ETSI TS 103 325 V1.1.1 (2015-04)

Smart Body Area Network (SmartBAN); Low Complexity Medium Access Control (MAC) for SmartBAN

Reference

DTS/SmartBAN-005

Keywords

health, interface, interoperability, protocol

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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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1 Scope

The present document specifies low complexity medium access control (MAC) for SmartBAN.

The present document applies to short range, wireless communication between wearable sensors devices and the hub coordinator. The present document specifies MAC protocol designed to facilitate spectrum sharing with other devices.

The specification describes:

- Channel Structure.
- MAC Frame Formats.
- MAC functions.

The devices are capable of operating in all or any part of the frequency band shown in Table 1.

Table 1: Industrial, Scientific and Medical (ISM) frequency band

Direction of Transmission	Industrial, Scientific and Medical (ISM) frequency band
Transmit / Receive	2,4 GHz to 2,4835 GHz

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 reference document (including any amendments) applies.

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

[1] ETSI TS 103 326 (V1.1.1) (2015-03): "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 reference 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) (2001-12): "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™ Std. 802.15.6-2012: "IEEE Standard for Local and metropolitan area networks - Part 15.6: Wireless Body Area Networks".

[i.3] IEEE™ Std. 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".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions 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

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 coordinated the medium access and power management of the nodes in the SmartBAN

inactive period: period in time following an active transmission sequence during which the equipment 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

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

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
CRC	Cyclic Redundancy Check
C-Req	Connection Request
D/SR	Downlink/Slot Reassignment
D-Beacon	Data Channel Beacon
DCH	Data Channel
D-Frame	Data Frame
DL	Downlink
D-Req	Disconnection Request
D-Res	Disconnection Response
EUI-48™	Extended Unique Identifier-48 bits
FCS	Frame Check Sequence
FEC	Forward Error Correction
IFS	Inter-Frame Spacing
IM	Information Module
ISM	Industrial, Scientific and Medical
IU	Information Units
MAC	Medium Access Control
NACK	Negative Acknowledgement
NID	Node ID
PHY	Physical Layer
REP	Repetition Coding
Rx	Receive

S-Ras	Slot Reassignment
Tx	Transmit
UL	Uplink

4 Introduction and Background

Modern medical and health monitoring equipment are moving towards the trend of wireless connectivity between the data collection or control centre and the medical devices or sensors. Therefore, the need for 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, provision of additional control messages (in the form of C-Beacons) for the low duty cycling nodes while maintaining simple and flexible protocol. SmartBAN also has provision for multi-use channel access mechanism for emergency and other high priority access and for improved channel utilization.

The distinct characteristics of the SmartBAN are:

i) asymmetrical relation between hub and the device, where the hub performs most scheduling and computations;

ii) minimized listening period for the node;

iii) additional provisioning of beaconing messages and thus reliable and enhanced connectivity.

5 General MAC Framework

5.0 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. 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.

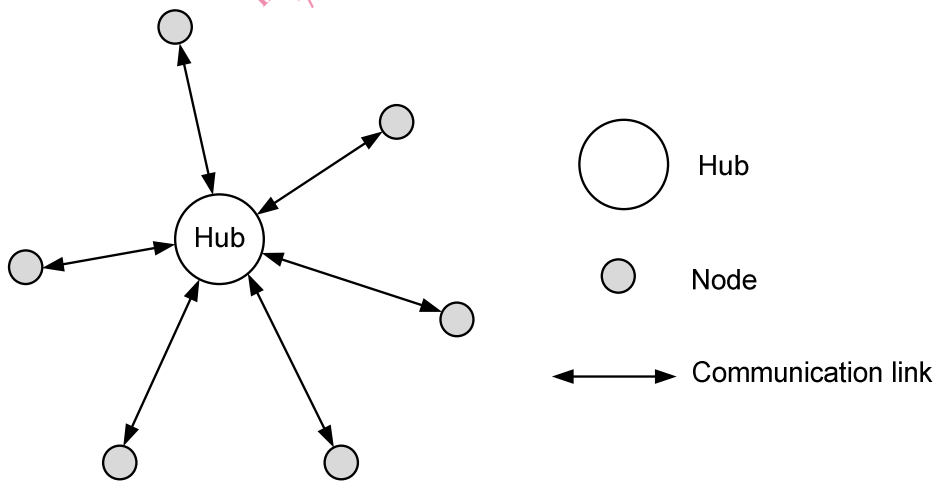

Figure 1: SmartBAN Topology

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.

5.1 Frequency Spectrum

The frequency of operation shall fall within 2 401 - 2 481 MHz. The channels shall be arranged in blocks of 2 MHz with centre frequencies:

$$f_c = 2\,402 + 2\times n \text{ MHz, where } n = 0 \text{ to } 39.$$

The channels are categorized into data and control channels with:

- 3 Control channels, where control frames (in the form of Control Channel Beacon) from the hub is transmitted;
- 37 Data channels, where data, control, and management frames are transmitted.

The list of channels can be found in ETSI TS 103 326 [1].

5.2 Channel Format

5.2.1 Control Channel (CCH) Format

Only hub devices shall transmit on control channels. A hub shall select one control channel from the list of control channels in ETSI TS 103 326 [1], Table 1 and transmit one control beacon frame (C-Beacon) on the chosen control channel (CCH) every T_C seconds. The format of the C-Beacon is set out in clause 6.1.

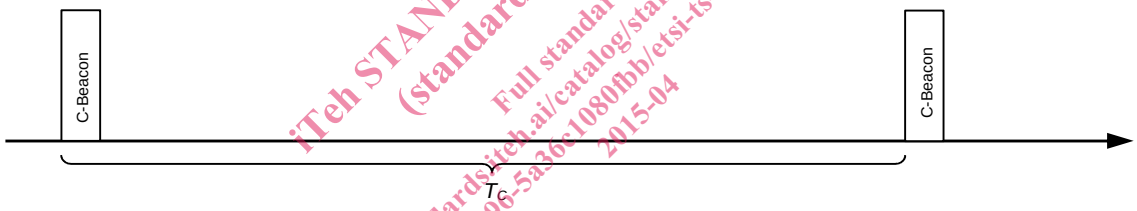

Figure 2: Control Channel

5.2.2 Data Channel (DCH) Format

5.2.2.0 Data channel description

Both hub and node devices may transmit on the data channels. A hub shall select one data channel from the list of data channels in ETSI TS 103 326 [1], Table 1 on which both hub and node devices in the associated SmartBAN may transmit. For any SmartBAN, the data channel is partitioned into time intervals of T_D seconds, known as the Inter-Beacon Interval. The boundaries of each Inter-Beacon Interval shall be marked by the transmission of a data channel beacon (D-Beacon). A hub shall transmit a D-Beacon at the beginning of each Inter-Beacon Interval.

Each Inter-Beacon Interval shall be partitioned into L_D distinct time epochs known as slots. The duration of each time slot is T_S. The duration of each Inter-Beacon Interval shall be $L_D \times T_S$ seconds. Any device transmitting in a time slot shall ensure that the transmission takes place within the duration of that time slot.

Each Inter-Beacon Interval shall consist of four distinct periods:

- Beacon Period, consisting of one single time slot, where the D-Beacon frame shall be transmitted by the hub. No nodes shall transmit in this period;
- Scheduled Period, consisting of N_S time slots, where scheduled transmissions and acknowledgements occur;
- Control and Management Period, consisting of N_{CM} time slots, where unscheduled access, and management and control signalling occur;