Bluetooth Health Device Profile (HDP)

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1. Bluetooth in Medical Applications

Bluetooth as near-distance wireless technology is very suitable for many medical applications. Wireless sensors in hospitals, homes (assisted living) and applications using a GSM//3GPP networked infrastructure for forwarding medical data to a central server are just few examples. Particular applications using the mobile phone as kind of gateway are very interesting. The aging of the population, together with diseases such as diabetes, results in increased health care costs. Introducing new techniques for medication, reporting of physiological parameters and the ability to exchange medical data between hospitals and doctors may reduce costs for the healthcare system.

Up to now, Bluetooth systems for medical application use proprietary implementations and data format. In most cases applications that run on top of the Serial Port Profile (SPP) are used. Such systems are – if they don´t come from one supplier – non-interoperable. Since the implementation is customized for just one vendor and /or device, data exchange between such systems is often difficult. Even Bluetooth interoperability with PC´s using different Bluetooth stack versions from different vendors is hard to achieve. Specific SPP solutions depend on virtual COM ports and specific stack APIs. Such an approach creates dependencies on a specific stack and in some cases on the operating systems used. To solve those issues the Bluetooth **S**pecial **I**nterest **G**roup (SIG) started a program several years ago to define a new medical application.. In June 2008 the Bluetooth SIG released the Bluetooth **H**ealth **D**evice **P**rofile (HDP).

2. Health Device Profile (HDP)

In 2006, the Medical Working Group (Med WG) of the Bluetooth SIG began defining a specification addressing the needs of the medical community. Under Bluetooth, a profile defines the characteristics and features including function of a Bluetooth system. The end result of this work was the HDP specification that included the MCAP (**M**ulti-**C**hannel **A**daptation **P**rotocol) and made use of the **D**evice **I**D Profile (DI).

Figure 1 describes the architecture of a Bluetooth system with the HDP and applications.

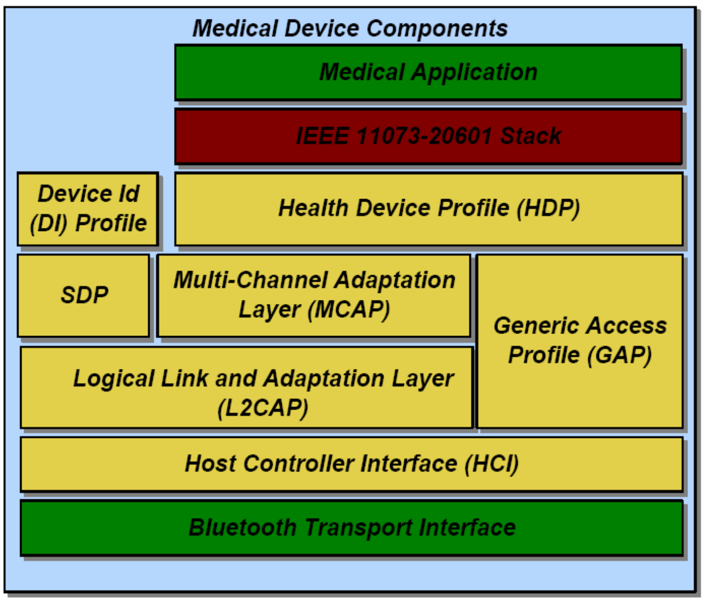

Figure 1

Figure 1 describes the interaction between a Bluetooth Protocol and a HDP in an overall Medical Device application.

Medical Application describes the actual device application, including its user interface, application behavior, and integration layer to the IEEE 11073-20601 stack implementation.
IEEE 11073-20601 Stack performs building, transmission, reception, and parsing of IEEE PDU packets for the associated agent/manager being developed. This component will directly link to the HDP.
Device ID (DI) Profile is a Bluetooth profile designed to provide device specific information through use of the Service Discovery Protocol (SDP). If vendor specific information is required as part of a particular Medical Device, this profile provides specific behavior to acquire this information. A good HDP implementation offers API's to register and query for such vendor specific information. These API's can then be integrated directly into the Medical Application.
Health Device Profile (HDP) is the core Bluetooth profile designed to facilitate transmission and reception of Medical Device data. The API´s of this layer interact with the lower level MCAP layer, but also perform SDP behavior to connect to remote HDP devices.
SDP is the **S**ervice **D**iscovery **P**rotocol used by all Bluetooth profiles to register and/or discover available services on remote devices so that connections over L2CAP can be established.
Multi-Channel Adaptation Layer (MCAP) is used by HDP and facilitates the creation of a Communications Link (MCL) for exchanging generic commands, and also one or more Data Links (MDL) to transfer actual Medical Device data. MCAP is specific for the HDP and guarantees reliable transmission of data.
Generic Access Profile (GAP) describes the required features of all core Bluetooth profiles including inquiry, connection, and authentication procedures.
Logical Link and Adaptation Layer (L2CAP) supports protocol multiplexing, packet segmentation and reassembly, quality of service, retransmission, and flow control for the Bluetooth packets transmitted through MCAP.
Host Controller Interface (HCI) describes the commands and events that all Bluetooth hardware implementations (controllers) can understand.
Bluetooth Transport Interface describes the UART, USB, SDIO, 3-wire, ABCSP, etc. transport interface to the actual Bluetooth hardware components being used. Typically, UART and USB are the most widely used transports.

HDP provides several primary features. These include control channel connection/disconnection, data link creation (reliable or streaming), data link deletion, data link abort, data link reconnection, data transmission (over one or more data links) and clock synchronization

HDP provides two roles – **Sink** and **Source** (see Figure 2). A Source is the small device that will act as the transmitter of the medical data (weight scale, glucose meter, thermometer, etc.). The Sink is the feature rich device that will act as the receiver of the medical data (mobile phone, desktop computer, health appliances, etc.).

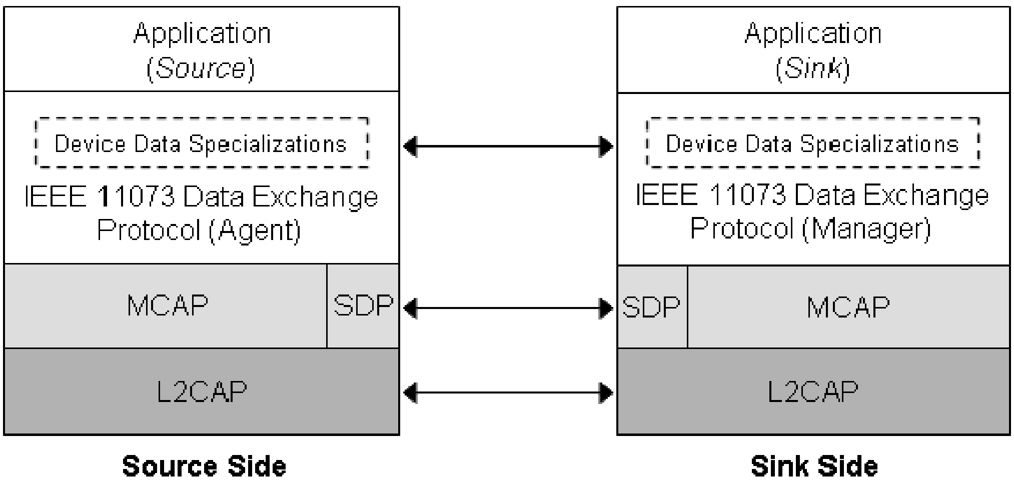

Figure 2

HDP devices acting as a source device are weight scales, blood pressure meters, thermometers, or glucose meters which transmit application data over a reliable data channel to a sink (PC, mobile phone, or PDA). Other source devices such as pulse oximeter, EEG, or ECG transmit application data over a streaming data channel to a sink (PC, mobile phone, or PDA).
Multiple source devices transmit application data over reliable and streaming data channels to a sink. This data can then be routed on to a physician through an alternate transport (Internet, mobile phone network) to medical server application at a hospital.
Source Device may be a combination device (pulse oximeter with thermometer capability) utilizing multiple Data Channels.
Figure 3 shows an application with two different devices using reliable and streaming channels.

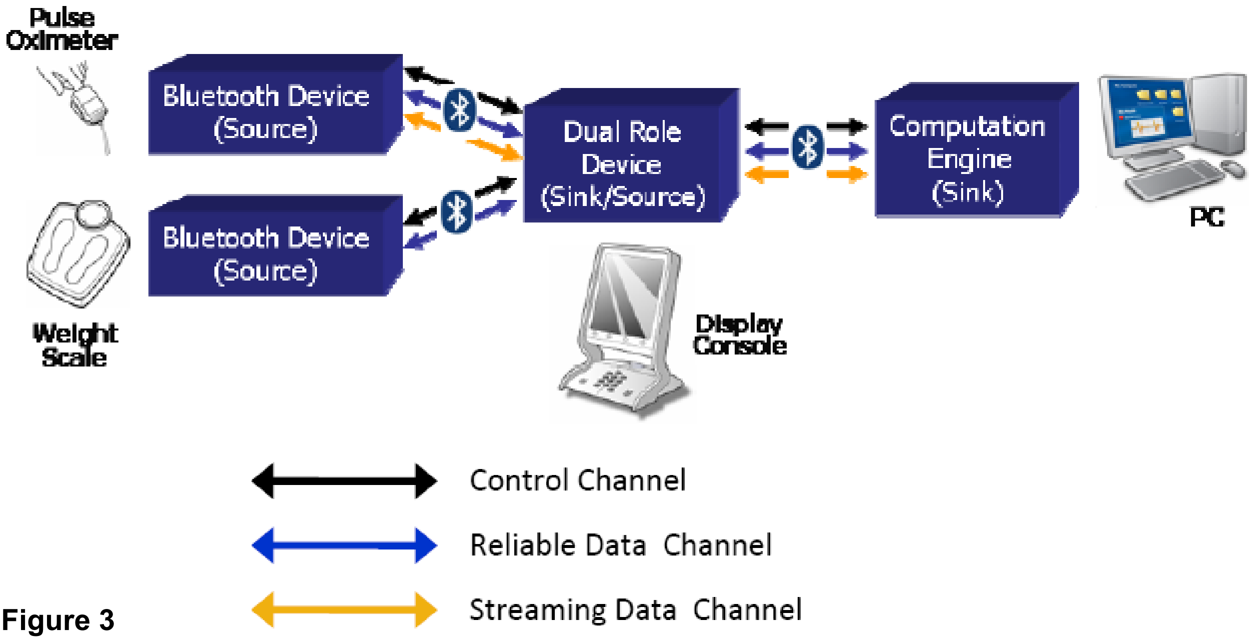

Figure 3

HDP/MCAP is using connection-oriented channels which allow quick detection of a broken connection and immediately reconnection of L2CAP channels. Between two HDP devices a control channel and one or two data channels (streaming data channel or reliable data channel) are established. To support a more reliable transmission on L2CAPlevel the field check sequence (FCS) within L2CAP could be supported (optional).

To allow the combination of several sensor signals HDP supports the synchronisation of signales in order to combine them for better analysis by the doctor. HDP is using the Bluetooth master clock and the clock offset of the slave. Therefore, HDP devices work as Sync-Master or Sync-Slave. The time stamp could have a resolution of up to 1 µs. Transmission delays – result of delays within the device itself – could be specified in the SyncLeadTime field. This allows a re-synchronization in the source devices. Time representation follows IEEE 1003.1-2001 (absolute time in seconds).

Each HDP device has one or more MCAP Data End Points (MDEP). A MDEP describes the HDP application in one device.

HDP recommends usage of sniff modes and the enhanced security functions (Secure Simple Pairing, SSP) of Bluetooth 2.1. Encryption is mandatory. The length of the PIN is at least 6 numbers (Bluetooth 2.0) or 6 alphanumerical characters (Bluetooth 2.1). To assure coexistence issues with other wireless systems and in order to assure a stable and almost error free signal transmission, usage of Bluetooth 2.0/2.1+EDR (Enhanced Data Rate), AFH (Adaptive Frequency Hopping) and transmit power control is strongly recommended.

If the transmission of audio data (e. g. stethoscope) is required, one of the Bluetooth voice profiles (Headset) using SCO (voice channels) must be used.

HDP does not define the data format and data content. The Bluetooth SIG mandates for HDP the usage of the IEEE 11073-20601 Personal Health Device Communication Application Profile as the only allowed protocol for data exchange between HDP devices and the IEEE 11073-104xx Device Specification.

IEEE 11073-20601 defines the data exchange protocol and IEEE 11073-104xx defines the data format including size and coding of all data exchanged between HDP devices. Figure 4 shows the architecture of an Bluetooth device with IEEE-11073-20601 and Device Specifications with IEEE-11073 (-104xx).

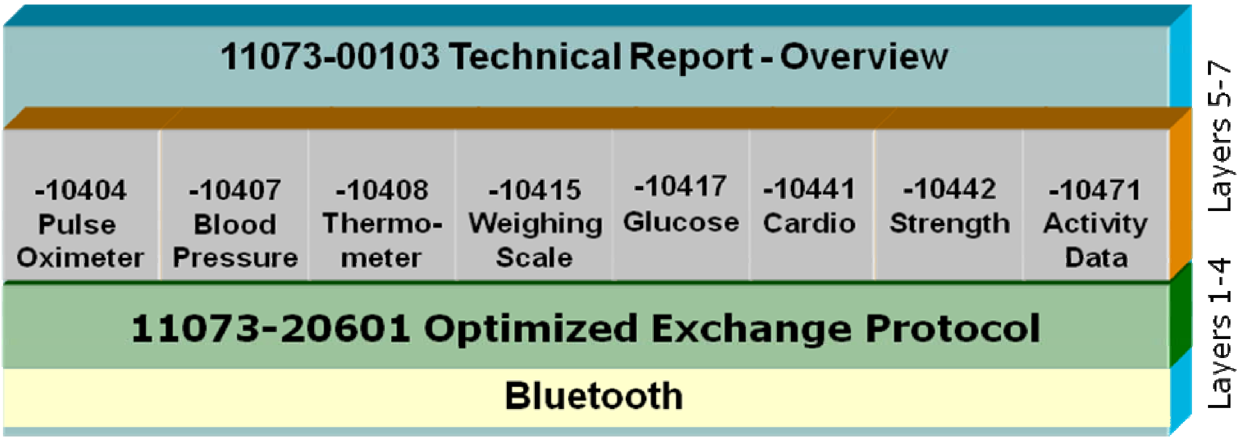

Figure 4

The length of transmitted data is in most cases 896 bytes for transmit and 224 bytes for receive. Exception is the oximeter (transmit: 9216 bytes; receive: 256 bytes). Segmentation and Reassembly (SAR) of data packages is supported. The data size values are used for the configuration of Bluetooth MTU (Maximum Transmission Unit) size. Table 1 lists all IEEE 11073-104xx standards for the currently defined devices. For more information's on IEEE 11073 please refer to [3] and [4].

IEEE 11073-	**Gerät**
10404	Pulse Oximeter
10406	Heart Rate Monitor (Pulse)
10407	Blood Pressure Monitor
10408	Thermometer
10415	Weighing Scale
10417	Glucose Meter
10441	Cardiovascular (incl. Fitness Monitor)
10442	Strength (incl. Fitness) Monitor
10471	Activity Data Monitor
10472	Medication Monitor
20601	Data Exchange Protocol

11073-20601 includes services for a reliable communication, mechanism for event reporting, object access via GET/SET and the domain information (object-oriented description with attributes for the device configuration). Device description and attribute definitions are using ASN.1. An oximeter has objects for pulse, oxygen saturation and curve progression. All data is sent via Data Update Events.
Devices establish on 11073-20601 level a logical connection. The communication happens between a HDP Source Node (11073-20601 Agent) and HDP sink nodes (11072-20601 Manager). Agent or manager could start the data transmission. Mangers could ask for one data value or request data for a defined time (in seconds) or data is requested via start/stop from the agent. Agent's don´t process any data. Bluetooth link disconnection is not immediately reported to the 11073-20601 layer. Instead automatic reconnection is processed.

By mid September 2009, several medical devices (Weighing Scale, Blood Pressure Monitor) using HDP will be listed on the Bluetooth qualification web site as end products. End products are not used as Bluetooth qualified components but rather are products used by real people to solve real medical problems.

References

[1] Bluetooth Specification 3.0 + HS (Bluetooth SIG)
[2] Health Device Profile Specification v1.0 (Bluetooth SIG)
[3] IEEE-11073, IEEE WG Meeting, San Antonio, January 2008
[4] IEEE-11073-20601 und IEEE-104xx Specifications
[5] iAnywhere Health Device Profile White Paper

Links

www.bluetooth.org
www.continuaalliance.org
http://standards.ieee.org

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