ISSN 1349-3531

NICT NEWS

National Institute of Information and Communications Technology

2005
MAY
《No.350》

Innovative Communications Technology for Rapid Color Change

— Effective Use of Three Wave Elements (Amplitude, Frequency, and Phase) —

Tetsuya Kawanishi

Senior Researcher
Photonic Information Technology Group
Basic and Advanced Research Department

Joined the Communications Research Laboratory (currently NICT) in 1998. Mainly engaged in research on high-speed modulators, optical millimeter wave generation, and optical frequency control.

Introduction

Optical communications services are now affordable for home users, as often seen in TV commercials today, as optical data transmission technology becomes more and more common in daily life. With further progress toward the integration of broadcasting and communications through business alliances and cooperation, such as highly noted recently, we will undoubtedly see a sharp increase in the need for instantaneous exchange over the Internet of data of large sizes and motion pictures of increasingly higher quality. Research for the development of various optical communications technologies is now underway to address this formidable near-future demand. At the same time, remarkable progress has been made in the development of the wireless communications technologies used in mobile phones, wireless LAN, electronic commerce, and RFID tags. Although one would assume that light and radio waves are entirely different phenomena, these two things in fact share certain wave properties.

A wave is characterized by three elements: amplitude (intensity), frequency (color), and phase (timing). Communications systems perform data transmission by varying any of these elements in a process referred to as modulation. To date various methods of modulation have been subjects to study and development. For example, frequency modulation has been widely applied to wireless communications. However, in optical communications, research efforts have instead predominantly focused on amplitude and phase modulation, due to the inability of existing technologies to change optical frequencies (i.e., the colors of light) quickly and stably. To address this problem, NICT developed the world's first optical high-speed FSK (frequency shift keying) modulator, capitalizing on a unique device structure. This technology enables us to vary the intensity, color, and oscillation timing of light quickly and stably. In this article, I will describe the basic mechanism of the optical FSK modulator and discuss example research into a communications system adopting this technology.

Basic mechanism of optical FSK modulator

A change in the relative velocity of a light or sound wave translates into a change in its frequency. One of the most familiar examples of this phenomenon is seen in the change in pitch of an ambulance siren as the vehicle races toward the observer (higher), then away (lower). This phenomenon, known as the Doppler effect, occurs when the wave source is moving. The newly developed optical FSK modulator makes specific use of this phenomenon. The system has four phase modulators, each of which is capable of quickly changing the velocity of light waves. When this is done in a repeated manner, three light waves will be generated: a light wave of the original color, and light waves that are reddish or bluish relative to the original color. (In fact, there are only slight actual differences in color. Optical communications systems use infrared rays that are physically invisible, but in this article, I will use "red (or reddish)" and "blue (or bluish)" for convenience.) By selectively extracting the red or blue light wave from these three waves, chromatic light communications become possible.

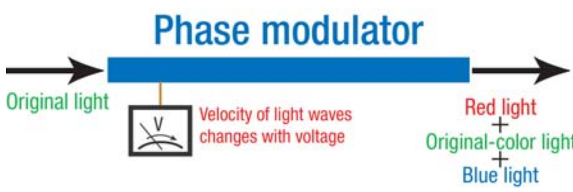
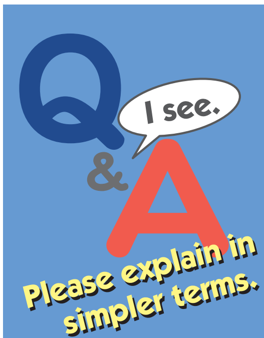


Figure 1: Basic Mechanism of optical phase modulator

The optical FSK modulator uses wave interference to eliminate unnecessary light waves. If the crests and troughs of one wave co-



Q What is the difference between the "blue" or "bluish" light described in this article and the new blue-light LED that made headlines a while ago?

A A major difference between the two lies in how the light is generated. An LED (a semiconductor device mainly made from gallium arsenide and gallium nitride) lights at a low voltage when electric current passes through it. On the other hand, the optical FSK modulator itself does not light, but instead makes the color of a laser light reddish or bluish relative to the original.

Q The optical FSK modulator is already commercially available, according to this article. How large is it?

A In one case, an optical FSK modulator made by a manufacturer under license from NICT is 130 mm (length) x 15 mm (width) x 10mm (thickness), a little bit larger than a pack of chewing gum. Its principal users include companies and research institutes dealing with optical communications components, high-precision optical measurement, and high-speed communications.

incide with those of another wave (in phase), these two waves intensify each other; if the crests of one wave are combined with the troughs of another wave (in opposite phase), these two waves cancel out each other.

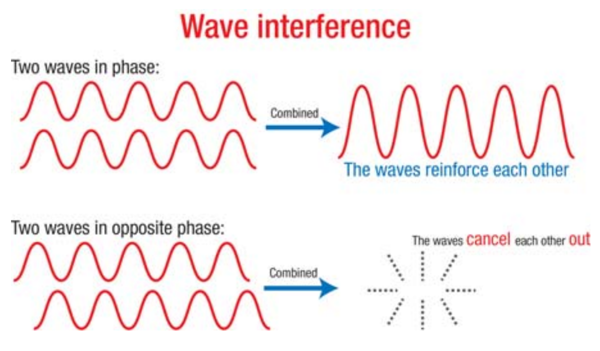


Figure 2: Wave interference (timing and output)

This phenomenon is referred to as wave interference. The optical FSK modulator system has four phase modulators that work in pairs. First, each pair of the phase modulators removes the light waves of the original color. Then, red and blue light waves are extracted from these two pairs and combined.

The system adjusts the phases so that the red light waves reinforce each other while the blue light waves cancel out each other , or vice versa. To adjust the phases, the FSK modulator applies a voltage to the section in which light waves from both pairs are combined. By quickly changing this voltage to shift the colors (i.e., the frequencies), we can generate optical FSK modulation signals at high speed.

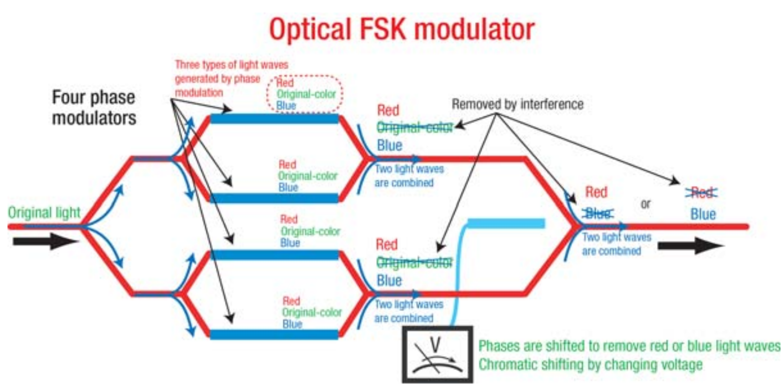


Figure 3: Making-up principle of optical FSK modulator

FSK modulation for flexible modification of label information

Packet communications systems are now in wide use on the Internet and in mobile phone services. Each packet holds data (the "payload") and a label. Label information (such as destination address) is used to select a transmission path. Packets are therefore analogous to parcel post packages carried to a destination based on the address information affixed to the surface. To increase processing speed in optical communications, we are researching a technique to convert label information only (not the payload) into electronic signals at the relay points where the transmission paths are selected. Accordingly, NICT has developed a technique to rewrite label information flexibly, applying optical FSK modulation to label processing, and has validated its principle experimentally. We reached a transmission speed of 10 Gbps, a worldwide first for a communications system based on FSK modulation. We also developed the world's first technique to convert optical FSK modulation signals into optical PSK modulation signals.

Conclusion

Through the development of an optical FSK modulator, we were the first to achieve high-speed optical frequency control, previously viewed as a particularly difficult challenge. We have already completed the corresponding technology transfer and the optical FSK modulator is now commercially available. By further increasing modulation speeds and developing various optical frequency control techniques, we hope to establish a technology to manipulate all three wave elements (amplitude, frequency, and phase) quickly and accurately, in the process helping to increase the speed and capacity of next-generation communications systems. Since this technology has significant potential in the measurement and environmental monitoring fields, we also intend to establish constituent technologies to provide secure and convenient infrastructural components based on this technology. This will be particularly helpful in the so-called ubiquitous era, in which we can expect to see the merger of information and communications technology, and environmental measurement technology..

Life & Tech-nology

● Future potential of variable colors of light

You will not directly see or come into contact with optical FSK modulators in daily life. However, optical FSK modulation will enable optical communications at speeds of approximately 10 terabits (10^{12} bits) per second, when combined with the wavelength multiplex technique (in which multiple optical signals are sent through a single fiber-optic line). This technology is thus expected to have a wide range of applications: in transmission and broadcasting of high-capacity data such as high-definition motion pictures, in optical communications components, in optical frequency measurement, in ultrahigh-speed and precision optical measurement based on gas-sensing*, and so on.

* A technique to detect physical quantities of gas. Gas concentrations and other properties are detected irradiating light that resonates with the gas molecules.

Development of Next-Generation Mobile Satellite Communications Systems

— Prototyping and Evaluation of Mobile Satellite Phones —

Naokazu Hamamoto

Research Supervisor
Wireless Communications Department

Joined the Radio Research Laboratory (currently NICT) in 1977. Since then, engaged in R&D projects in fixed and mobile satellite communications systems.

Introduction

Thanks to the remarkable development of terrestrial mobile phone networks in recent years, we can now talk on the phone almost anywhere as we go about our daily activities. However, it is not yet possible to use mobile phones in every corner of the country. For example, you cannot use mobile phones in remote mountain areas or on isolated islands lacking base stations for terrestrial mobile systems. In such areas, mobile satellite phones are useful. Using satellite-borne radio relay facilities, mobile satellite phone systems cover wide areas; further, these systems do not suffer from degradation of service in times of disaster, as is the case with terrestrial systems when base stations are damaged.

Currently, two types of mobile satellite phone systems are available: Iridium (US) and Globalstar (US), which use a multitude of low-earth-orbit satellites; and ACeS (Indonesia) and Thuraya (UAE), which use one or two Geo-stationary satellites. The former reduces the size of ground terminals by reducing the distance between the ground and satellites, while the latter reduces the size of these terminals by using large satellite-mounted reflector antennas 10 m or more in diameter. Although a Geo-stationary satellite system covers smaller areas compared to an orbital satellite system, service can be initiated with only one Geo-stationary satellite in position.

In Japan, the N-star satellites provide mobile satellite communications services, but these satellites lack sufficient capacity to handle mobile satellite phone services. However, satellite technologies are advancing rapidly and it is expected that future Japanese satellites will provide mobile satellite phone services. NICT has been working on prototyping and evaluating mobile satellite phones since fiscal 2002, collecting basic technical data in preparation for the development of actual satellite phones.

Overview of prototype mobile satellite phones

Photo 1 shows two prototypes of mobile satellite phones (prototype phone terminals) designed for use with a Geo-stationary satellite system. The handset type terminal can be used for voice communications in the same manner as terrestrial mobile phones (i.e., held to the user's ear). The PDA (Personal Digital Assistance)-type terminal is intended to add the functions of an electronic organizer or a pocket computer to the satellite phone and can be used in voice or data communications. In combination with a satellite dish approx. 50 cm in diameter, this PDA terminal can also serve as a base station. These prototype terminals operate on six AA or AAA batteries. Mobile satellite phones available in foreign countries are

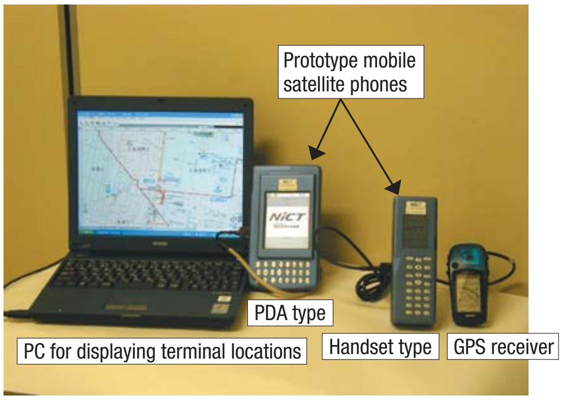


Photo 1: **Mobile satellite phones (handset and PDA types). These phones can send location information in combination with GPS receivers.**

Q & A
I see.
Please explain in simpler terms.

Q Would you explain briefly the "N-Star" commercial satellites communications services?

A N-Star is the name given to NTT's series of communications satellites. N-Star-a, launched in August 1995, is in a Geo-stationary orbit at longitude 132° east. N-Star-b, launched in February 1996, is in a Geo-stationary orbit at longitude 136° east. Their main mission specifications stipulate the high-speed broadband use of the Ka band (in a multi-beam design) to cover all of Japan (with the exception of remote islands); in terms of telephony and ISDN, the use of the Ka band (single-beam design) and the Ku band to cover the same area; in mobile communications, the use of C and S bands to cover all of Japan. These satellites have been in service for nearly ten years, and although they are designed to operate beyond the ten-year point, today's increasingly diverse communications demands have led to wide agreement that the time has come to replace them.

Q Would you briefly explain the Engineering Test Satellite VIII, scheduled to be launched next year?

A The Engineering Test Satellite (ETS)-VIII is a world-class Geo-stationary satellite in the three-ton range, designed to carry out various space communications research missions. ETS-VIII features the world's largest and most advanced deployable antenna reflectors. Each of the two antenna reflectors with a diameter of 13 m (one for transmission and the other for reception) consists of 14 hexagonal modules. The full length of the antenna reflectors is 37 m. Using a Geo-stationary orbit at 146° east and 2-GHz frequency bands, ETS-VIII is planned to provide voice and high-speed mobile packet communications services. The Japan Aerospace Exploration Agency (JAXA) is in charge of the development of ETS-VIII's main equipment and antenna reflectors as well as the launch of the satellite, and NICT is in charge of the development of satellite-borne communications equipment.

not very convenient to carry due to the inevitably large rod antennas on their bodies. We significantly enhanced the portability of our prototype phone terminals by incorporating small, flat patch antennas into their bodies. Further, using a prototype phone terminal in combination with a small commercial GPS receiver, it is possible to send its location information to a base station for PC map display. This function is intended for use in emergency communications in disaster-stricken areas, where mobile satellite phones are particularly useful. These prototype terminals use frequencies allocated to mobile satellite communications: 2.5 GHz (reception) and 2.65 GHz (transmission).

Evaluation of characteristics using the prototype phone terminal

To prevent attenuation of radio waves, it is presupposed that the mobile satellite phone be used at places where the satellite in communication is in view. However, the quality of communications is further affected by various additional factors, such as reflection or diffraction of radio waves due to structures or trees near the propagation path, the orientation of the terminals, and the presence of window panes. We evaluated the characteristics of a mobile satellite phone system using the prototype phone terminal, which is essential in preparation for actual use in the future.

For example, we measured fluctuations in intensity of received radio waves when the line of sight to the satellite was blocked from time to time by a building corner, as shown in Figure 1 (As a simulated satellite, we used a transmitter mounted on top of a 60-m tower). Even while the simulated satellite is completely visible, we observed fluctuation ranging over approximately 5 dB (maximum power level is about three times that of minimum power). This phenomenon must be taken into account in the system design and operation stages. According to our measurement results, if the system is designed with no margin (link margin) for the received power fluctuation, the communication becomes unstable within about 4 m from a building wall. Since transmitting power of the prototype terminal is 1 W (about twice the power required by terrestrial mobile phones), we must also assess the biological effects on the human head. In cooperation from the Koichi Ito Laboratory at the Chiba University Graduate School of Science and Technology, we measured the specific absorption rate (SAR) when a prototype terminal is held next to the human head (Photo 2). The results show that, under ordinary conditions of use, SAR is nearly 2 W/Kg, the upper permissible limit. However, it is possible to reduce this value to a safer level by adjusting the position of the antenna.

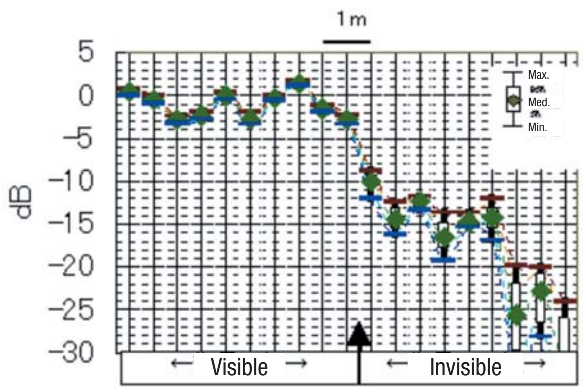


Figure 1: Fluctuation of received power as the line of sight to the satellite is irregularly blocked.

Photo 2: Appearance of the measurement of SAR using a human head phantom

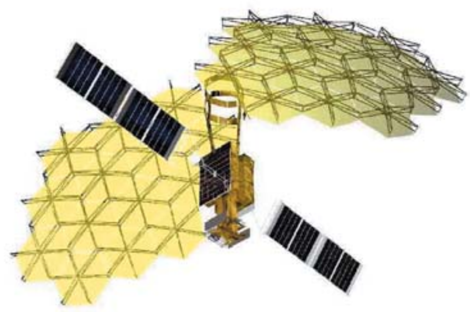


Figure 2: Appearance of the measurement of SAR using a human head phantom.

Conclusion

To establish next-generation mobile satellite communications technology, the launch of the Engineering Test Satellite VIII, equipped with large deployable antenna reflectors 13 m in diameter (Figure 2), is scheduled for next year in Japan. Our prototype mobile satellite phones are specifically designed for use with this satellite too. We hope that communications experiments for the evaluation of its operability in various fields such as disaster prevention and telemedicine will move us toward future use of mobile satellite phones.

Life & Technology

● Kashima Space Research Center, a "Mecca" of satellite communications research

NICT's Kashima Space Research Center plays a leading role in R&D of satellite communications technology such as the mobile satellite phone technology described in this article. The fruits of its R&D activities have been widely adopted throughout society: for example, the international TV broadcasting of the Tokyo Olympic Games via satellite in 1964, and the commercialization of communications satellite (CS) and broadcasting satellite (BS) services. With more than 40 years of tradition and a solid track record, the Kashima Space Research Center will continue to support the future growth of satellite communications.

NICT Intellectual Property Policy

Tatsuhito Otake
Director, Intellectual Property and Alliance Division
Strategic Planning Department

On January 18, 2005, we established the "National Institute of Information and Communications Technology Intellectual Property Policy" (referred to below as the "IP policy"), a comprehensive description of NICT's IP strategy (the policy text can be found at: http://www2.nict.go.jp/kk/e416/partner/policy.html).

This IP policy declares both internally and externally—i.e., to researchers and partner companies as well as to the public—that NICT intends to promote widespread use of its research results by cultivating intellectual property such as patents and returning the benefits of the property to society at large. The scope of this policy includes not only the creation and protection of intellectual property (as the name suggests), but also the use of this property—in other words, technology transfer.

The formulation of NICT's IP policy can be traced to Prime Minister Koizumi's statement in his policy speech of February 2002, "As a national goal, we will protect the results of research and other creative activities as intellectual property and use this property strategically to enhance the international competitiveness of Japanese industries." (Table 1)

March 2002	Strategy Council on Intellectual Property	Launched
July 2002	Intellectual Property Strategy Outline	Finalized
March 2003	Basic Law on Intellectual Property	Took effect
As above	Intellectual Property Strategy Headquarters	Set up
July 2003	Intellectual Property Promotion Plan	Finalized
May 2004	Intellectual Property Promotion Plan 2004	Finalized
June 2005	Intellectual Property Promotion Plan 2005	Finalized (planned)

Table 1: **Japan's progress toward a nation built on intellectual property**

The government then launched a "Strategy Council on Intellectual Property" to lay the groundwork for the creation of intellectual property through human resource development, research incentives, the establishment of technology licensing organizations (TLOs), and support for venture businesses. The council is now working on its "Intellectual Property Promotion Plan 2005," with the aim of making Japan a "nation built on intellectual property." Based on this annual plan, we formulated an appropriate IP policy for NICT.

NICT's IP policy consists of the following sections: (1) "Fundamental Principles" states both internally and externally NICT's intention to return the benefits of its research activities to society at large. (2) "Scope and Ownership of Intellectual Property" defines IP categories such as patents, know-how, and programs, and stipulates that all such intellectual properties belong to NICT. (3) "Organization and System" specifies a primary point of contact, the use of TLOs, and support for research such as seminars. (4) "Strategy to Obtain Patents" requires researchers to work on R&D with commercialization in mind and to file patent applications as early as possible. (5) "Technology Transfer through TLOs" describes the presentation of NICT's research results (including technologies) to companies and assessment of these companies' needs. (6) "NICT's Support for Technology Transfer" describes support for technology transfer activities such as the collection and provision of information for researchers and companies. (7) "Intellectual Property Licensing" specifies NICT's licensing policy and allocation of received royalties to research funds. (8) "Incentives to Inventors" requires that performance in technology transfer activities be incorporated into the evaluation of individual researchers. (9) "Information Management" stipulates confidentiality requirements, as an enormous amount of information is exchanged in collaborative activities with industry and academia. (10) "Miscellaneous" specifies support for venture businesses that will use NICT's research results and measures against violations of intellectual property rights.

For the past several years, NICT has been filing about 200 patent applications annually. Recently we have seen an increase in the number of license agreements on obtained patents. Through cooperation with our researchers in overall NICT in the implementation of our IP policy, we hope to contribute to society by promoting the use of NICT's intellectual property even further.

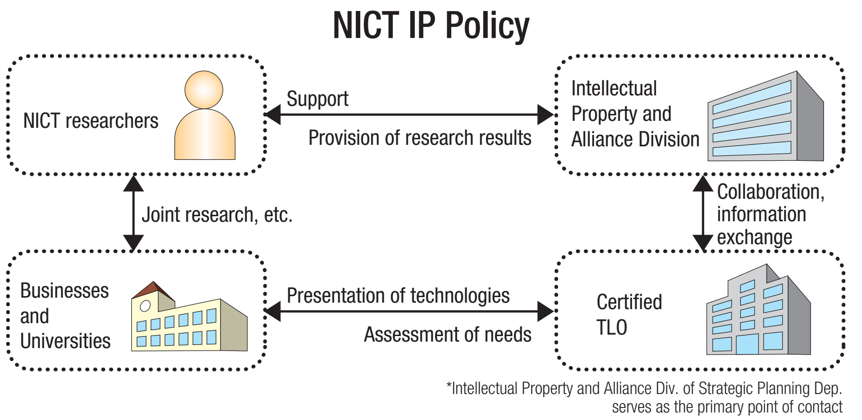


Figure: **Conceptual drawing of NICT IP Policy**

Kenichi Takizawa
Researcher, UWB Technology Group
Yokosuka Radio Communications Research Center, Wireless Communications Department

First Step toward Standardization Based on UWB Technology

— IEEE Adopts Proposal by NICT et al. as Baseline for Sensor Network Standard —

In March 2005, a wireless system standardization meeting (IEEE802.15.4a) took place in Atlanta, Georgia, in the United States and a standard proposal submitted by a joint team, including NICT (Table 1), was adopted as a baseline for the new standard. This represents the first step toward standardization based on ultra-wideband (UWB) wireless communications technology.

IEEE802.15.4a is one of the task groups set up under a standards committee of the Institute of Electrical and Electronic Engineers (IEEE); the group works on standardization of the physical layer (PHY) of wireless personal area networks (WPANs) intended to provide lower data rates, ultra-low power consumption, and high-precision ranging (Figure 1). IEEE802.15.4 finalized standardization of the physical layer of low-rate WPANs in May 2003, and IEE802.15.4a began in July 2003 as a task group responsible for the standardization of an alternative to the IEEE802.15.4 physical layer. This task group received 26 proposals by January 2005 and adopted the proposal by the group including NICT in March 2005.

Japan	NICT, Fujitsu, Oki Electric Industry, Hitachi, YRP Ubiquitous Networking Laboratory
Asia	17 organizations in total including Samsung, ETRI, Institute of Infocomm Research, and China UWB Forum
Europe	11 organizations in total including STMicroelectronics and France Telecom
North America	10 organizations in total including Freescale Semiconductor, Time Domain, and Staccato Communications

Table 1: Joint team members

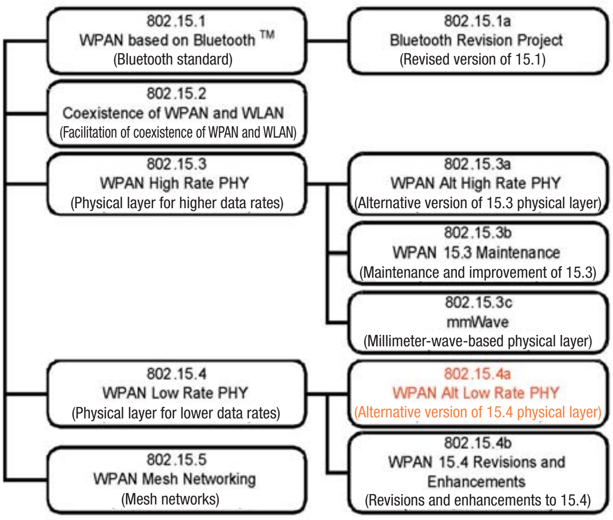


Figure 1: Composition of IEEE802.15

The adopted standard proposal is based on a direct sequence UWB wireless communications system promoted by NICT and other members of the joint team. This system offers features of both UWB wireless communications (high-precision ranging for distance measurement, lower power consumption, etc.) and of a direct sequence system (high tolerance to environments featuring numerous reflected waves received, minimal interference with other wireless systems, etc.). To achieve ultra-low power consumption, this standard proposal requires the use of a signal format that can be sent or received by terminals with a very simple receiver configuration. The aim of this requirement is to provide flexibility in power consumption and communications performance (transmission speed, error rates, etc.) so that the IEEE802.15.4a physical layer can be used by a greater number of applications.

This standard proposal intends to provide a physical layer (IEEE802.15.4a) that is as small as an SD memory card, operates for several months or longer on a single button battery, and achieves a data rate of several megabits per second (Mbps) at a distance of 30 m or less (Figure 2). Due to its ranging precision (less than several dozen centimeters), this layer is expected to find particular application in sensor networks. A sensor network connects sensing elements (for temperature, distance, humidity, etc.) and various terminals (home appliances, mobile devices, etc.). Depending on how the information is processed, sensor networks can be used for a variety of purposes: automatic control of home appliances, tracking and management of people and goods, and detection of intruders, to name a few. It is likely that these types of sensor networks, based on the IEEE802.15.4a standard, will be available within the next few years.

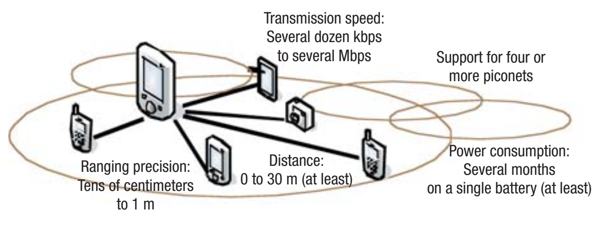


Figure 2: Technical requirements of IEEE802.15.4a

Information on IEEE802.15.4a standardization activities:
http://www.ieee802.org/15/pub/TG4a.html

Showing of DVD Images at Central America Joint Pavilion, EXPO 2005 Aichi Japan

Collaborative Research Management Division
Collaborative Research Management Department

On March 10, the Collaborative Research Management Department presented the Republic of Honduras (Mr. Carlos Manuel Zerón, the Honduran ambassador to Japan) with virtual-reality images of the Mayan ruins in Copan, converted to DVD format. These VR images were originally produced at NICT's Komaba SVR Research Center (Project Leader: Dr. Michitaka Hirose, Professor, University of Tokyo) with the collaboration of the Honduran Institute of Anthropology and History.

We prepared these images in response to a request from Honduran President Ricardo Maduro. When he visited Japan last May, he observed a VR theater and requested the exhibition of VR images at the Central America Joint Pavilion of the EXPO 2005 Aichi Japan opening this March.

After NICT Vice President Kato presented the DVD to Mr. Carlos Manuel Zerón, the Honduran ambassador to Japan, we viewed the images on-screen and discussed the images. This ceremony was also attended by Ms. Diana Patricia (Pavilion Director), Ueno (Executive Director of our department), and Mr. Takeuchi (Director, Research and Development Office, Ministry of Internal Affairs and Communications).

As part of the "Japan-Central America Year" events, a summit meeting including Japan and eight Central American countries will take place this summer in Japan. Mr. Zerón reported that President Maduro was eager to show the VR images of the Copan ruins to the seven other presidents during their visit to Japan, and Mr. Kato acceded to the request.

We chose to use the DVD format at the EXPO 2005 because it would be difficult to provide true VR images for operational and maintenance reasons. The images are now being shown using a 120" (2,438 mm x 1,829 mm) screen mounted on a side wall of the Tikal Temple I of Guatemala at the Central America Pavilion.

Note: Komaba SVR Research Center concluded its activities in March 2005 upon completion of its projects.

NICT NEWS
May 2005 No. 350

Published by:
Public Relations Division, General Affairs Department
National Institute of Information and Communications Technology

4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795 Japan
■ Tel: (042) 327-5392 ■ Fax: (042) 327-7587
■ e-mail: publicity@nict.go.jp ■ URL: http://www.nict.go.jp/

NICT NEWS at: http://www.nict.go.jp/overview/news/nict-news.html