Bluetooth - One of the Best WPAN Solutions for Bridging PAN and Wider Networks?

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Abstract

In this paper we present the advantages of Bluetooth to other WPAN technologies and try to answer the question: why is Bluetooth a promising WPAN technology and bridge to wider networks. Finally we give a method to design protocols which make the wide usability possible with the help of patterns.

Keywords: Bluetooth, WPAN, protocol engineering, SDL, design pattern

1. Introduction

Nowadays it is important to get the important information from everywhere as soon as possible. The devices make it possible have to be designed to be handheld and mobile. To access the information these WPAN equipments have to connect to other devices or networks. One of the technologies developed for wireless short range communication is Bluetooth. In the following part we will see, why is Bluetooth a very promising technology for this kind of communications.

2. Why is Bluetooth so suitable for WPAN ?

Communicate with help of RF signals has a lot of advantages. We do not have to point our devices at each other because the propagation of radio waves is independent of direction, even more RF signals passes over non metal objects. That's why this part of electromagnetic spectrum is ideal for mobile communication. We can take our mobile phone or PDA into other room without breaking the connection. It is one of the most important properties of WPAN devices. Several different technologies have been developed for short range RF communication, for example Home RF, IEEE 802.11 for WLAN and Bluetooth. Each of them has its special environment and application optimized for. Home RF, IEEE 802.11b and Bluetooth work in the 2.4 GHz ISM band, that's why it doesn't need any radio license to use them. It causes a big problem: this radio band is full of signals which can generate interference between communicating devices. Bluetooth applies a quick frequency hopping scheme to avoid interference by using FHSS with a nominal 1600 hops/sec speed.

The ideal WPAN devices have another important attribute: they are small enough to fit in a pocket, they minimize power consumption and are as cheap as possible. Bluetooth satisfies these criteria. Telling the truth, Bluetooth was designed just for suiting for WPAN environment. It is proved by the fact, that IEEE accepted Bluetooth specification for the base of his 802.15 WPAN standard. This will help Bluetooth become a leader WPAN technology [1].

Besides it is suitable for WPAN devices, Bluetooth has another advantage. This technology not only replaces cables but is able to establish networks. Bluetooth supports point to point and point to multipoint connections as well. One Bluetooth network - a piconet - can be formed by up to 8 devices. These piconets can be organized to bigger network called scatternet.

3. Connection with other networks

The system was designed to be able to work together with extant network protocols just like the popular IP based TCP, UDP, WAP or object exchanging protocols (OBEX). We can use Bluetooth for voice only applications too. This co-operation with large scale of applications is realized by L2CAP (Logical Link Control and Adaptation Protocol). One of this protocol's services is protocol multiplexing allowing different protocols work over Bluetooth. Figure 1 shows the Bluetooth protocol stack [2]. We can see the several upper layer protocols over L2CAP.

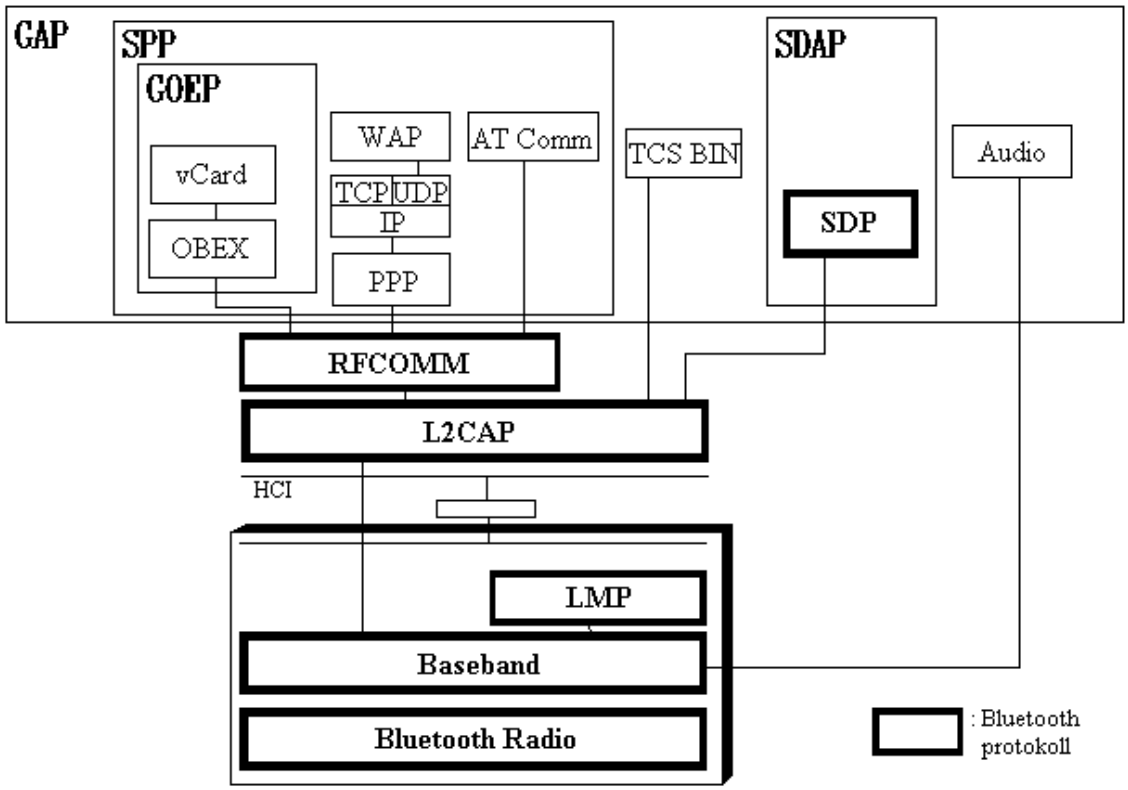

Figure 1. The Bluetooth protocol stack and profiles

Thanks L2CAP the point-to-point protocol (PPP), mobile and line Internet (WAP, IP), data exchange protocols using client-server model with different content type (OBEX, vCard, vCalendar, vNote, vMessage) can run over the Bluetooth protocol stack. We are able to control modem and fax devices also.

Another protocol called BNEP (Bluetooth Network Encapsulation Protocol) gives L2CAP the ability to handle the common network protocols, the same that are supported by Ethernet encapsulation [3]. BNEP is situated over L2CAP too. These protocols widen the broad variety of Bluetooth applications.

4. The wide scale of Bluetooth applications

We can see (Figure 2) that Bluetooth is an ideal WPAN technology to form ad-hoc networks and to access remote networks (wired or wireless) through network access points. These properties make it possible to reach a remote host connecting to a LAN or WAN easily using our personal device [4]. This way we can get information up to date, we are able to control real-time systems, the mobile device can work as a monitoring or alarming set.

Using Bluetooth for reaching another devices or networks makes it possible disabled people to have special personalized interface as a Bluetooth device to access the common computers or other equipments for their work. Their PAN devices have to be specially designed, Bluetooth can connect them to usual LANs.

To mention another application, to phone over Bluetooth means to spare the cost of the call if we want to communicate with other person having Bluetooth device placed in the area of the scatternet. We only have to pay for calls on bigger distance, which can be made e.g. over GSM.

The key protocols make the wide usability of Bluetooth real are: L2CAP and BNEP.

5. Bluetooth profiles

The Bluetooth developing group, the SIG (Bluetooth Special Interest Group) determined some basic profiles for Bluetooth. A profile is (one or more) vertical slice in the protocol stack describing the mandatory protocols and parameter ranges for different user scenarios. Using these profiles interoperability problems will be eliminated between Bluetooth devices of different manufacturers.

The used protocols are application-dependent, but the base Bluetooth protocols (Bluetooth Radio, Baseband, LMP, L2CAP, SDP) are used in every cases - excepting audio transfer,

so the implementations of the basic protocols are reusable in different use cases applying different parameters.

There are four general profiles determined covering the common user scenarios. (Figure 1.) The Generic Access Profile (GAP) handles discovery and connection establishment between unconnected devices. It is a basic profile, every Bluetooth device must support it.

The second defined profile is the Service Discovery Application Profile (SDAP). It is responsible for searching for specific or general services in the range of the Bluetooth unit. SDAP re-uses parts of the GAP.

The Serial Port Profile (SPP) emulates serial ports on two devices and connects them with Bluetooth. It is used in case of dial-up networks, fax, headset or LAN access. This profile re-uses the pattern of GAP too.

Finally the Generic Object Exchange Profile (GOEP) defines the protocols needed for applications uses object exchange. This kind of profiles can be File Transfer Profile, Object Push Profile or Synchronization Profile. GOEP uses GAP and SPP, so protocol engineers, who work out protocol stack for object exchanging Bluetooth devices, can re-use GAP and SPP implementations.

In practice for every usage model there is one or more adaptable profile.

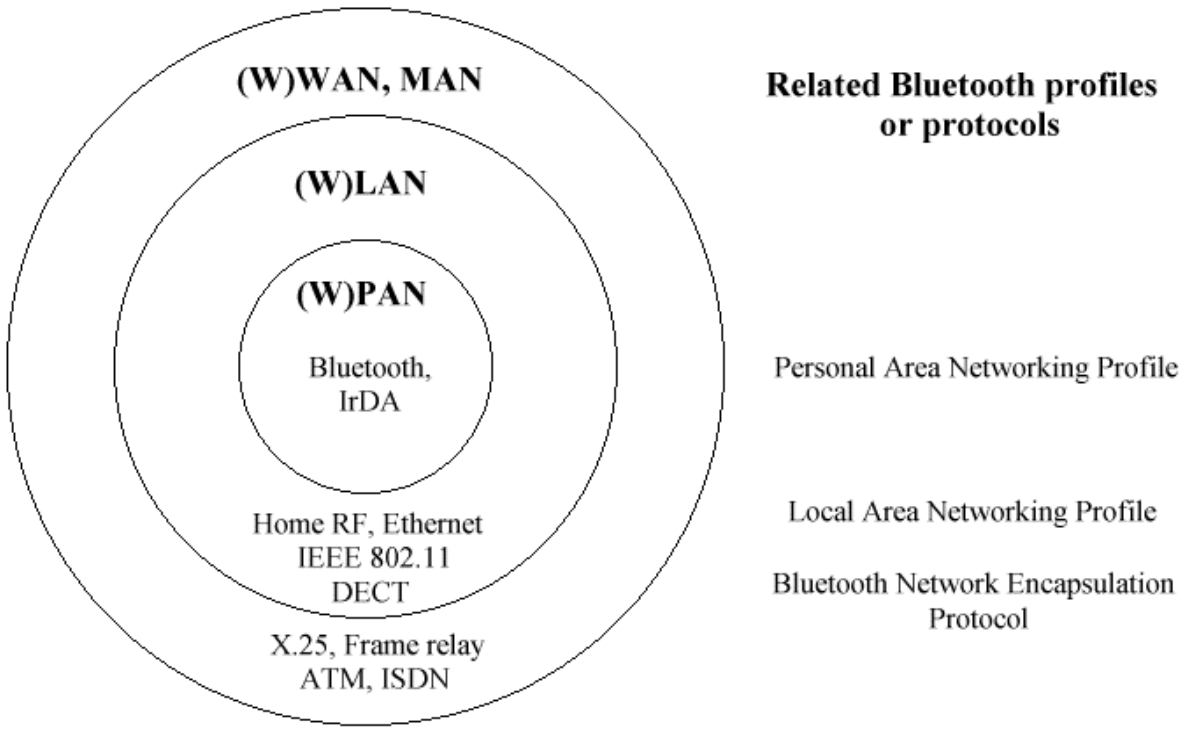

Figure 2. Bluetooth's role in interoperability between PANs, LANs and wider networks

5. Pattern based formal protocol design

There are several applications to realize them protocol engineers have to reuse these protocols with modified parameters. During the analysis reusable patterns have to be detected and designed with the help of formal languages. This kind of language is SDL, which was developed for specificating and describing distributed interactive real-time systems [5]. It is suitable for realizing protocols. The SDL description is hierarchical, it increases the transparency of the design. In the first step we have to build the model for the given protocol. It is made by means of formal patterns, in SDL this role is played by the packages. If we design the patterns, we can use them for different use cases by changing they parameters. It is very effective in case of protocols used for several different applications, like e.g. L2CAP and BNEP.

SDL is a good choice because SDL description can be converted easily into final code just like C, or we can generate TTCN description and test cases for the phase of test. With the help of this family of formal languages (SDL, MSC for sequence charts, TTCN and ASN.1 for abstract data definition) the whole life circle of protocol development can be covered.

With the hierarchy levels of SDL we can differ the static and dynamic parts of the protocols: the protocol system, the protocol entity and the protocol behavior. If we determine the reusable patterns of these levels, we can easily apply them for different use cases as we have seen it in the section dealing with Bluetooth profiles. It makes it

easy to develop the variants of protocols simply reusing the predefined pattern. This makes the developing procedure efficient especially for these kinds of protocols like L2CAP and BNEP which offer the use of wide variety of network types over Bluetooth.

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