MULTIMEDIA DELIVERY IN WIRELESS PERSONAL AREA NETWORKS

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Abstract

This paper discusses the Wireless Area Networks (WPANs) and its QoS support for multimedia delivery purpose. The WPAN framework and its specifications will be introduced before analysing the current QoS support of some standardized technologies. After that, the working groups will be analysed, focused on QoS aspects; and finally, some other QoS technologies for multimedia delivery which is implemented at application layers will be briefly introduced.

Keywords: Bluetooth, multimedia, WPAN, QoS

1. Introduction

The growth of portable electronic product has created a need in the ability devices to communicate or share information. There is no doubt that consumer has accepted the wireless technology. The introduction of wireless communication has changed human's lives dramatically. The ability to communicate anywhere and anytime can increase the quality of lives and the productivity for business. The IEEE 802 has wireless standard for this communication which is IEEE 802.15 for Wireless Personal Area Network (WPAN). The IEEE 802.15 targets the WPAN and is aim for low power and cost, small network and short distance. Bluetooth came as the first technology that claims the devices to operate in Personal Operating Space (POS). However, it has limitation to the effective data transfer rate of 500~700 Kbps. Then IEEE 802.15.3 introduced as high data rate personal area networking with up to 55Mbps. IEEE 802.15.4 standard for WPAN to build up a set of high level communication protocols using small, low power digital radios so that the applications would be cheaper, smaller, and simpler than Bluetooth and other current standards in WPAN.
The primary goal of designing the future wireless network is to support important future applications. Multimedia communication applications have come forward to be the most important future applications [6]. A multimedia communication is the combination different information types (video, images, audio and text) with real-time or non real-time delivery requirements. Since multimedia application is the most important form of application, it has the most characteristic and networking requirements.

2. WPAN architectures and multimedia applications

2.1 Bluetooth architecture

The general structure of a Bluetooth system consists of a microprocessor that handles all the baseband specifications and several software layers that structure the data so that it may be sent properly over a Bluetooth link. The frequency hopped spread spectrum (FHSS) technique is used in the Bluetooth standard as the medium access control protocol.

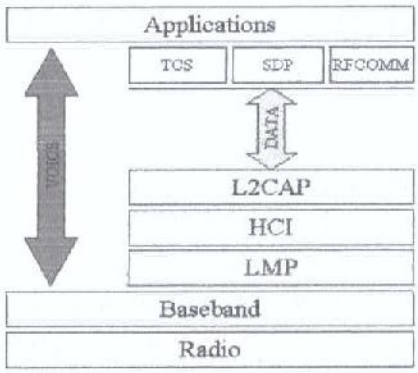

Figure 1. Bluetooth Architecture

2.2 802.15 framework

There are many specifications in the 802.15 (WPAN) frameworks. Some of them has been standardized and some of them are just the propose architectures. The working groups which are developing standards for each specification will be discussed later in this paper; at this time, the hierarchical chart of WPAN framework is described below:

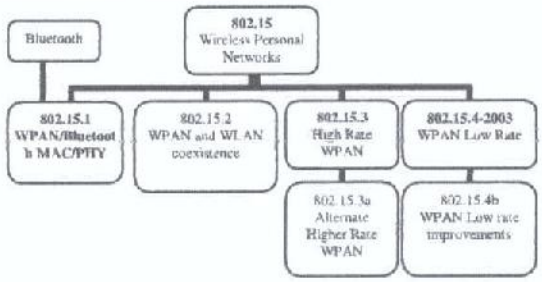

Figure 2. WPAN Framework

802.15.1: This specification adopted the MAC and PHY layers of Bluetooth 1.1 which is readily having the exponential applications and devices as well as profiles. The Bluetooth standard is divided into some small classes:

- Class 1 (100 mW) has the longest range at up to 100m.
- Class 2 (2.5 mW) is most common and allows a quoted transmission distance of 10m.
- Class 3 (1 mW) is the rarest and allows transmission of 10cm, with a maximum of 1m.

802.15.3: This specification has been standardized providing high data rates, low power, low cost for multimedia applications.

- Data Rates: 11, 22, 33, 44, & 55 Mbps.
- Quality of Service isochronous protocol
- Ad hoc peer-to-peer networking
- Security
- Low power consumption
- Low cost
- Designed to meet the demanding requirements of multimedia applications.

802.15.4-2003: This specification has been standardized providing high data rates, low power, low cost for multimedia applications.

- Support for critical latency devices, such as joysticks.
- CSMA-CA channel access.
- Automatic network establishment by the coordinator.
- Fully handshaked protocol for transfer reliability.
- Power management to ensure low power consumption.

2.3 Multimedia Application

Wireless Personal Area Network devices has a short range(~10 meter) and also has data transfer rate of up to 55Mb/s, which is to be increased in the future. The dynamic topology of the networks allows the portable devices to leave and enter networks within a short time (~1 second). Few applications using Bluetooth application are mentioned below [4].

- In the office

Cordless connection to peripherals such as notebook, printer, PDA, desktop computer, fax machine, mouse, and keyboard - all can be instantly connected via Bluetooth technology. Next, Bluetooth transforms meetings and conferences

- On the move

Cordless connection to mobile peripherals using Bluetooth technology for instant connection between a notebooks PC or mobile printer and sending an email without even taking the mobile phone out of our pocket is one of the example. Surf the Internet with Bluetooth technology on board, it is easy to surf the Internet,

2.4 Multimedia Application Requirement

Different multimedia applications have different QoS requirements in terms of the QoS parameters which will be mentioned later. Users usually can determine the applications' QoS requirements by investigating the factors that influence the application requirements. The factors are application interactivity level Interactive and noninteractive applications. An interactive application involves action-reaction, request-response or exchange of information between people-to-people, people-to-machine or machine-to-machine. The delay requirements can be determined by the depth of interactivity. For example, voice application which involve human interaction, have strict delay requirements, while video streaming playback which involve less interaction, do not require real-time response. Another factor is user or Application characteristics which are delay tolerance and intolerance, adaptive and nonadaptive characteristic. Tolerance and intolerance describe the users' sensitivity to change in QoS parameter values, while adaptive and nonadaptive characteristic describe mostly the mechanism request by the application to adapt to QoS degradation. Then Application criticality: Mission-critical and non-mission-critical applications which describe the importance of application usage which determines the strictness of the QoS requirements also one of the factor that influence the application requirements

3. Quality of Service (QoS)

There is growing need to meet and provide support for multimedia delivery within endsystems. This will enable the development of a variety of applications such as interactive video, virtual shopping mall, news services and many more. An important aspect of running these applications is that the requirement of quality-of-service (QoS) guarantee for transfer and processing the data.

3.1 QoS Parameters

Throughput or bandwidth refers to the data rate which is generated by application. Throughput measured by the number of bits per second or called bit rate or bandwidth. The requirement of throughput depends on application characteristic. Users can select video quality by adjusting the frame size or rate, color depth and compression. Real time applications require a certain period of time on the delivery of information between the sources to the destination. The longer delay may cause data missing which can reduces the quality of the application. Then there is delay jitter that refers to the variation in the delay which is initiated by the components along the communication path. Delay variations are happened because each packet in the network travels through different paths and the network conditions of the packet can be different. Next, packet loss or error rate can be caused by network congestion and bit errors that occur because of noisy communication channel.

3.2 QoS in WPAN

The QoS mechanisms in Bluetooth are defined as follow:

- Classification

It is defined at the Logical Link Control and Adaptation Protocol (L2CAP) layer. A classifier will use the channel identifier to identify the packets and send them to appropriate queue. Bluetooth does not define the classification of voice packets which do not pass through the L2CAP layer.

- Channel Access

Bluetooth uses collision-free channel access which can provide QoS support for applications with strict QoS requirements.

- Packet Scheduling

There are two packet scheduling schemes: Intrastation packet scheduling which SCO packets are transmitted in the reserved time slot and ACL packets are transmitted into the rest of time slot, and Interstation packet scheduling which for the SCO, the slave is allowed to transmit in the reserved time or for the ACL, in response to a POLL message.

- QoS signalling

There are two levels of QoS signalling: L2CAP QoS signalling which exchanges the QoS information between L2CAP of master and slave, and LM QoS signalling which are used for the request and response of the polling interval of the ACL link.

3.3 IEEE 802.15.3 QoS Support

IEEE 802.15.3 supports both synchronous and asynchronous data services. An 802.15.3 networks consist a collection of devices (DEVs). One of the DEV also performs as a piconet coordinator (PNC). Channel access mechanism will be focused in IEEE 802.15.3 Medium Access Control (MAC) which has two modes of operation: Contention Access Period (CAP) and Contention-Free Period (CFP).

- QoS in Contention Access Period

A DEV accesses the channel and competes for bandwidth with other DEVs using the CSMA/CD mechanism. Therefore, CAP only provides best effort service. CAP is suitable for asynchronous data services.

- QoS in Contention-Free Period

The QoS support at this mode is based on the use of TDMA (Time Division Multiple Access) architecture with the provision of guaranteed time slots (GTSs). The PNC has full authority to allow the DEV to access the channel in a specific time for a specific duration. CFP provides certain QoS assurances in bandwidth and delay which support high-bandwidth asynchronous data and isochronous data.

3.4 IEEE 802.15.4 QoS Support

There are three traffic types which are pictured by IEEE 802.15.4:

- Periodic data: the traffic is generated in a regular fashion. The amount of data is defined by the application itself and mostly is low data rate (example, sensor traffic)
- Intermittent data: the traffic is generated once in a while, not continuously. The data generation is activated by external stimulus. An example is the light switch traffic
- Repetitive low-latency data: the traffic is generated continuously and requires low-latency data transfer (example, the mouse device traffic)

IEEE 802.15.4 has two channel access schemes which are CSMA/CD and TDMA. CSMA/CA adequately supports periodic and intermittent data, while TDMA is applied to repetitive low latency data.

4. Bluetooth security

Similar to 802.11 standards, Bluetooth does not provide end-to-end security but only link authentication and encryption. Three main security services are offered:

- Authentication
- Confidentiality
- Authorization

Bluetooth operates in 3 different security modes suitable for different situations and applications.

- Security Mode 1: Non-secure
- Security Mode 2: Service-Level enforced Security mode.
- Security Mode 3: Link-level enforced security mode.

5. Results

At the upper layers, QoS is usually implemented using network-aware applications (*adaptive QoS system)* for multimedia delivery. With these applications, the quality of multimedia delivery is controlled to gain as much quality as possible based on the characteristics of the multimedia application and the current status of connection.

Network-awareness, network-adaptation multimedia delivery: This technology considers the available bandwidth to determine the best compression ratio of the multimedia streams. This is implemented not only at the time the multimedia streams are commenced to be streamed but also during the streaming time. If the bandwidth fluctuates (maybe because of interference), the application will change the compression ratio on the fly to reduce the size of streams in order to keep the quality of the delivering streams. Apart from the compression ratio, the sampling rates (number of frames transmitted per second) of the audiovisual streams could be adaptable on the fly based on network's parameters and the required quality of service. Next, QoS implementation at lower layers can be described as follow:

- Ultra wideband (UWB) and next generation standards of WPAN

UWB technology is a radio communication technique based on very short duration pulses (nanoseconds or less) whilst the bandwidth is very large (800 Mbps) at short distance (less than 10m) with a very low power source. This technology has been utilizing in many standards. UWB is being considered to be used in next generation of Bluetooth, the physical layer protocols for the high data rate IEEE 802.15.3a standard and the its sibling IEEE 802.15.4a WPAN standards.

- ZigBee and IEEE 802.15.4

ZigBee based on the IEEE 802.15.4 standard for WPAN to build up a set of high level communication protocols using small, low power digital radios so that the applications would be cheaper, smaller, and simpler than Bluetooth and other current standards in WPAN. As of 2005, the estimated cost of the radio for a ZigBee node is about $6, much cheaper than it in Bluetooth devices. ZigBee specifications have just been approved on December 2004, and then the owners, ZigBee Alliance association – with nearly 25 companies at when this paper is writing, have successfully completed rigorous testing to ensure their platforms meet strict performance criteria established by the Alliance. ZigBee's ability to offer the market numerous interoperable platforms helps product manufacturers find the best platform for their products [7].

The current issues in Bluetooth security are involving mobile phones which are recently reported that the expert hackers can access the information stored in the mobile phone using Bluetooth links. There are two famous methods that related with this illegal and improper access to information which are bluesnarfing and bluebugging. Bluebugging allows skilled individuals to access the mobile phone commands using Bluetooth wireless technology without notifying or alerting the phone's user [6]. The attacker can access the phone book, send and receive text, eavesdrop on phone conversation, or even connect to the internet. Bluesnarfing allows hackers to gain access to data stored on a Bluetooth enabled phone using Bluetooth wireless technology without alerting the phone's user of the connection made to the device [6]. The information that can be accessed by an attacker is more privacy such as phone book, calendar, or IMEI (International Mobile Equipment Identity). The attacker must be within 10 meter range to another to perform those methods. Two major vendors of mobile phone, Nokia and Sony Ericsson have developed software upgrade to defence against bluesnarfing and bluebugging. They have also worked hard to product the new phones with the software to against these attacks. Another kind of attack on mobile phone is DoS (Denial of Service) which has been popular for attacking internet web-site and network. Even though this attack does not make any damage in the information inside the phones, but it can make annoyance to the users, for example the hacker can temporarily disable the product's Bluetooth services. Therefore, future Bluetooth core specifications are planned to include features that will make it impossible to penetrate the devices.

6. Conclusion

As described above, QoS supports in WPAN is very critical, especially for those that have been implemented as 802.15 based networking. Nevertheless, up to now, QoS support in WPAN is very limited compared to other standards. This is the result of WPAN motivation, that's focusing in low power, low cost implementation for cable replacements for variety applications (while WiFi is the cable replacement for LAN networking only). However, at the time of writing of this paper, there're very limited applications using WPAN standards other than Bluetooth. This can be explained as the standards have not been finalized, but this may be because of the fact that the technologies have not been cheap enough to be accepted in the market.

The benefit of WPAN and other wireless application has been proved. However, since these technologies using unlicensed frequency band, there would be many other devices/technologies using the same frequency and causing much interference to devices using WPAN technologies. QoS support in WPAN needs to be improved more to avoid many disadvantages that can happen in near future.

As the working groups are building new standards for WPAN architectures, in near future, there should be some new standards being approved. The standards such as 802.15.3a, 802.15.4b may be established in near future. Up to that time, the proposed QoS architectures mentioned above will be realistic. In the mean time, there are many other researches focusing at upper layers to improve multimedia delivery solutions for WPAN. As a result, QoS support for multimedia delivery in WPAN is expected to have better scenes.

7. References

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