Device Connectivity Technologies Using Short-distance Wireless Communications

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Seamless device connectivity in a multi-network environment is an essential technology for achieving a Human-Centric Intelligent Society as proposed by Fujitsu. In particular, device connectivity enabled by short-distance wireless communication technologies such as Wi-Fi, Bluetooth, and near field communication (NFC) can provide users with ideal services regardless of place or circumstances in the fields of entertainment, health, and communications. For example, there is audio-visual device connectivity for playing content stored on a smartphone on a TV and for outputting content stored on a recorder to a TV by smartphone control. There is also in-vehicle device connectivity for controlling hands-free calling and audio playback from an in-vehicle device, and there is healthcare device connectivity for gathering up data obtained from measurement devices, storing that data on network servers, and using the data for medical care, physical fitness, etc. This paper provides an overview of short-distance wireless communication technologies and describes Fujitsu's approach to connecting smartphones to audio-visual devices, in-vehicle devices, and healthcare devices as an application of those technologies.

1. Introduction

The smartphone market began to expand rapidly in 2010 and is still growing today. Smartphones enable users to make calls, send and receive e-mail, browse the Internet, and download and execute applications the same as feature phones. But unlike feature phones, smartphones allow for the creation of applications in conjunction with the operating system (OS) and a vendor-provided software development kit (SDK) and come equipped with software developed by OS vendors, application development companies, and device makers. Furthermore, in addition to communication technologies supporting the 3rd- and 4th-generation (3G/4G) networks provided by mobile phone operators, smartphones incorporate Wi-Fi and other forms of short-distance wireless communication technologies. These short-distance wireless communication capabilities give users more freedom in the way they communicate and enhance overall device usability.

Smartphones may also be equipped with an open platform, and those that are require technologies that conform to global industry standards or international standards in contrast to proprietary specifications dictated by communications operators (i.e., the "Galapagos syndrome" [Galapagos syndrome describes the phenomenon of a product or a society evolving in isolation from globalization; it refers to a similar phenomenon observed in the Galápagos Islands where plants and animals evolved in isolation from other locations.]) as in the case of feature phones. Given this distinctive feature of smartphones, it is essential that a device maker determine, when developing a smartphone product, what functions and features will appeal to users and thus become a selling point.

In this paper, we first describe three common types of short-distance wireless communication technologies:

1) Wi-Fi (wireless LAN), Digital Living Network Alliance (DLNA)
2) Bluetooth, Bluetooth low energy (BLE)
3) Near field communication (NFC)

We then introduce "device connectivity" functions, services, and applications that use these technologies. Finally, we touch upon services and applications that we envision for smartphones of the future in step with the evolution of short-distance wireless communication technologies.

2. Wi-Fi, DLNA

The DLNA[1] is an industry organization that publishes guidelines covering basic protocols and media formats for achieving interoperability among household electrical appliances, portable devices, and personal computers (including peripheral devices) in a home network for the purpose of sharing content.

As shown in **Figure 1**, the DLNA guidelines specify Universal Plug and Play (UPnP) for device discovery and content selection and display, Hypertext Transfer Protocol (HTTP) and Real-time Transport Protocol (RTP) for media transfer, Transmission Control Protocol/ Internet Protocol (TCP/IP) for network connectivity, and Digital Transmission Content Protection over Internet Protocol (DTCP-IP)[2] for digital rights management (DRM). DTCP-IP has functions for device authentication and key sharing, copy control, content encryption, and removal of unauthorized devices. The DTCP standard was enhanced in 2011 to include new specifications for remote access and media formats and a mechanism for transferring and controlling the copy count. With these enhancements, a user can access copyrighted video content on the user's home media server from outside the home and play that content on his or her smartphone and can, depending on the copy count, transfer copyrighted content on the smartphone to another smartphone.

The DLNA guidelines also stipulate Wi-Fi to be the standard wireless interface for device interoperability. Of particular importance here is 802.11n wireless communications technology, which supports high-speed communications for the playback of high-definition video requiring transfer speeds of 6 Mb/s or greater.

These guidelines also establish device classes that specify the functional capabilities of different types of devices. Device classes include Digital Media Server (DMS) specifying server functions for transferring content-related information and the content itself, Digital Media Player (DMP) specifying player functions for performing server/content searches and playing back content, Digital Media Renderer (DMR) specifying the rendering function for simply playing back content, and Digital Media Controller (DMC) specifying the controller function for issuing instructions so that content on a DMS is played back by a DMR. The guidelines also specify the connection procedures between these classes.

Applications	Servers, players, renderers, controllers
Copyright protection (DRM)	DTCP-IP
Media formats	• MPEG-2, H.264 • Advanced Audio Coding, etc.
Device discovery, content selection/display	UPnP
Media transfer protocols	HTTP, RTP
Network connectivity (to match text)	TCP/IP
Physical-link/ data-link protocol	Wireless LAN (802.11g/n)

Figure 1
Configuration of basic DLNA model.

3. Bluetooth, Bluetooth low energy

The Bluetooth wireless communication standard, which uses the 2.4-GHz band, is presently transitioning to next-generation versions. Version 3.0 High Speed (Bluetooth 3.0 + HS)[3] features higher throughput (up to 24 Mb/s), and Version 4.0 (Bluetooth 4.0)[4] features the BLE function, which significantly reduces power consumption.

Bluetooth 3.0 includes "enhanced power control," which prevents brief disconnections and eliminates the problem of headset link loss. It also supports "unicast connectionless data," which simplifies the negotiation process between devices. This function reduces the time it takes to establish a connection and begin using the device. Bluetooth 3.0 eliminates several weak points and improves reliability and usability. With the +HS extension, it supports data transfer up to 24 Mb/s (symmetric communications), which is significantly greater than supported speeds.

Bluetooth 4.0, though capable of communication speeds up to only 1 Mb/s, significantly saves on power by adding the BLE function, in which transmit/receive data packets are extremely short (8–27 octets). This packet-data specification is aimed at communications with sensors embedded in household electrical appliances and other equipment. Bluetooth 4.0 therefore targets a range of products including home electronics and personal electronic devices (such as wristwatches) that had hitherto not been targeted for wireless communications.

Fujitsu was among the first to implement a profile supporting the BLE function by providing it in its 2012 summer handset models.

4. NFC

The NFC[5] short-distance wireless communication standard uses the 13.56-MHz band. With NFC, simply bringing two devices close to each other (within about 10 cm) activates communications.

NFC incorporates a variety of specifications, including Japan's original FeliCa standard and the ISO/IEC 14443 (Type A and Type B) international standard. These specifications have been incorporated in contactless smartcards and smartphones for reading and writing data and exchanging information, which are useful functions for driver's licenses, passports, card-type digital money, etc. NFC is also used as a means of exchanging the data required for Bluetooth secure simple pairing (SSP) and authentication in the Wi-Fi Protected Setup standard. It can thus be used to create services such as personal authentication and mobile payments.

5. Device connectivity technologies

5.1 Audio-visual device connectivity

Smartphones, in addition to being mobile phones, feature large, high-resolution screens, enabling users to enjoy high-quality video content with a personal device in either indoor or outdoor settings. The smartphone is increasingly taking on the role of a multimedia player.

At the same time, the complete transition to digital broadcasting (i.e., the termination of analog broadcasting) in Japan in July 2011 has led to a rapid spread of digital home appliances having connectivity functions specified by DLNA or the High-Definition Multimedia Interface (HDMI), enabling connection with a home network. In line with this trend, Fujitsu has concentrated its efforts on establishing connectivity between smartphones and audio-visual devices such as TVs and recorders and was quick to equip its smartphones with TV/recorder device-connectivity functions (**Figure 2**). These functions make it possible to transfer high-definition (HD)-quality video content between two devices for playback, to view content currently being received by a device on another device, and to save transferred content for later viewing.

In this scenario, TV/recorder equipment connects to a home network (**Figure 3**), and a smartphone accesses this equipment via Wi-Fi. Implementation of this function requires that three technical issues be

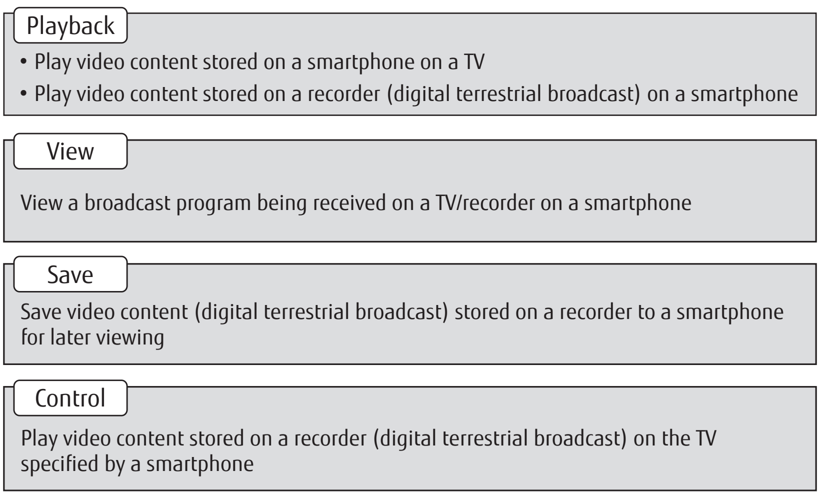

Figure 2
Connecting with TV/recorder equipment (functions).

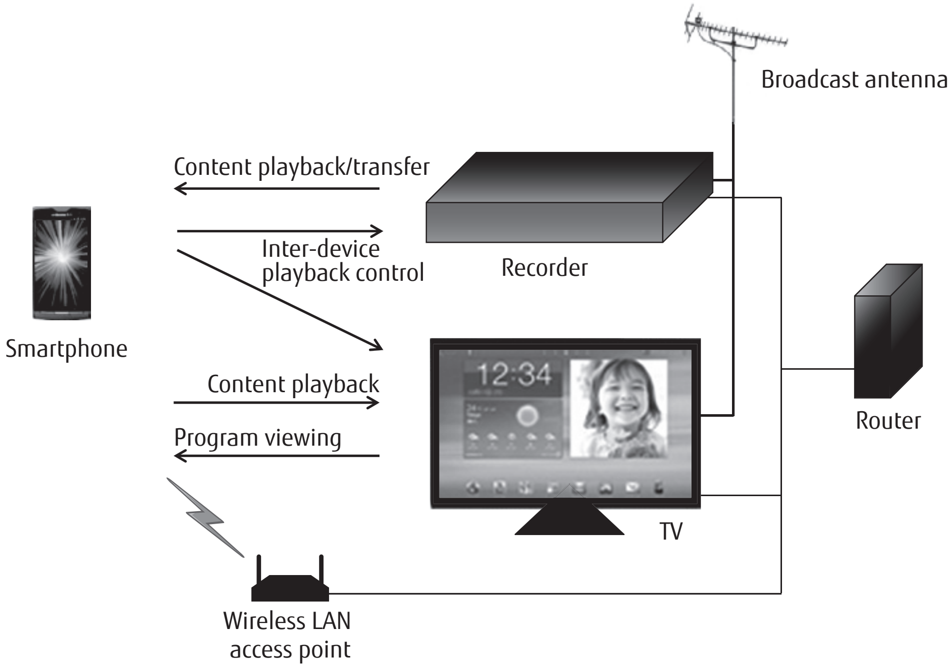

Figure 3
Connecting with TV/recorder equipment (device configuration).

addressed.

1) Ensuring compatibility

Content stored on a device targeted for connection must be compatible for playback on the accessing device, and the two devices must be compatible enough to establish a connection. In general, connectivity and playback can be achieved provided that the devices in question conform to certain standards. However, the availability of many optional standards and the existence of proprietary functional extensions that depend on the device maker or model can make it difficult to ensure 100% compatibility. For this reason, Fujitsu is continuously testing devices for compatibility and adding functions whenever a new compatibility issue arises.

2) Improving video quality while saving power

A number of important factors come into play when attempting to improve the quality of video playback. These include maintaining the playback frame rate, synchronizing video and audio playback, controlling network jitter, and simply improving picture and audio quality. For example, if the processing clock of the CPU was speeded up to support the playback of computationally heavy HD video, current would be consumed in a wasteful manner for some types of video content. Similarly, if the screen's backlight was always made brighter to improve visibility in a bright environment, current consumption would naturally increase, thereby shortening playback time. To deal effectively with these problems, it is imperative in the development of smartphones that a balance be achieved between improving video quality and reducing power consumption.

Fujitsu's approach to improving video quality while saving power in smartphones is to adaptively control the CPU clock and backlight brightness on the basis of the attributes of the video content and information obtained from sensors.

3) Improving usability

One problem when trying to improve usability is the tendency to assume some technical knowledge with regard to Wi-Fi or DLNA on the part of the user for the tasks of configuring device connectivity and specifying particular devices or content. In other words, it is difficult to design intuitive operations for these tasks. Another problem is that the user interface for inputting settings differs from one TV/recorder device to another, which prevents connectivity from being established through the use of uniform settings and/or functions on the smartphone side. These problems present obstacles to improving usability.

To address these problems and improve usability, Fujitsu is working to improve the user interface in smartphone applications and to make it easier to use TV/recorder equipment through joint product development with TV/recorder makers.

5.2 In-vehicle device connectivity

Connectivity functions between a smartphone and an in-vehicle device such as a car navigation system include a voice-calling function (hands-free calling) that enables calls to be made or received via the in-vehicle device (**Figure 4**). They also include a function for displaying a list of the smartphone's contents on the in-vehicle device and, for example, playing a song selected by the user on that device. To ensure mutual connectivity between a smartphone and in-vehicle device, it is important that those devices incorporate the specifications established by the Bluetooth Special Interest Group (SIG). However, in the above hands-free call control and music playback control, specifications for processing time on the in-vehicle-device side, for example, may not be stipulated in detail, which may cause timeouts on the smartphone side and prevent the connection from being maintained. To minimize the effect of this problem, Fujitsu conducts connectivity tests for new functions at an early stage and seeks to solve any connectivity problems as soon as possible. When appropriate, Fujitsu works to transform a connectivity solution into an industry standard with the aim of maintaining a technological edge in this field.

Looking forward, we will be studying the equipping of in-vehicle devices with BLE as well as NFC and Wi-Fi display technologies. In this regard, we envision the ultra-low power consumption of BLE to be useful in collecting data from the vehicle sensors that gather up all sorts of information on the vehicle. As for NFC, we expect it to be used for achieving personalization as in seat adjustment, door unlocking, and music to be played. When a person is about to get into his or her car, for example, NFC can be used to simultaneously unlock the door and read out information identifying that person as the driver. At the same time, the car's seats can be automatically adjusted to a previously registered setting, and music matching the driver's preferences can be prepared for playback at the usual volume. Additionally, pairing between in-vehicle devices and a smartphone can be easily set up through SSP using NFC. Finally, we are studying Wi-Fi display technology not only for mirroring a smartphone's display or video contents on a TV but also for notifying the smartphone of requests made through user operations on the TV and feeding back such requests to content/playback processing on the smartphone.

5.3 Healthcare device connectivity

The Continua Health Alliance develops connectivity guidelines[6] for achieving a health management ecosystem that obtains data from sensor devices using communication technologies like USB and Bluetooth, stores that data on network servers via smartphones or personal computers using the data description format specified in IEEE 1394, and applies that data for medical care, physical fitness, and other purposes. Fujitsu was the first smartphone maker in Japan to obtain Continua certification for smartphone products. Current Fujitsu smartphones are capable of handling data from weighing machines and blood pressure monitors (**Figure 5**).

Continua is studying the use of NFC to make it

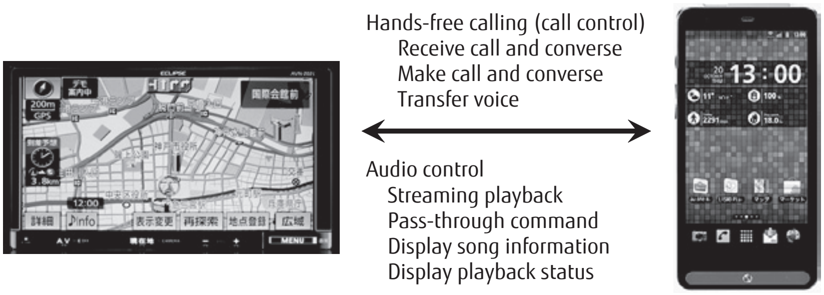

Figure 4
Configuration of in-vehicle device connectivity.

even easier to extract data from sensor devices and a system for checking a person's vital signs by continuously collecting data using BLE in a permanently connected state. It is also looking at health services that provide feedback to users, such as selecting a running course on the basis of the user's current state of health using data stored on network servers, and at an application for providing remote medical care from a major hospital using vital-signs data stored on a server.

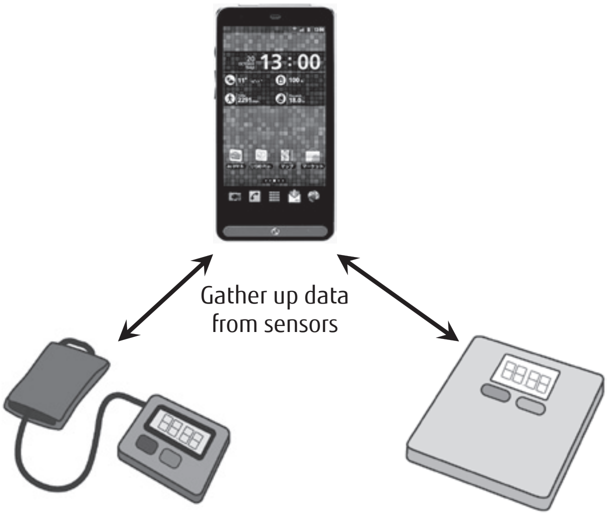

Figure 5
Configuration of healthcare device connectivity.

Healthcare device connectivity is a service that can be used on a variety of levels, from young people who are serious about keeping in shape to elderly people who need to check their vital signs on a regular basis. It is also a field that Fujitsu is committed to developing as part of its promotion of a Human-Centric Intelligent Society.

In this endeavor, improving usability by simplifying connection operations, shortening connection time, and reducing power consumption is a major technical issue that needs to be addressed.

5.4 Future outlook for device connectivity

Fujitsu plans to monitor technological trends closely and to take the lead in exploiting new technologies with the aim of creating a Human-Centric Intelligent Society device connectivity in which users can seamlessly access devices and obtain information in accordance with their behavior, circumstances, and location (**Figure 6**).

6. Conclusion

Looking forward, we can expect short-distance wireless communication technologies such as Wi-Fi (wireless LAN), Bluetooth, and NFC to feature increasingly faster data-transfer speeds and increasingly lower levels of power consumption while operating in a

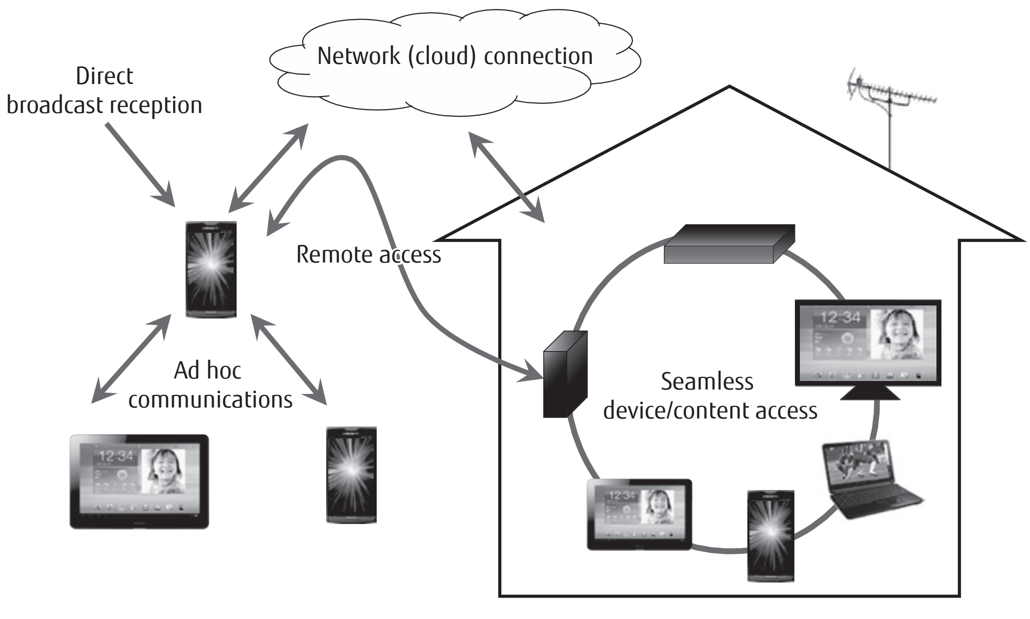

Figure 6
World of Human-Centric Intelligent Society device connectivity.

multi-network environment. We predict that functions and services using these technologies will be proposed and that standardization essential to achieving these functions and services will progress. With customer needs in mind, Fujitsu is committed to formulating and proposing industry standards and maintaining its technological leadership.

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