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Transmission of IPv6 Packets over Bluetooth Low Energy
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Abstract

Bluetooth low energy is a low power air interface technology that is defined by the bluetooth SIG. The standard bluetooth radio has been widely implemented and available in mobile phones, notebook computers, audio headsets and many other devices. The low power version of bluetooth is a new specification and enables the use of this air interface with devices such as sensors, smart meters, applicances, etc. There is an added value in the ability to communicate with sensors over IPv6. This document describes how IPv6 is transported over bluetooth low energy using 6LoWPAN techniques.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on September 11, 2011.

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1. Introduction

Bluetooth Low Energy (BT-LE) is a radio technology targeted for devices that operate with coin cell batteries, which means that low power consumption is essential. BT-LE can also be integrated into existing Bluetooth (BT) devices so that devices such as mobile phones and PCs can operate with existing BT accessories as well as BT-LE accessories. An example of a use case for BT-LE accessory is a heart rate monitor that sends data via the mobile phone to a server on the Internet. BT-LE is designed for transferring small amount of data (in most cases less than 10bytes) less frequently (e.g. every 500ms) at modest data rates (e.g. 300kbps). BT-LE enables low cost sensors to send their data over the Internet via a gateway such as a mobile phone. BT-LE is especially attractive technology for Internet of Things applications, such as health monitors, environmental sensing and proximity applications.

Considering the expected explosion in the number of sensors, IPv6 is an ideal protocol due to the large address space it provides. This document describes how IPv6 is used on Bluetooth Low Energy links in a power efficient manner along with efficient application protocols that enable the integration of BT-LE devices into services.

[RFC4944] specifies the transmission of IPv6 over IEEE 802.15.4. The bluetooth low energy link in many respects has similar characteristics to that of IEEE 802.15.4. Many of the mechanisms defined in [RFC4944] can be applied to the transmission of IPv6 on bluetooth low energy links. This document specifies the details of IPv6 transmission over blue-tooth low energy links.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2.1. Terminology

Bluetooth Low Energy

Bluetooth low energy is a low power air interface technology specified by the Bluetooth Special Interest Group (SIG).

Bluetooth Network Encapsulation Protocol (BNEP)

Define BNEP.

Gateway

Network element connecting the BT-LE sensors to the Internet. Can be e.g a home gateway or a mobile device.

ND-Proxy

A gateway that operates as a proxy for IPv6 neighbor discovery

CoAP/HTTP Proxy

A gateway that operates as a CoAP/HTTP proxy for the BT-LE sensors. Link local addresses are used between the sensors and the CoAP/HTTP proxy

6to4 prefix

An IPv6 prefix constructed by combining well-known IPv6 prefix with public IPv4 address

6to4/6RD router

A router that has only IPv4 uplink connectivity and thus uses 6to4/6RD prefix in the BT-LE network

3. Bluetooth Low Energy protocol stack

Bluetooth Low Energy is a low power wireless technology developed by the BT-SIG. The lower layer of the BT-LE stack consists of the RF and the Link layer which are implemented in the BT-LE controller. The upper layer consists of the Logical Link Control and Adaptation Protocol (L2CAP), Generic Attribute protocol (GATT) and Generic Attribute profile (GAP) as shown in Figure 1. GATT and BT-LE profiles together enable the creation of applications in a standardized way without using IP. L2CAP provides multiplexing capability by multiplexing the data channels from the above layers. L2CAP also provides fragmentation and reassembly for larger data packets. Link Layer (LL) is responsible for managing the channels and Physical Layer (PHY) transmits and receives the actual packets.

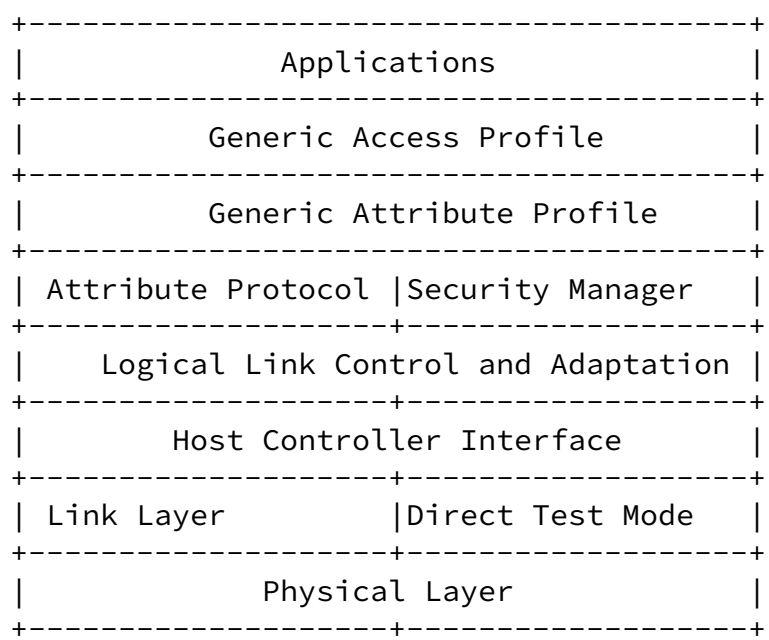

Figure 1: BT-LE Protocol Stack

3.1. Support for IPv6 over BT-LE

The Bluetooth Network Encapsulation Protocol (BNEP) has been developed for encapsulating any network protocol for Bluetooth L2CAP. BNEP assumes that L2CAP supports connection oriented channel. Either a connection oriented channel needs to be added to the current BT-LE specification, over which BNEP, parts of 6LoWPAN, IPv6 and application protocols can be run or a new fixed channel ID may be reserved for BNEP traffic. Figure 2 illustrates IPv6 over BT-LE stack.

Constrained Application Protocol (CoAP) is an application protocol specifically designed for resource constrained environments. CoAP could be run on top of IPv6 supporting requests from the server and requests of cached replies from a CoAP/HTTP proxy in the BT-LE gateway.

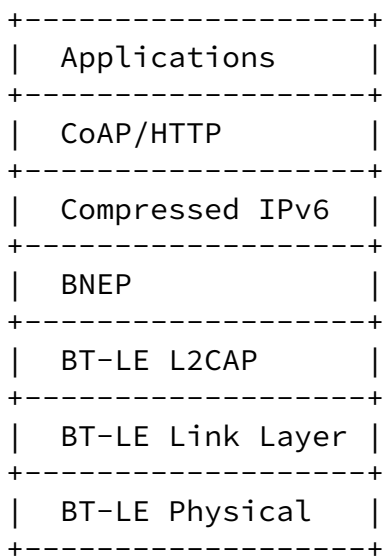

Figure 2: IPv6 over BT-LE Stack

4. Requirements

BT-LE technology sets strict requirements for low power consumption and thus limits the allowed protocol overhead. 6LoWPAN standard [RFC4944] provides useful generic functionality like header compression, link-local IPv6 addresses, Neighbor Discovery and stateless IP-address autoconfiguration for reducing the overhead in 802.15.4 networks. This functionality can be partly applied to BT-LE.

5. Addressing Model

The link model of BLE needs to be considered and what kind of addressing is possible.

6. MTU Issues

Generally the sensors generate data that fits into one Link Layer packet (23 bytes) that is transferred to the collector periodically. IP data packets may be much larger and hence MTU size should be the size of the IP data packet. Larger L2CAP packets can be transferred with the SAR feature of the Link Layer. If an implementation cannot support the larger MTU size (due to cost) then SAR needs to be supported at upper layers.

One option to support SAR would be to implement SAR functionality in

the BNEP layer. Existing SAR functionality defined in [RFC4944] could also be used, taking into account BT-LE specific features such as different MTU in the L2CAP layer.

7. LowPan Adaptation for BLE and frame format

Transmission of IPv6 Packets over IEEE 802.15.4 Networks [RFC4944]

defines an adaptation layer between IP and 802.15.4 radio networks. In these networks link layer does not support SAR functionality and thus IP packets must fit into the payload that is available in the 127 octect long physical frame after variable size frame overhead has been added. In BT-LE networks this kind of adaptation is not needed if SAR is supported in the Link Layer. is a

8. IPv6 Address configuration

SLAAC and other means to configure an address on a BLE device. Neighbor Discovery Optimization for Low-power and Lossy Networks [I-D.ietf-6lowpan-hc]. Might also add something about hard-coding well-known gateway or server addresses.

9. IPv6 LLA in BLE

Link local address format in BLE

10. Unicast and Multicast address mapping

Do we have to use multicast addresses in ultra low power network? I dont know whether the same format specified for 802.15.4 can be reused. Will need expert guidance here.

11. Header compression

Compression Format for IPv6 Datagrams in Low Power and Lossy Networks (6LoWPAN) [I-D.ietf-6lowpan-hc].

In [RFC4944] different types of frame formats and related headers have been defined to support fragmentation and mesh addressing. In BT-LE context LoWPAN_HC1 compressed IPv6 header would be used by default. Support for fragmentation and mesh headers can be added if required. In BT-LE link with header compression IPv6 header (originally 40 Bytes) can be compressed to only 2 Bytes with link-local addresses and 26 Bytes with Global addresses. UDP header

(originally 8 Bytes) can be compressed to 4 Bytes. IMO this section

should be the same as with 6lowpan.

12. IANA Considerations

This document does not have any IANA requests at this time. This may change with further development of the specification.

13. Security Considerations

The transmission of IPv6 over bluetooth low energy links has similar requirements and concerns for security as zigbee. Security at the IP layer needs to be reviewed as part of the development of the IPv6 over bluetooth low energy specification.

14. Additional contributors

Kanji Kerai and Jari Mutikainen from Nokia have contributed significantly to this document.

15. Normative References

[I-D.ietf-6lowpan-hc]
Hui, J. and P. Thubert, "Compression Format for IPv6 Datagrams in Low Power and Lossy Networks (6LoWPAN)", draft-ietf-6lowpan-hc-15 (work in progress), February 2011.

[I-D.ietf-6lowpan-nd]
Shelby, Z., Chakrabarti, S., and E. Nordmark, "Neighbor Discovery Optimization for Low-power and Lossy Networks", draft-ietf-6lowpan-nd-15 (work in progress), December 2010.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", RFC 4944, September 2007.

[RFC4994] Zeng, S., Volz, B., Kinnear, K., and J. Brzozowski, "DHCPv6 Relay Agent Echo Request Option", RFC 4994, September 2007.

Appendix A. Bluetooth Low energy basics

This section will provide background material on the basics of bluetooth low energy.

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