

6Lo Working Group  
Internet-Draft  
Intended status: Informational  
Expires: May 3, 2018

MS. Akbar  
Bournemouth University  
AR. Sangi  
Huaiyin Institute of Technology  
M. Zhang  
J. Hou  
Huawei Technologies  
C. Perkins  
Futurewei  
A. Petrescu  
CEA, LIST  
R.N.B.Rais  
Ajman University  
October 30, 2017

Transmission of IPv6 Packets over Wireless Body Area Networks (WBANs)  
draft-sajjad-6lo-wban-01

Abstract

Wireless Body Area Networks (WBANs) intend to facilitate use cases related to medical field. IEEE 802.15.6 defines PHY and MAC layer and is designed to deal with better penetration through the human tissue without creating any damage to human tissues with the approved MICS (Medical Implant Communication Service) band by USA Federal Communications Commission (FCC). Devices of WBANs conform to this IEEE standard.

This specification defines details to enable transmission of IPv6 packets, method of forming link-local and statelessly autoconfigured IPv6 addresses on WBANs.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

Internet-Draft

IPv6 over WBANs

October 2017

This Internet-Draft will expire on May 3, 2018.

## Copyright Notice

Copyright (c) 2017 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

## Table of Contents

|                             |   |                    |
|-----------------------------|---|--------------------|
| <a href="#">1.</a>          | Introduction . . . . .                            | <a href="#">2</a>  |
| <a href="#">1.1.</a>        | Frame Format and Addressing Modes . . . . .       | <a href="#">3</a>  |
| <a href="#">1.2.</a>        | Why 6lo is required for IEEE 802.15.6 . . . . .   | <a href="#">4</a>  |
| <a href="#">2.</a>          | Conventions and Terminology . . . . .             | <a href="#">5</a>  |
| <a href="#">3.</a>          | Topology and Scope of Communication . . . . .     | <a href="#">5</a>  |
| <a href="#">4.</a>          | Protocol Stack . . . . .                          | <a href="#">6</a>  |
| <a href="#">5.</a>          | Maximum Transmission Unit (MTU) . . . . .         | <a href="#">7</a>  |
| <a href="#">6.</a>          | Specification of IPv6 over WBAN . . . . .         | <a href="#">7</a>  |
| <a href="#">6.1.</a>        | Stateless Address Autoconfiguration . . . . .     | <a href="#">8</a>  |
| <a href="#">6.2.</a>        | IPv6 Link-Local Address . . . . .                 | <a href="#">8</a>  |
| <a href="#">6.3.</a>        | Unicast and Multicast Address Mapping . . . . .   | <a href="#">8</a>  |
| <a href="#">6.4.</a>        | Header Compression . . . . .                      | <a href="#">8</a>  |
| <a href="#">6.5.</a>        | Fragmentation and Reassembly . . . . .            | <a href="#">9</a>  |
| <a href="#">7.</a>          | IANA Considerations . . . . .                     | <a href="#">9</a>  |
| <a href="#">8.</a>          | Security and Privacy Considerations . . . . .     | <a href="#">9</a>  |
| <a href="#">9.</a>          | References . . . . .                              | <a href="#">9</a>  |
| <a href="#">9.1.</a>        | Normative References . . . . .                    | <a href="#">9</a>  |
| <a href="#">9.2.</a>        | Informative References . . . . .                  | <a href="#">10</a> |
| <a href="#">Appendix A.</a> | Patient monitoring use case - Spoke Hub . . . . . | <a href="#">10</a> |
| <a href="#">Appendix B.</a> | Patient monitoring use case - Connected . . . . . | <a href="#">12</a> |
| <a href="#">Appendix C.</a> | Changes . . . . .                                 | <a href="#">13</a> |
|                             | Authors' Addresses . . . . .                      | <a href="#">13</a> |

## [1.](#) Introduction

Wireless Body Area Networks (WBANs) are comprised of devices that conform to the [[IEEE802.15.6](#)], standard by the IEEE. IEEE 802.15.6 provides specification for the MAC layer to access the channel. The coordinator divides the channel into superframe time structures to

allocate resources [[SURVEY-WBAN](#)] [[MAC-WBAN](#)]. Superframes are bounded by equal length beacons through the coordinator. Usually beacons are sent at beacon periods except inactive superframes or limited by regulation.

Task group for 802.15.6 was established by IEEE in November 2007 for standardisation of WBANs and it was approved in 2012. This standard works in and around human body and focus on operating at lower frequencies and short range. The focus of this document is to design a communication standard for MAC and physical layer to support different applications, namely, medical and non-medical applications. Medical applications refer to collection of vital information in real time (monitoring) for diagnoses and treatment of various diseases with help of different sensors (accelerometer, temperature, BP and EMG etc.). It defines a MAC layer that can operate with three different PHY layers i.e. human body communication (HBC), ultra-wideband (UWB) and Narrowband (NB). IEEE 802.15.6 provides specification for MAC layer to access the channel. The coordinator divides the channel into superframe time structures to allocate resources. Superframes are bounded by equal length beacons through coordinator. The purpose of the draft is to highlight the need of IEEE 802.15.6 for WBANs and its integration issues while connecting it with IPv6 network. The use cases are provided to elaborate the scenarios with implantable and wearable biomedical sensors. 6lowpan provides IPv6 connectivity for IEEE 802.15.4; however, it does not work with IEEE 802.15.6 due to the difference in frame format in terms of size and composition.

### 1.1. Frame Format and Addressing Modes

Figure 1 shows the general MAC frame format consisting of a 56-bit header, variable length frame body, and 18-bit Frame Check Sequence (FCS). The maximum length of the frame body is 255 octets. The MAC header further consists of 32-bit frame control, 8-bit recipient Identification (ID), 8-bit sender ID, and 8-bit WBAN ID fields. The frame control field carries control information including the type of

frame, that is, beacon, acknowledgement, or other control frames. The recipient and sender ID fields contain the address information of the recipient and the sender of the data frame, respectively. The WBAN ID contains information on the WBAN in which the transmission is active. The first 8-bit field in the MAC frame body carries message freshness information required for nonce construction and replay detection. The frame payload field carries data frames, and the last 32-bit Message Integrity Code (MIC) carries information about the authenticity and integrity of the frame. The IEEE 802.15.6 standard supports two kinds of addresses:

1. 8-bit short address, which is the sender ID. This address is located in the MAC header used for communication.
2. 48-bit EUI-48 address, which is used for the association process. For some certain frame types, e.g. Security Association frames, this MAC address exists inside the MAC payload, for the node joining process.

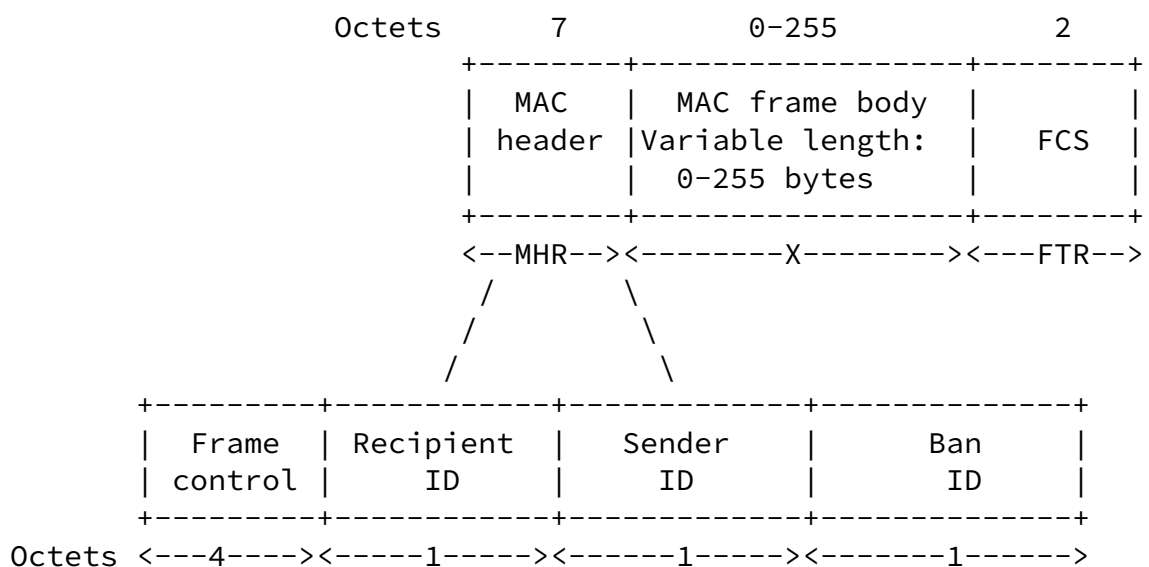


Figure 1: The general MAC frame format of IEEE 802.15.6

[1.2.](#) Why 6lo is required for IEEE 802.15.6

Based on the characteristics defined in the overview section, the

following sections elaborate on the main problems with IP for WBANs.

The requirement for IPv6 connectivity within WBANs is driven by the following:

- o The number of devices in WBANs makes network auto configuration and statelessness highly desirable. And for this, IPv6 has (default auto-configuration as a) ready solutions.
- o The large number of devices poses the need for a large address space, moreover a WBAN may consist of 256 nodes maximum and IPv6 is helpful to solve this address space limitation.
- o Given the limited packet size of WBANs, the IPv6 address format allows subsuming of IEEE 802.15.6 addresses if so desired. Applications within WBANs are expected to originate small packets. Adding all layers for IP connectivity should still allow transmission in one frame, without incurring excessive fragmentation and reassembly. Furthermore, protocols must be

designed or chosen so that the individual "control/protocol packets" fit within a single 802.15.6 frame. Along these lines, IPv6's requirement of sub-IP reassembly may pose challenges for low-end WBANs healthcare devices that do not have enough RAM or storage for a 1280-octet packet [[RFC2460](#)].

- o Simple interconnectivity to other IP networks including the Internet.
- o However, given the limited packet size, headers for IPv6 and layers above must be compressed whenever possible.

## [2.](#) Conventions and Terminology

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 [[RFC2119](#)].

## [3.](#) Topology and Scope of Communication

This is a standard for short-range, wireless communication in the vicinity of, or inside, a human body (but not limited to humans). It

uses existing industrial scientific medical (ISM) bands as well as frequency bands approved by national medical and/or regulatory authorities. Support for quality of service (QoS), extremely low power, and data rates from 10Kbps to 10 Mbps is required while simultaneously complying with strict non-interference guidelines where needed. The Table 1 shows a comparison of WBAN and other available technologies in terms of data rate and power consumption.

| Standard         | Provided data rate | Power requirement | Battery lifetime |
|------------------|--------------------|-------------------|------------------|
| 802.11 ac (WiFi) | 700 Mbps           | 100 mW - 1000 mW  | Hours - days     |
| Bluetooth        | 1Mbps - 10 Mbps    | 4 mW - 100 mW     | Days - weeks     |
| Wibree           | 600 Kbps maximum   | 2 mW - 10 mW      | Weeks - months   |
| ZigBee           | 250 Kbps           | 3 mW - 10 mW      | Weeks - months   |

|          |                     |               |                |
|----------|---------------------|---------------|----------------|
| 802.15.4 | 250 Kbps<br>maximum | 3 mW - 10 mW  | Weeks - months |
| 802.15.6 | 1Kbps - 10<br>Mbps  | 0.1 mW - 2 mW | Months - years |

Table 1: Comparison of WBAN

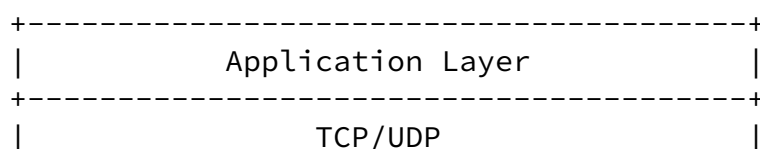
Data rates, typically up to 10Mbps, can be offered to satisfy an evolutionary set of entertainment and healthcare services. Current personal area networks (PANs) do not meet the medical (proximity to human tissue) and relevant communication regulations for some application environments. They also do not support the combination of reliability, QoS, low power, data rate, and non-interference required to broadly address the breadth of body area network (BAN) applications.

The IEEE 802.15.6 working group has considered WBANs to operate in either a one-hop or two-hop star topology with the node in the centre of the star being placed on a location like the waist. Two feasible types of data transmission exist in the one-hop star topology: transmission from the device to the coordinator and transmission from the coordinator to the device. The communication methods that exist in the star topology are beacon mode and non-beacon mode. In a two-hop star WBAN, a relay-capable node may be used to exchange data frames between a node and the hub.

#### 4. Protocol Stack

The IPv6 over IEEE 802.15.6 protocol stack is presented in Figure 2. It contains six elements from bottom to top including IEEE 802.15.6 PHY layer, IEEE 802.15.6 MAC layer, Adaptation layer for IPv6 over

IEEE 802.15.6, IPv6 layer, TCP/UDP layer and Application layer. The adaptation layer supports the mechanisms like stateless address auto-configuration, header compression and fragmentation and reassembly.



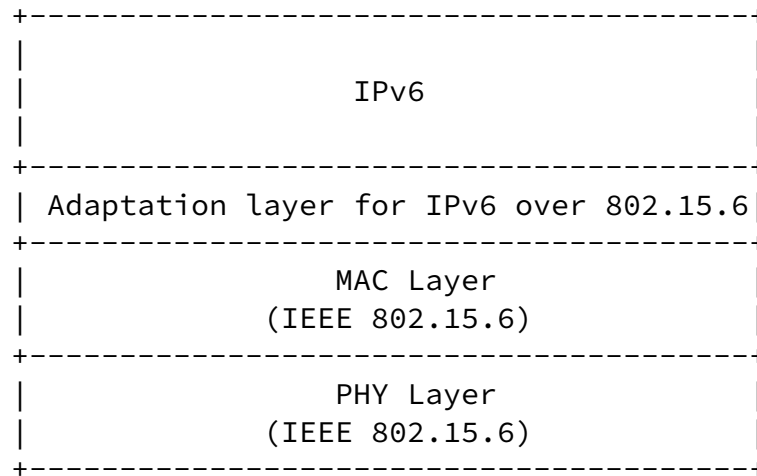


Figure 2: Protocol stack for IPv6 over IEEE 802.15.4

### 5. Maximum Transmission Unit (MTU)

The IPv6 packets have the MTU of 1280 octets and it expects from every link layer to send data by following this MTU or greater. Thus maximum Transmission Unit (MTU) of MAC layer describes the implementation of fragmentation and reassembly mechanism for the adaptation IPv6 layer over IEEE 802.15.6.

The IEEE 802.15.6 has the MTU of 256 octets, if we consider link layer security overhead (16 octets for AES-128) leaves 240 octets which is not sufficient to complete a IPv6 packet. Therefore, an adaptation layer below IP layer is required to manage fragmentation and reassembly issues.

### 6. Specification of IPv6 over WBAN

Due to stringent QoS requirements in WBAN, a 6Lo adaptation layer is needed to support the transmission of IPv6 packets. 6LoWPAN standards [RFC4944], [RFC6775] and [RFC6282] provides useful information including link-local IPv6 address, stateless address auto-configuration, unicast and multicast address mapping, header compression and fragmentation and reassembly. These standards are referred in the specifications of 6Lo adaptation layer which is illustrated in the following following subsections:

#### 6.1. Stateless Address Autoconfiguration



An IEEE 802.15.6 device performs stateless address autoconfiguration to obtain an IPv6 Interface Identifier (IID). The IPv6 EUI-64 format address is obtained through the EUI-48 bit MAC address of IEEE 802.15.6 node. The 64-bit IID SHALL be derived by utilizing 8-bit node address and 8-bit BAN ID (part of MAC header) as follows:

ID: 0xYY00:00FF:FE00:00XX

Where YY is the BAN ID, XX is the node address. As this generated IID is not globally unique, the "Universal/Local" (U/L) bit (7th bit) SHALL be set to zero.

### 6.2. IPv6 Link-Local Address

The IPv6 link-local address [[RFC4291](#)] for an IEEE 802.15.6 interface is generated by appending the interface identifier to the prefix FE80::/64.

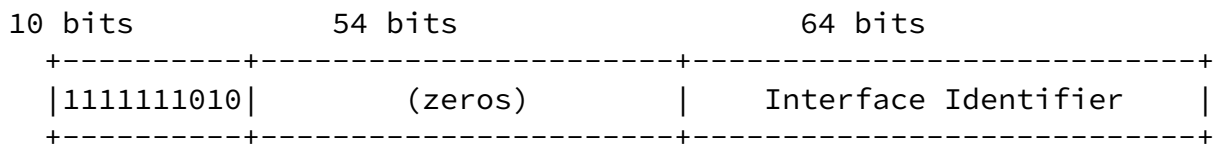


Figure 3: IPv6 Link Local Address in IEEE 802.15.6

### 6.3. Unicast and Multicast Address Mapping

The address resolution procedure for mapping IPv6 unicast addresses into IEEE 802.15.6 link-layer addresses follows the general description in [section 7.2 of \[RFC4861\]](#), unless otherwise specified. Multicast address mapping is not supported in IEEE 802.15.6.

### 6.4. Header Compression

The IEEE 802.15.6 PHY layer supports a maximum PSDU (PHY Service Data Unit) of 256 octets. Because of the limited PHY payload, header compression at 6Lo adaptation layer is of great importance and MUST be applied. The compression of IPv6 datagrams within IEEE 802.15.6 frames refers to [[RFC6282](#)], which updates [[RFC4944](#)]. Multiple header compression stacks are defined in [RFC6282](#) which specifies the fragmentation methods for IPv6 datagrams on top of IEEE 802.15.4; however, for IEEE 802.15.6, a LoWPAN encapsulated LoWPAN\_HC1 compressed IPv6 datagram can be used as IEEE 802.15.6 does not require mesh header due to IEEE 802.15.6 communication scope. Moreover, static header compression techniques of [[RFC7400](#)] can also be used as header compression.

## [6.5.](#) Fragmentation and Reassembly

IEEE 802.15.6 provides Fragmentation and reassembly (FAR) for payload of 256 bytes. FAR as defined in [[RFC4944](#)], which specifies the fragmentation methods for IPv6 datagrams on top of IEEE 802.15.4 MUST be adapted to work with IEEE 802.15.6. All headers MUST be compressed according to [[RFC4944](#)] encoding formats, but the default MTU of IEEE 802.15.6 is 256 bytes which MUST be considered.

## [7.](#) IANA Considerations

[TBD]

## [8.](#) Security and Privacy Considerations

IPv6 over WBAN's applications often require confidentiality and integrity protection. This can be provided at the application, transport, network, and/or at the link. IEEE 802.15.6 considers the security as a key requirement for healthcare applications and defines a complete framework. This framework defines three levels of security which can be used according to requirements. Overall, it covers privacy, confidentiality, encryption and authentication. AES-64 is preferred for encryption due to its efficiency.

## [9.](#) References

### [9.1.](#) Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC2460] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", [RFC 2460](#), DOI 10.17487/RFC2460, December 1998, <<https://www.rfc-editor.org/info/rfc2460>>.
- [RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", [RFC 4944](#), DOI 10.17487/RFC4944, September 2007, <<https://www.rfc-editor.org/info/rfc4944>>.
- [RFC4861] Narten, T., Nordmark, E., Simpson, W., and H. Soliman, "Neighbor Discovery for IP version 6 (IPv6)", [RFC 4861](#), DOI 10.17487/RFC4861, September 2007, <<https://www.rfc-editor.org/info/rfc4861>>.

Internet-Draft

IPv6 over WBANs

October 2017

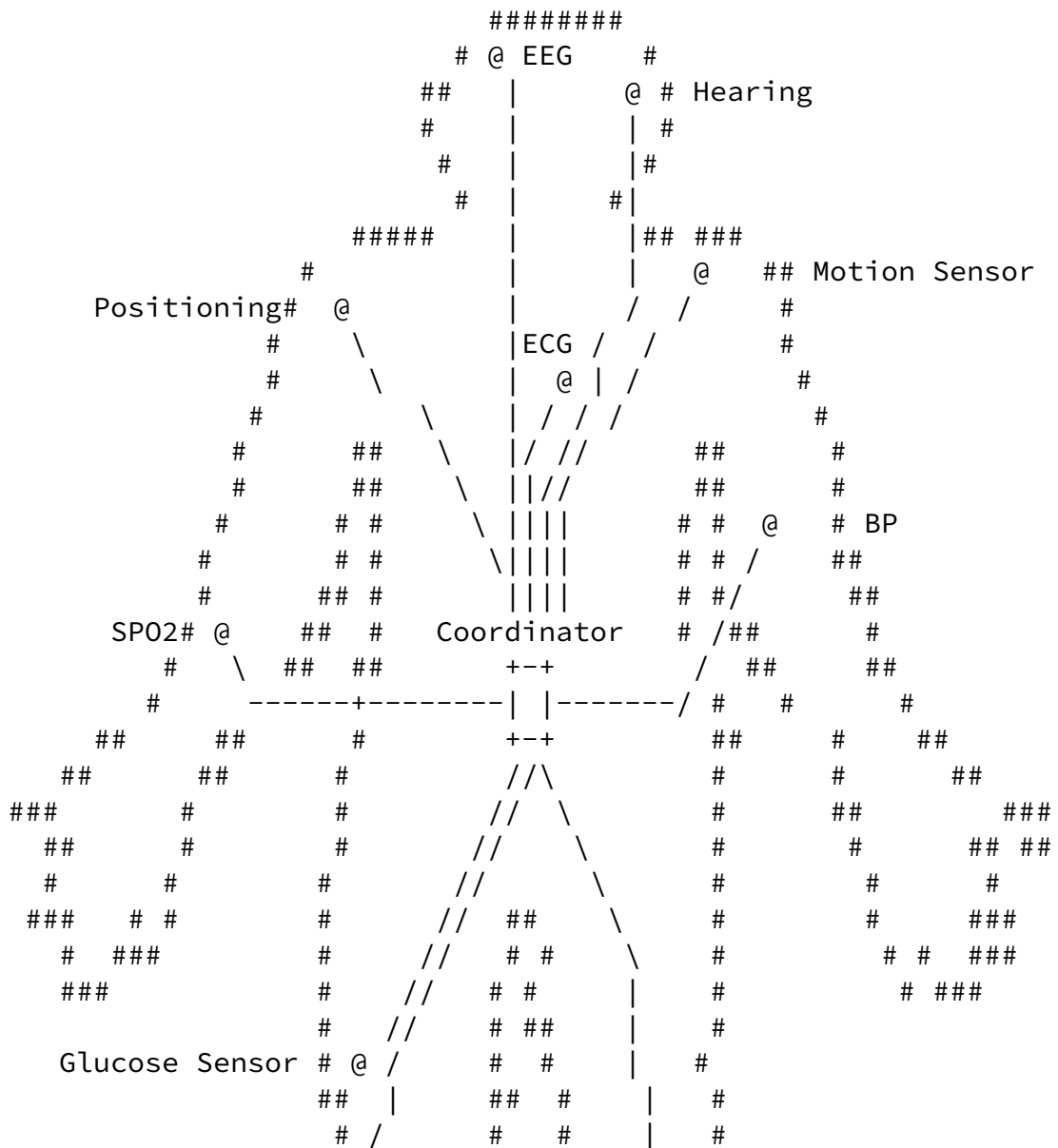
- [RFC4291] Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", [RFC 4291](#), DOI 10.17487/RFC4291, February 2006, <<https://www.rfc-editor.org/info/rfc4291>>.
- [RFC6282] Hui, J., Ed. and P. Thubert, "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks", [RFC 6282](#), DOI 10.17487/RFC6282, September 2011, <<https://www.rfc-editor.org/info/rfc6282>>.
- [RFC7400] Bormann, C., "6LoWPAN-GHC: Generic Header Compression for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)", [RFC 7400](#), DOI 10.17487/RFC7400, November 2014, <<https://www.rfc-editor.org/info/rfc7400>>.
- [RFC6775] Shelby, Z., Ed., Chakrabarti, S., Nordmark, E., and C. Bormann, "Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)", [RFC 6775](#), DOI 10.17487/RFC6775, November 2012, <<https://www.rfc-editor.org/info/rfc6775>>.

## 9.2. Informative References

- [IEEE802.15.6]  
"IEEE Standard, 802.15.6-2012 - IEEE Standard for Local and metropolitan area networks - Part 15.6: Wireless Body Area Networks", 2012, <<https://standards.ieee.org/findstds/standard/802.15.6-2012.html>>.
- [SURVEY-WBAN]  
Diffie, W., Samaneh Movassaghi, Mehran Abolhasan, Justin Lipman, David Smith, and Abbas Jamalipour, "Wireless body area networks: A survey", Communications Surveys and Tutorials, IEEE , vol. 16, no. 3, pp. 1658-1686, 2014.
- [MAC-WBAN]  
Minglei Shu, Dongfeng Yuan, Chongqing Zhang, Yinglong Wang, and Changfang Chen, "A MAC Protocol for Medical Monitoring Applications of Wireless Body Area Networks.",

[Appendix A](#). Patient monitoring use case - Spoke Hub

Refer following diagram:



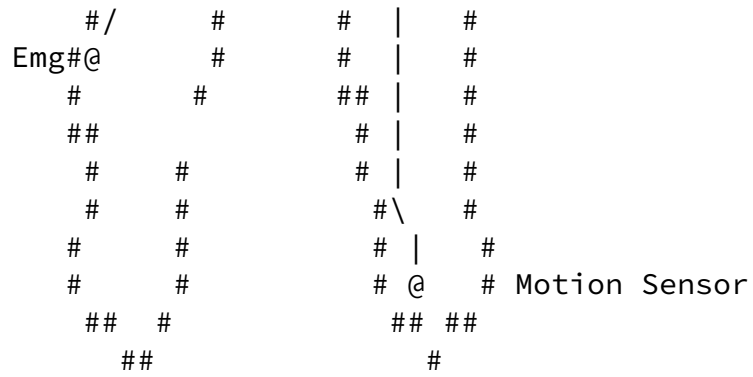
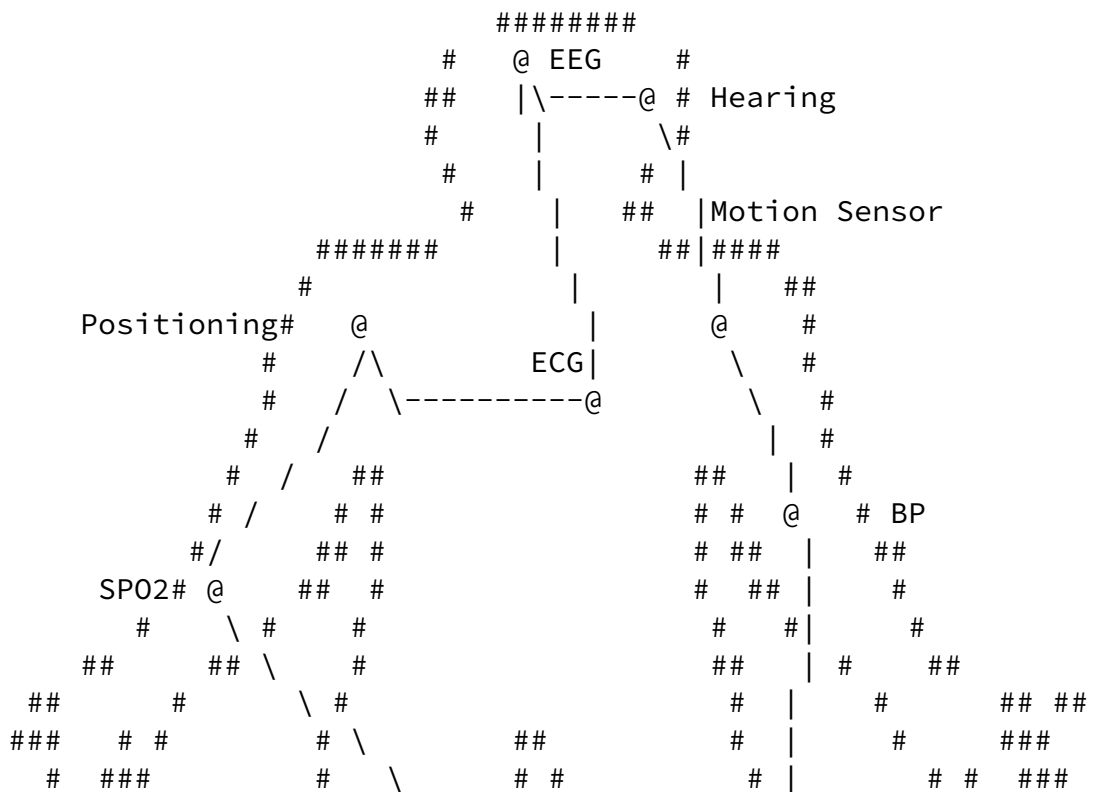


Figure 4: Patient monitoring use case - Spoke Hub

[Appendix B](#). Patient monitoring use case - Connected

Refer following diagram:



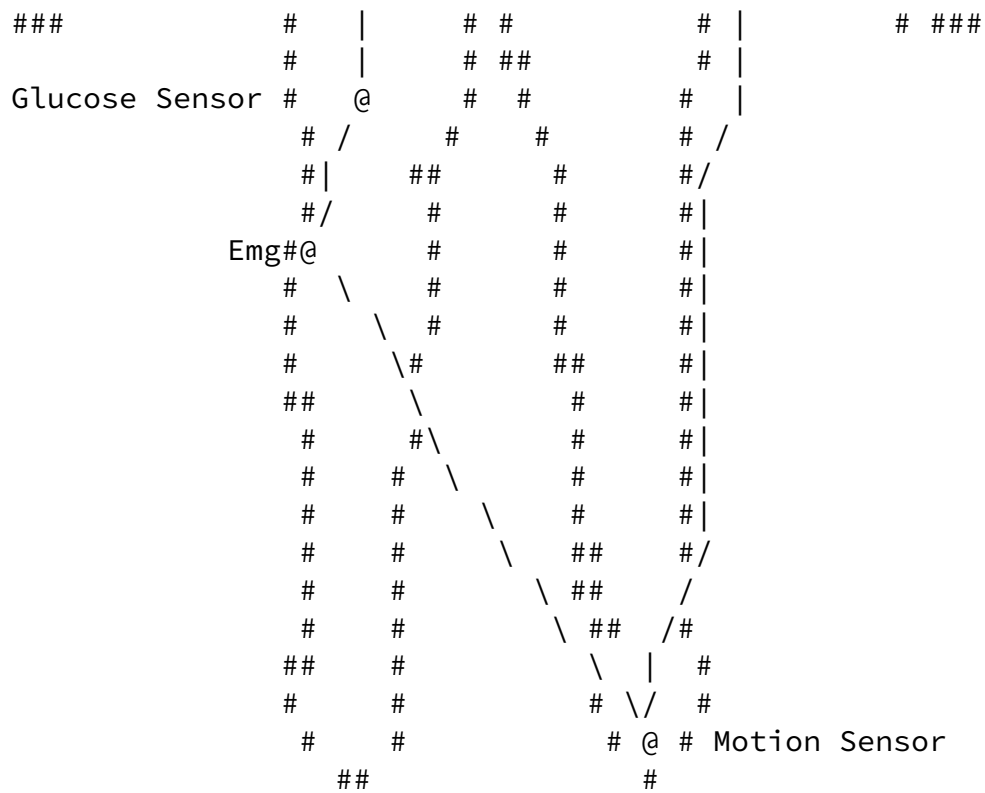


Figure 5: Patient monitoring use case - Connected

### [Appendix C.](#) Changes

Compared with version-00, this updated draft is no longer all informative. Two main changes have been made as below:

1. Introduction part of 802.15.6 is simplified and more focused on the features that relates to the 6lo-WBAN adaptation layer, e.g. MAC frame format including MAC address and MTU, topology and scope of communication, and why the 6lo-WBAN adaptation layer is needed.
2. The 6lo-WBAN adaptation layer is specified in this draft titled as "Specification of IPv6 over WBAN" that lists the main features needs to be added in the 6lo adaptation layer including the formation of IID, IPv6 link-local address, unicast address mapping, header compression, and fragmentation and reassembly. These parts have never been mentioned in other documents related to WBAN, and in this version, we provide a guidance for such IPv6

enabled WBAN implementations.

#### Authors' Addresses

Muhammad Sajjad Akbar  
Bournemouth University  
Fern Barrow, Dorset  
Poole BH12 5BB  
United Kingdom

Email: makbar@bournemouth.ac.uk

Abdur Rashid Sangi  
Huaiyin Institute of Technology  
No.89 North Beijing Road, Qinghe District  
Huaian 223001  
P.R. China

Email: sangi\_bahrian@yahoo.com

Mingui Zhang  
Huawei Technologies  
No. 156 Beiqing Rd. Haidian District  
Beijing 100095  
China

Email: zhangmingui@huawei.com

Akbar, et al.

Expires May 3, 2018

[Page 13]

---

Internet-Draft

IPv6 over WBANs

October 2017

Jianqiang Hou  
Huawei Technologies  
101 Software Avenue  
Nanjing 210012  
China

Phone: +86 15852944235  
Email: houjianqiang@huawei.com

Charles E. Perkins

Futurewei  
2330 Central Expressway  
Santa Clara 95050  
Unites States

Email: [charliep@computer.org](mailto:charliep@computer.org)

Alexandre Petrescu  
CEA, LIST  
CEA Saclay  
Gif-sur-Yvette, Ile-de-France 91190  
France

Phone: +33169089223

Email: [alexandre.petrescu@cea.fr](mailto:alexandre.petrescu@cea.fr)

Naveed Bin Rais  
Ajman University  
University Street, Al Jerf 1  
Ajman 346  
United Arab Emirates

Email: [naveedbinrais@gmail.com](mailto:naveedbinrais@gmail.com)