise.

Predictive maintenance of field devices

It is a major challenge for plant instrumentation to devise a means to effectively maintain all the sensors scattered throughout a plant, but one to which predictive maintenance relying on the fieldbus gives an answer. Predictive maintenance is expected to reduce total maintenance costs to a tenth that of breakdown maintenance. Yokogawa will aggressively pursue the realization of predictive maintenance by adding a new sensing function for predictive maintenance to sensors, as well as by elaborating a structure to operate software that performs predictive maintenance. Figure 7 illustrates the predictive maintenance function of the EJA series differential pressure transmitters.

IPv6 demonstration using micronodes

Yokogawa values the fact that information can effect qualitative changes when many devices are dispersed on a network. Thus Yokogawa developed micronodes, IPv6-compatible small sensor devices, and through various applications including the following three instances, has realized unforeseen merits that micronodes distributed on networks can provide. Figure 8 shows examples of these micronode applications.

In Example 1, we employed 103 units of temperature sensing micronodes to measure the Nippon Convention Center in Makuhari, Chiba Prefecture, thereby demonstrating that new added value can be realized by networking abundant information from sensors scattered in different locations, including the capability of forecasting the flow of visitors from chronological changes in temperature distribution.

Example 2 interactively collects marketing data from 100 households using networked remote controllers. Users can be provided with customized services in return for their non-volitionally transmitted personal data.

Example 3 is a micronode for special CD players that allow customers to listen to excerpts before buying CDs. It was developed for an enterprise which was not previously networked until it decided to boost its business with the micronode. This example has shown that customers' purchasing habits and CD sales recorded by POS equipment correlate with each other, proving the micronode's usefulness in commercial ventures.

Applications of mobile agents

Yokogawa is amassing application expertise for mobile agent technology, in full realization of its increasing importance for ubiquitous computing. These efforts are intended to 1) assess the feasibility of building a system that centers on resultant products; 2) implement a system architecture that seamlessly unites the MES and control layers; and 3) study an architectural model for production systems through mobile agent technology. Although by carrying out the applicable research projects a considerable amount of such expertise has been acquired and organized, we have concluded that these ideas are not yet mature enough for practical application.

Network Sensing Technology

This item will be discussed in a separate report.

CONCLUSION

Yokogawa has declared the "Yokogawa ubiquitous initiative" toward the future, by consolidating and harmonizing its years of research and development results. With the Corporate Research and Development Headquarters at the vanguard, we are resolved to continue focusing our resources in multiple aspects on establishing a ubiquitous computing environment, which will be one of Yokogawa's mainstays in the future. Yokogawa looks forward to the active participation and involvement of other enterprises in the challenge of realizing the aforementioned strategies, and welcomes partnerships with distinguished enterprises and academic institutions ◆