Development of Wireless Home Gateways for Information Appliances
- Wireless Integrated Server at Home (WIS@H) -

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Networking with household appliances and personal computers scattered throughout a house provides a ubiquitous network environment. When taking into consideration convenience for users, it would be necessary to develop wireless network connection equipment to realize ubiquitous networks that use a broadband IP network as its backbone network and connect not only people with people but also people with products, as well as products with products. We are currently developing a wireless home gateway (Wireless Integrated Server at Home: WIS@H) based on the millimeter-wave Wireless Personal Area Network (WPAN) being studied by IEEE802.15.3c, which is intended for the wireless transmission of uncompressed high definition images. This paper will introduce activities undertaken by Oki Electric in the development of the WIS@H system and other related IEEE activities.

Need for Wireless Transmission of Uncompressed High Definition Images

High definition television sets (HDTV) are becoming popular as the solution for the ever-increasing demand for high-resolution images. The amount of information for such high definition images requires a transmission rate of approximately 1.5Gbit/second in order to receive the streaming of data, if the data is not compressed (encoded) or if the compressed data is decompressed (decoded). For this reason it was generally necessary to compress the image using formats, such as MPEG2, in order to utilize such high definition images in a home environment.

If image data could be handled without compression it would be possible to obtain effects such as those mentioned below:

- It would no longer be necessary for household appliances to have individual decoders (data decoding functions).
- It would become possible to configure networks that do not depend on the format of the source of content.
- Even if data errors occur during transmission block noises or noise in the immediately following images will not occur unlike when data is decompressed.

Household appliances that communicate by exchanging standard quality images using wireless transmissions in the house are already on the market and demand for the wireless transmission of high definition images is currently emerging as a new market demand. The wireless transmission of uncompressed high definition images is a part of this market demand trend and is expected to raise the satisfaction of the user to a higher level.

Configuration of WIS@H system

It is not possible to respond to the demand of wireless transmission for uncompressed high definition images by using wireless LAN (IEEE 802.11a/b/g), which is recently starting to be used with information appliances, due to transmission rate constraints. Furthermore, the maximum transmission rate with an Ultra Wide Band (UWB), which is currently under study for practical implementation, is considered to be approximately 1Gbit/second, therefore, this will also be unable to respond to the demand.

However, WIS@H can make this possible. A typical configuration example of the WIS@H system is shown in Figure 1. The WIS@H server manages the internal contents stored on hard disks, DVDs, etc., as well as various other contents in the home as well as their flows through the reception of broadcast waves and through internet connections in this configuration. Although images are viewed through their display on high definition television sets and high definition display equipment, the contents are distributed from the WIS@H server via a Set Top Box (STB).

Example block diagrams of a WIS@H server and STB internal functions are shown in Figure 2. The content management section manages (stores, searches, playbacks, distributes, etc.) internal devices of the server and also processes the flow of data through a home network including IP network traffic (home network and internet) and television broadcast signals.

The broadcast radio signal received by a television antenna, can be used, for example, to extract the contents with a tuner and transferred to a required location in some circumstances, whereas in other instances the broadcast radio signal may be forwarded as is to a piece of equipment (with a built-in tuner), depending on the instructions issued by the content management section.

An effective transmission rate of 1.5Gbit/second becomes necessary on an application level, when transmitting the contents of uncompressed high definition images for communications between the WIS@H server and the STB. The use of millimeter-wave communications for this segment is a feature of the WIS@H system. Since millimeter-wave communications can be used for communications between the WIS@H server and personal computers at the same time as well an

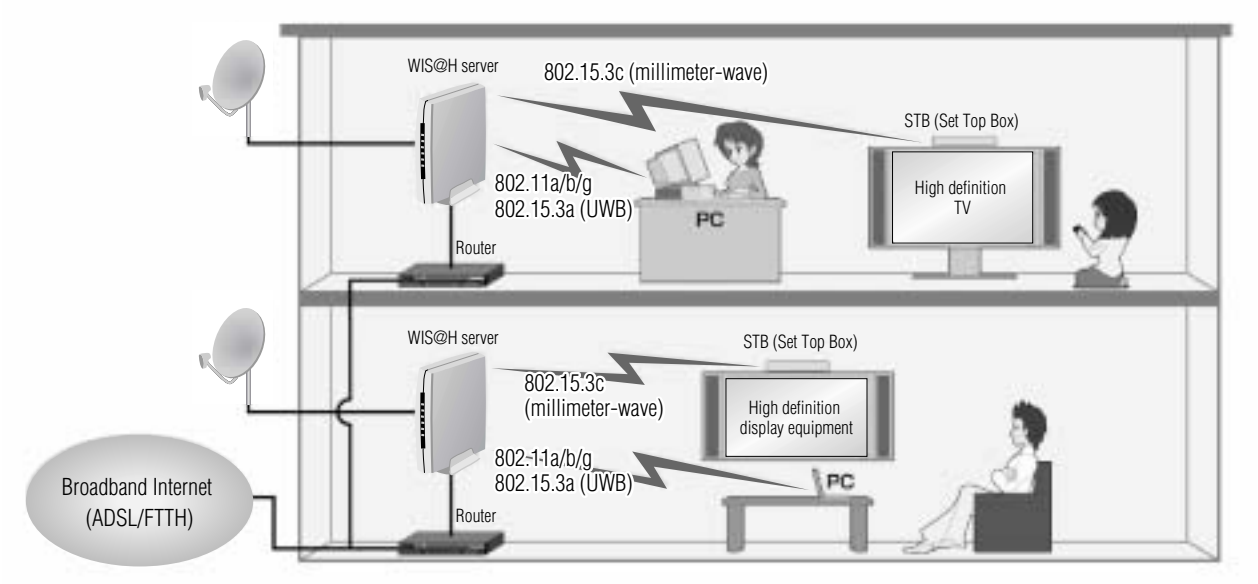


Fig. 1 Configuration example of WIS@H

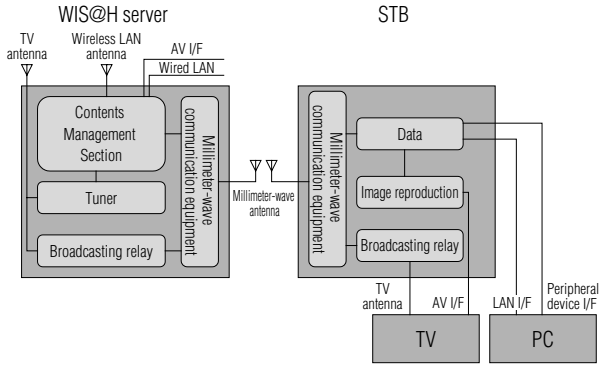


Fig. 2 WIS@H server and STB function block diagrams

operation, which responds to the use of a diverse range of information appliances in a home, becomes possible. On the other hand, the combined use of microwave communications is possible for communications between the WIS@H server and personal computers. Wireless Local Area Network (WLAN) of IEEE 802.11a/b/g as well as the WPAN (described later), such as the UWB, are included in such modes of communication. An appropriate selection of the communication mode between millimeter-wave communications and microwave communications is made by the WIS@H server, depending on the communication requirements (such as the communication rate) received from applications and the communication environment (communication distance, existence of obstacles, etc.).

Features of Millimeter-wave Communications

Communications using 60GHz frequency bands ranging from 59GHz to 66GHz are considered to be one of specified low-power communications bands in Japan and, just like wireless LAN, there is no need to obtain a license to operate them when they are used under specific conditions. This frequency band is suitable for communications at home for the reasons cited below and 60GHz frequency band millimeter-wave communications have been adopted for the WIS@H system for the same reasons.

- It is possible to utilize a wide range of frequency bands (restricted to 2.5GHz and lower by regulations) to conduct high-speed communications.
- Interference will not occur from communications using the 2.4GHz frequency band, which is already excessively used in homes, therefore, high quality communications that can be adopted for real-time applications are possible.
- Strong propagating-on-the-straight characteristics make it possible to conduct multiple independent communications in the same room.
- Privacy is easily protected since communications do not readily leak outside due to absorption decay caused by oxygen and decay caused by walls.

Although a portion of these aspects overlaps with those of optical wireless communications the following benefits exist, which are not available with optical wireless communications:

- Incidences of light entering from the outside will not have an impact.
- A high degree of communication control, such as point-to-multipoint communications, is possible.

Table 1 Comparison of home networks

Network classification	WPAN		WLAN	Wired LAN
Frequency band classification	millimeter-wave	microwave		-
IEEE standard	802.15.3c*	802.15.3a* (UWB)	802.11 a/b/g	802.3, etc.
Communication speed	◎	○	△	◎
Communication range	○	△	◎	- (cabling)
Non-line-of-site communications	△	○	◎	- (cabling)
QoS	◎	◎	○	○
Ad hoc characteristics	◎	◎	△	- (cabling)

* Standardization work being conducted.

When operating home networks, including WLAN and wired LAN, it is important to respond to the operating environment and sustain interoperability by putting the right thing in the right place. Features of the respective network classifications are shown in Table 1.

Trends of Standardization – Millimeter-wave WPAN

WPAN is a wireless communication network, which caters to communications between personal computers and peripheral devices, as well as communications between information appliances, within a range to the extent that can be attributed to an individual (approximately 10m or less in terms of distance). Standardization of this WPAN wireless system is being conducted by the Working Group 15 (WG15)[1] of the IEEE 802 and the IEEE 802.15.3 is already established as a standard for communications between multimedia equipment in 2003. The maximum transmission speed according to this standard, unfortunately, is 55Mbit/second, which is not adequate for responding to the ever-increasing traffic requirements and therefore, the development of a standard able to deliver transmission speeds considerably higher became necessary.

We proposed the standardization of WPAN that uses millimeter-wave to IEEE, in collaboration with the National Institute of Information and Communications Technology (NICT) in 2003, which led to the organization of an Interest Group (IG3c) by the WG15. This group has been engaged in activities under our chairmanship since the very start and was first reclassified as a Study Group (SG3c) and elevated to a Task Group (TG3c)[2] in March 2005. The group is conducting activities relating to the call for of specific standardization proposals. The IEEE is expected to decide on a standard relating to the millimeter-wave WPAN in fiscal 2007.

In the Japanese domestic scene on the other hand, the special interest group (SIG) involved in the millimeter-wave personal area communications, which was established as part of the Multimedia Mobile Access Forum (MMAC Forum) in October 2004, has been conducting studies geared for the domestic standardization in collaboration with activities being conducted in relation to the IEEE 802.15.3c. A decision was made to upgrade this group to a millimeter-wave WPAN Work Group in July 2005 and the group has since been conducting full-scale activities in their specified area.

Technology Development for Millimeter-wave WPAN

Technologies shown in Figure 3 are essential for the realization of compact millimeter-wave communications that can be built into home appliances able to assure the quality of service (QoS) in high-speed operations of wireless home gateways.

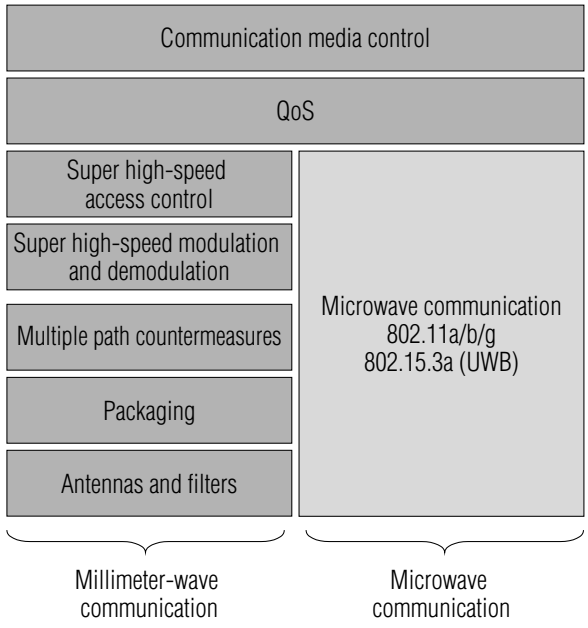


Fig. 3 Communication technologies for wireless home gateways

Antennas and Filters

In consideration for the integration of these devices into various home appliances, it is essential to create a

mechanism to miniaturize and lower the costs of these devices. Use of materials with low losses and highly precise machining processes are the keys for such a mechanism.

Packaging

In terms of high frequency and high-speed transmissions, it will be necessary to develop high power amplifiers and systems that do not require high quality oscillators (low phase-noise and high frequency stability).

Furthermore, in terms of miniaturization and to lower costs, it is essential to have a compact single-chip modularization technology as well as a packaging technology.

Multiple Path Countermeasures

A multiple path environment has a large impact particularly on high-speed communications indoors, making it essential to develop antenna technologies and modulation technologies, such as the Orthogonal Frequency Division Multiplexing (OFDM), as countermeasures.

Super High-Speed Modulation, Demodulation and Super High-Speed Access Control

It is necessary to develop a method that enables the acceleration of speed as well as a single-chip device or a high-density mounting technology.

QoS

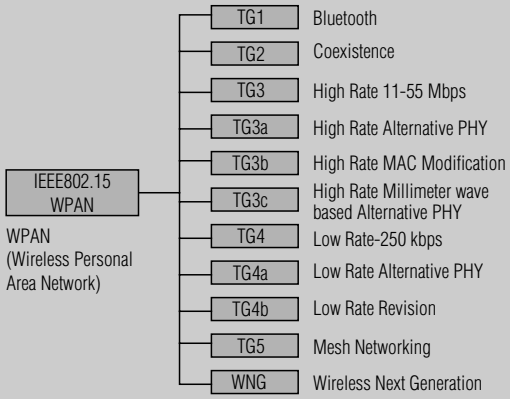
Since the 802.15.3 is a WPAN standard for real-time transmissions, which only allows for small delays in some cases, such as video transmissions, the Time Division Multiple Access (TDMA) has been adopted for the purpose of using a method of pseudo-static channel time division. No specific method of allocation, however, has been defined in the standard. It is important to develop an algorithm that can facilitate flexible allocations that respond to the scenario of communication usage in the home.

Communication Media Control

It is also important to select appropriate communication media suitable for the communication requirements of applications and the communication environment, as well as develop a technology that can sustain the quality level of communications by complementing these media, one with the other, as required.

TIPS [WPAN standardization by IEEE 802.15]

Other than the 802.15.3, which has been mentioned in this paper, the WG15 has completed standardizations for the 802.15.1 (Bluetooth) and 802.15.4 (ZigBee™*1)), while work is currently ongoing for the standardization of communications using the UWB. Furthermore, a group (WNG) organized to discuss the next generation WPAN has started their activities.



*1) ZigBee is a trademark of Koninklijke Philips Electronics N.V.

Conclusion

We aim to make a ubiquitous network environment for information appliances in the home by making the WIS@H system available to users as early as possible and we will continue to strongly promote the WPAN standardization, while developing and offering proposals relating to optimum wireless technologies for high definition image transmissions in the home.

References

1) http://grouper.ieee.org/groups/802/15/
2) http://www.ieee802.org/15/pub/TG3c.html

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