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Smart Body Area Network (SmartBAN);
Hub to Hub Communication for
SmartBAN Medium Access Control (MAC)

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Smart Body Area Network (SmartBAN).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

The present document defines technical specifications for hub to hub communication capability for ETSI SmartBAN. The specifications extend the general Medium Access Control (MAC) framework defined for SmartBAN by enabling the communication between hubs of two neighbouring SmartBANs.

Hub to hub communication procedure can be divided into eight steps as follows:

1) Hub to hub communication initialization.
2) Neighbour SmartBAN discovery.
3) Inter-beacon interval realignment.
4) Resource pre-allocation.
5) Hub to hub connection initialization.

6) Hub to hub channel access.

7) Modifying hub to hub connection.

8) Ending hub to hub communication.

The present document is structured as follows: firstly, the additional management frames and information units required for the hub to hub communication are defined. Secondly, the present document details the operational procedures for the hub to hub communications. Finally, Annex A includes two normative flowcharts defining the hub to communications.

Introduction

Modern medical and health monitoring equipment is moving towards the trend of wireless connectivity between the data collection or control centre and the medical devices or sensors. Therefore, a standardized communication interface and protocol between the actors are required. This network of actors performing some medical monitoring or functions is called a Smart Body Area Network (SmartBAN).

A SmartBAN is a simple, low complexity, low energy communication network that allows wireless connectivity between the devices and a hub. The distinct features of the SmartBAN are ease of access, minimal listening, reliable data transfer, and provision of additional control messages (in the form of C-Beacons) for the low-duty cycling nodes while maintaining a simple and flexible protocol. SmartBAN also provides a multi-use channel access mechanism for emergency and other high-priority access and improved channel utilization.

The basic access specifications for Medium Access Control (MAC) are defined in [1] and for physical layer (PHY) in [2]. The present document extends [1] by defining technical specifications for hub to hub communications enabling communication between the hubs of neighbouring SmartBANs.

Additional information can be found in the following documents:

- ETSI EN 300 328-1 [i.1] defines requirements for equipment operating in the 2,4 GHz ISM band;
- IEEE 802.15.6-2012 [i.2] defines an alternative standard for Wireless Body Area Networks; and
- IEEE 802.15.4-2011 [i.3] defines a standard for Wireless Personal Area Networks;
- ETSI TS 103 805 [i.4] defines relay functionality for SmartBAN MAC defined in ETSI TS 103 325 [1].

1 Scope

The present document extends the low complexity Medium Access Control (MAC) for SmartBAN defined in ETSI TS 103 325 [1] with hub to hub communication capability. The main scope of the present document is to define specifications for enabling hub to hub communication between the hubs of neighbouring SmartBANs.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 325 (V1.2.1) (2022-07): "Smart Body Area Network (SmartBAN); Low Complexity Medium Access Control (MAC) for SmartBAN".

[2] ETSI TS 103 326 (V1.2.1) (2021-07): "Smart Body Area Network (SmartBAN); Enhanced Ultra-Low Power Physical Layer".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 300 328-1 (V1.3.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using spread spectrum modulation techniques; Part 1: Technical characteristics and test conditions".

[i.2] IEEE™ 802.15.6-2012: "IEEE Standard for Local and metropolitan area networks - Part 15.6: Wireless Body Area Networks".

[i.3] IEEE™ 802.15.4-2011: "IEEE Standard for Local and metropolitan area networks - Part 15:4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specification for Low-Rate Wireless Personal Area Networks".

[i.4] ETSI TS 103 805: "Smart Body Area Network (SmartBAN); Relay Functionality for SmartBAN Medium Access Control (MAC)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

active period: period within the superframe period that is ready for frame reception and transmission

active state: internal power management state that is ready for the frame reception and transmission

allocation: one or more time intervals that a node or a hub obtains using an access method for initiating one or more frame transactions

beacon: frame transmitted by a hub to facilitate network management, such as the coordination of medium access and power management of the nodes in the SmartBAN, and to facilitate clock synchronization therein

beacon period: duration when a beacon is transmitted

connection: relation between a node and a hub in a Body Area Network (BAN), substantiated by an identification assigned to the node by the hub and by access arrangement between them

device: entity conforming to the SmartBAN medium access control and physical interface to the wireless medium

downlink: communication link for transfer of management and data traffic from a hub to a node, or in the context of the hub to hub communication, from target hub to initiating hub

frame: uninterrupted sequence of octets delivered by the Medium Access Control (MAC) sublayer to the Physical (PHY) layer, or vice versa, within a node or a hub

hub: entity that possesses a node's functionality and coordinates the medium access and power management of the nodes in the SmartBAN

hub to hub mode: optional enhanced operation mode where hubs of neighbouring SmartBANs may form a connection, obtain allocation(s), and transmit and receive management and data traffic between them

inactive period: period in time following an active transmission sequence during which the equipment other than the hub does not transmit or receive

medical device: any instrument, apparatus, appliance, software, material or other article, whether used alone or in combination, together with any accessories, including the software intended by its manufacturer to be used specifically for diagnostic and/or therapeutic purposes and necessary for its proper application, intended by the manufacturer to be used for human beings for the purpose of:

- diagnosis, prevention, monitoring, treatment or alleviation of disease;
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury or handicap;
- investigation, replacement or modification of the anatomy or of a physiological process;
- control of conception;

and which does not achieve its principal intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its function by such means

multi-use channel access mode: mode of operation where the slot structure during the scheduled and control and management periods is accessible by multiple different priorities based on a temporal order

node: entity conforming to the SmartBAN medium access control and physical interface to the wireless medium

operating frequency: frequency at which the equipment can be operated

priority channel access: highest priority access during multi-use channel access

relay: node entity that is temporarily assigned by the hub the functionality to relay frames received from the node to the hub or vice versa

relay mode: optional enhanced operation mode where a node entity is temporarily assigned by the hub the functionality to relay frames received from another node to the hub and vice versa

re-use channel access: lowest priority access during multi-use channel access enables re-use of scheduled but not utilized slots

scheduled access: one or more scheduled reoccurring time intervals that a node and a hub obtains using scheduled access for initiating frame transactions

NOTE: A scheduled allocation is an uplink or downlink allocation suitable for servicing high or low duty cycle periodic or quasi-periodic traffic on a committed schedule.

star network: logical network partition comprising a hub and zero or more nodes whose medium access and power management are coordinated by the hub

uplink: communication link for transfer of management and data traffic from a node to a hub, or in the context of hub to hub communication, from initiating hub to target hub

3.2 Symbols

For the purposes of the present document, the following symbols apply:

×	Mathematical multiplication of the term immediately preceding the symbol and the term immediately following the symbol
CP_{max}	Maximum Contention Probability
CP_{min}	Minimum Contention Probability
GHz	Gigahertz
L_D	Number of time slots in Inter-Beacon Interval
L_F	Length of MAC Frame Body (bits)
MHz	Megahertz
N_{CM}	Number of time slots in Control and Management Period
N_S	Number of time slots in Schedule Period
T_C	Interval between control channel beacons
T_D	Inter-Beacon Interval
T_{MUA}	Total duration of sensing period in Multi-use Channel Access
T_S	Duration of a time slot

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK	Acknowledgement
BAN	Body Area Network
C-Ass	Connection Assignment
C-Beacon	Control channel Beacon
CCH	Control Channel
C-Frame	Control Frame
D-Beacon	Data channel Beacon
DCH	Data Channel
D-Frame	Data Frame
EUI-48™	Extended Unique Identifier-48 bits
H-Conf	Hub to Hub Connection Confirmation
H-Creq	Hub to Hub Connection Request
IM	Information Module
ISM	Industrial, Scientific and Medical
IU	Information Units
MAC	Medium Access Control
PHY	Physical layer

S-Ras Slot Reassignment
WBAN Wireless Body Area Network

4 General MAC Framework

4.0 Different device types

This clause provides the basic MAC framework for the nodes and hubs.

Two different device types can participate in SmartBAN: medical sensor device (node) and coordinator device (hub). A hub is a device that acts as a SmartBAN coordinator. A node is any device that acts as an information source or an information sink. A relay is a node entity temporarily assigned by the hub the functionality to relay frames received from the node to the hub or vice versa. One hub and at least one node constitute a SmartBAN.

A SmartBAN shall be organized into a star topology consisting of at least one node communicating directly with the hub.

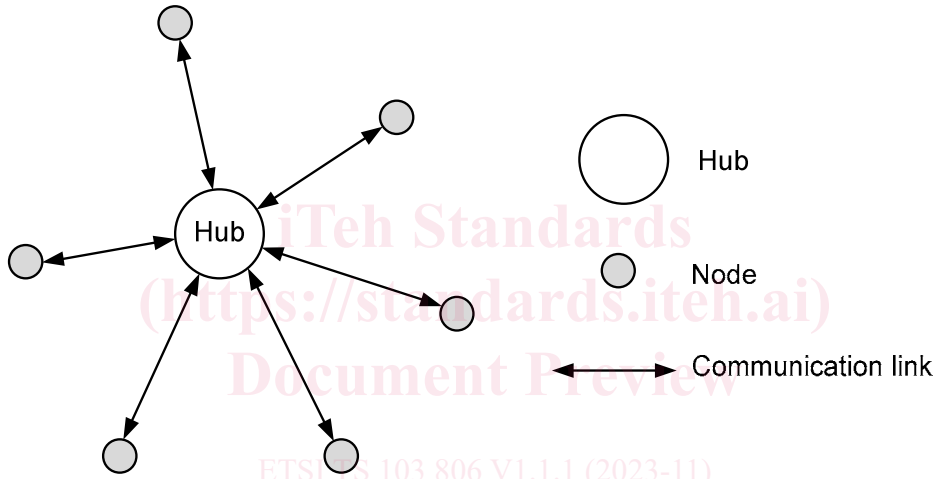

Figure 1: SmartBAN Topology

The hub and nodes shall communicate using communication media known as channels. A SmartBAN shall use two different channel entities to enable communication between the hub and nodes. The channel entities are assigned the following names:

- Data Channel (DCH).
- Control Channel (CCH).

Each SmartBAN shall utilize one Control Channel (CCH) and one Data Channel (DCH) at any one time.

4.1 Frequency Spectrum

Defined in ETSI TS 103 325 [1].

4.2 Channel Format

Defined in ETSI TS 103 325 [1].

4.3 User Priorities

Defined in ETSI TS 103 325 [1].

4.4 Node IDs

Defined in ETSI TS 103 325 [1].

4.5 Information Units

Information Units (IUs) encapsulate the required information for specific operations. IUs shall be defined as follows:

- IUs for Management, Control, and Data frame types:
  - Defined in ETSI TS 103 325 [1].
- IUs for General purpose frame type:
  - Operations requiring IUs shall use the appropriate Element ID listed in Table 1. An IU shall be formatted as in Figure 2.

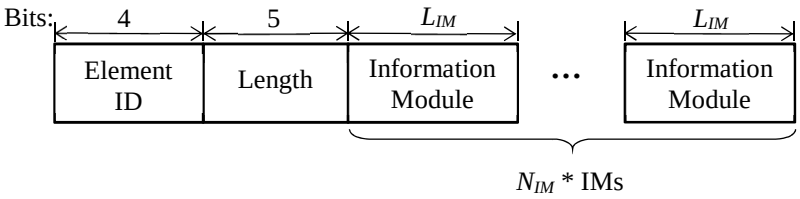

Figure 2: Structure of an Information Unit for General Purpose Frame Type

Table 1: Element ID for relay connectivity and hub to hub communication operations

Element ID	Operation	Notation	Description
0000	Isolated Node Notification	I-Notif	The way an isolated node notifies to the WBAN about its new status
0001	Node Status Request	N-Sreq	Explains the node status requirement when a certain node does not transmit in its scheduled slots
0010	Isolated Node Notification Listen	I-Listen	Explains the command details given to the nodes to start listening to Isolated Node Notifications
0011	Relay Nomination	R-Nom	Explains the details about the R-Beacon transmission period
0100	Proposed Relay Link Status	R-Status	Explains if the proposed relay link is successful/unsuccessful
0101	Stop Isolated Node Listening	S-Listen	Explains the command details given to the nodes to stop listening to Isolated Node Notifications
0110	Relay Connection	R-Conn	Describes the details of the relay connection
0111	Isolated Node Slot Reassignment ACK	I-SAck	Acknowledgement by the Isolated node for the new slot allocations
1000	Relay Disconnection Request	R-Dreq	Explains the requirement for a relay disconnection
1001	Relay Beacon	R-Beacon	Explains the beacon frame transmitted from a Relay to an isolated node
1010	Hub to Hub Connection Request	H-Creq	Specifies connection request command from a hub to request connection with a neighbouring hub
1011-1111	Reserved		Reserved

5 Frame Formats

5.1 MAC General Frame Format

Defined in ETSI TS 103 325 [1].