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Smart Body Area Networks (SmartBAN);
System Description

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Foreword

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

Modal verbs terminology

In the present document "**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 describes the system description of Smart BAN.

SmartBAN addresses the five major features below:

1) Smart Body Area Networks (SmartBAN) Unified data representation formats, semantic and open data model.
2) SmartBAN Data representation and transfer, service and application; Standardized interfaces, APIs and infrastructure for heterogeneity and interoperability management.
3) SmartBAN Measurements and Modelling of SmartBAN RF environment.
4) Low complexity MAC and routing for SmartBAN.
5) Enhanced, ultra-low power PHY for SmartBAN.

The following technologies are also to be defined:

- smart control;
- network management;
- implant communications;
- security; and
- privacy mechanisms.

SmartBAN takes a comprehensive view of BAN from lower layer (e.g. physical layer and MAC layer) to higher layer system aspects and end-to-end (e.g. heterogeneity management and semantic interoperability and monitoring and control). End-to-end connectivity (e.g. SmartBAN to Medical Centre or SmartBAN to SmartBAN) is illustrated by figure 1.

Figure 1: Scope of SmartBAN

SmartBAN facilitates the efficient use of multiple radio technologies. This will be handled in all the layers including semantic interoperabilities and a BAN coordinator will be introduced for that purpose (figure 2). This coordinator will also provide mandatory functionality related to routing and interactions with other application domains that includes e.g. SmartM2M, automotive, smart home environments.

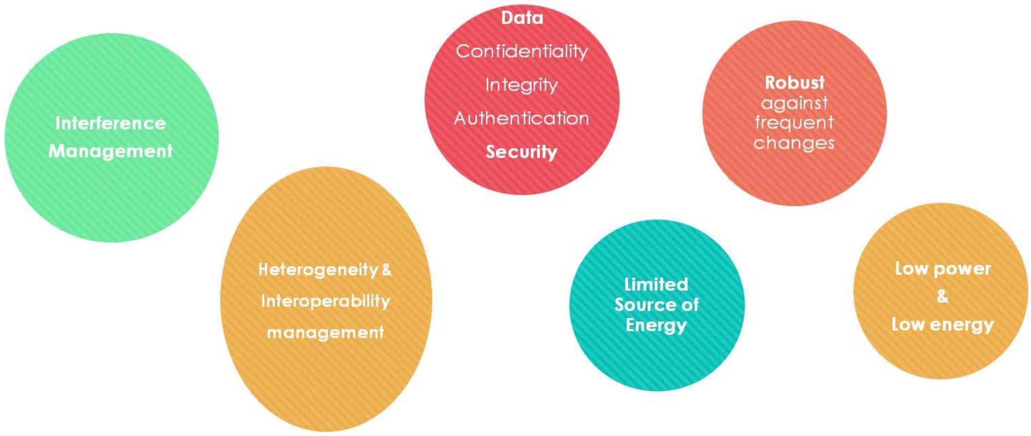

Figure 2: Summary of the SmartBAN environment main constraints

Figure 3 provides a an example of a possible future multi-radio (e.g. narrowband 2,4 GHz and UWB). The controller may be e.g. a handset or other device while other, simpler devices (e.g. smart watch or wristband) may serve as a relay/bridge within the BAN offering enhanced performance/robustness (e.g. relay around hidden devices) as well as opening the door for optimized SmartBAN solutions with enhanced connectivity (multi-radio).

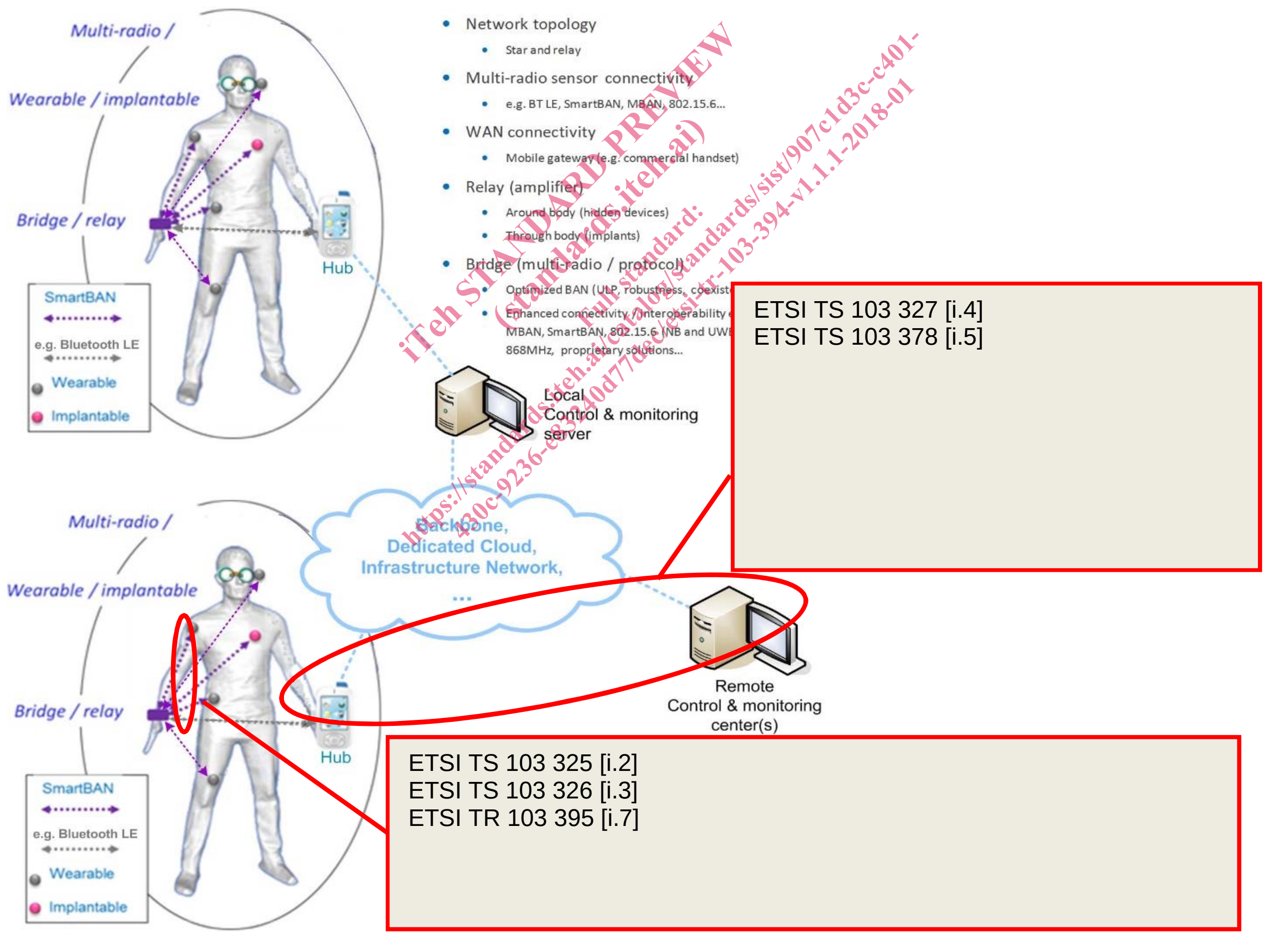

Figure 3: Future SmartBAN

2 References

2.1 Normative references

Normative references are not applicable in the present document.

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

[i.2] ETSI TS 103 325 (V1.1.1) (04-2015): "Smart Body Area Network (SmartBAN);Low Complexity Medium Access Control (MAC) for SmartBAN".

[i.3] ETSI TS 103 326 (V1.1.1) (04-2015): "Smart Body Area Network (SmartBAN);Enhanced Ultra-Low Power Physical Layer".

[i.4] ETSI TS 103 327: "Smart Body Area Networks (SmartBAN); Service and application standardized enablers and interfaces, APIs and infrastructure for interoperability management".

[i.5] ETSI TS 103 378 (V1.1.1) (12-2015): "Smart Body Area Networks (SmartBAN) Unified data representation formats, semantic and open data model".

[i.6] ETSI TS 103 378 (V1.2.1): "Smart Body Area Networks (SmartBAN) Unified data representation formats, semantic and open data model".

[i.7] ETSI TR 103 395: "Smart Body Area Network (SmartBan); Measurements and modelling of SmartBAN Radio Frequency (RF) environment".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

example 1: text used to clarify abstract rules by applying them literally

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
D	Delay
⊕	eXclusive OR (XOR)

3.3 Abbreviations

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

BAN	Body Area Network
BCH Code	Bose- Chaudhuri- Hocquenghem Code
BTLE	BlueTooth Low Energy
Dch	Data Channel
ECG	ElectroCardioGram
FCS	Frame Check Sequence
FEC	Forward Error Correction
IoT	Internet of Things
ISM	Industrial, Scientific and Medical
MAC	Medium Access Control
O&M	Observations and Measurements
OntoSensor	OntoSensor sensor ontology
OWL DL	Web Ontology Language Description Logic
OWL	Web Ontology Language
PHY	Physical Layer
PSDU	Physical Layer Service Data Unit
QoS	Quality of Service
RF	Radio Frequency
SensorML	Sensor Model Language
SSN	Semantic Sensor Network
SWSSN	Web-based Semantic Sensor
UWB	Ultra Wide Band
WSN	Wireless Sensor Network
WSSN	Wireless Semantic Sensor Network

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).

BAN uses small sensing devices and will need to meet the following technical requirements.

1) Very high energy efficiency:
BAN sensing nodes needs to be small and have batteries capable of providing sufficient power without charging.

2) Co-existence between other BANs or systems:
One of the possible channels for BAN is the Industrial, Scientific, and Medical (ISM) band which is used by wireless LANs and other systems. Additionally, BANs are moving with each other as the BAN users are moving. BAN is required to co-exist with other systems and neighbouring BANs.

3) Optimum control of QoS:
The sensing data has various transmission rates, allowable delay and allowable packets error rate. BAN should facilitate the transfer of these various sensing data with optimum QoS. Additionally, for medical care, minimizing the latency of emergency signals is also important.

4) Timely Access mechanism:
Node needs to connect to an intended hub within a short time.

In the present document, the system level description of SmartBAN is given. It also contains possible use cases for SmartBANs.

5 Comparisons with Other Related Standards

Table 1

Parameter		SmartBAN concept	BTLE	IEEE 802.15.6™ [i.1]
General system specs	System Architecture	Hub + smart relay coordination	One hub	One hub
	Networking communication interoperability (SmartBAN and non-SmartBAN nodes)	Yes	No	No
	Smart relay	Yes	No	No
PHY/MAC	FEC (forward error correction)	Yes	No	Yes
	Initial set up time	Fast	Less fast	Less fast
	Spread spectrum hopping	No	Yes	Yes (in limited cases)
	Channel reassignment	Yes	No	Multiple channel
	Very low latency emerging messaging	Very fast (timeslot)	No	Medium (superframe)
	Reutilization of scheduled unused time slots (efficiency parameter)	Yes	No	No
	Energy consumption/efficiency	Low (e.g. long sleep times)	Low	Medium
	Network complexity	Star concept + multi hub relay (planned)	Star concept	Star concept + relay
Smarts	Semantic approach, semantic interoperability, heterogeneity management, IoT compliance	Yes	No	No
	Additional semantic and data analytic enablers (e.g. semantic discovery, reasoning/rules)	Yes	No	No
	Automatic node discovery (e.g. semantic discovery of nodes, composition)	Yes	Partially	No
	Coexistence management by coordinator	High	Low	Low

6 Use Cases

6.0 Introduction

A number of use cases have been identified as potential scenarios for SmartBAN in this clause. These use cases serve as examples of scenarios from which the requirements are derived.

6.1 Safety Monitoring

Table 2

Category	Healthcare	Elderly care			
Situations	Home	Outdoors			
Example of Use case					
Attaching patch-type sensors on an elderly adult body, an alert signal and his/her pulse data are transmitted to the data server when he/she feels physically sick. These data and signal are also reported to care workers immediately.					
Necessity of accurate time stamping on the sensor data	Yes				

Sensors	Sampling rate/ quantization	Bit rate	Communication distance	# of Nodes	Real time/ Non real time
pulse wave or ECG	10 - 16 bit, 64 Hz - 1 kHz	640 bps - 16 kbps	up to 1,5 m	1	Real time
Accelerometer (body motion, posture)	10 - 16 bit, 64 Hz - 1 kHz	640 bps - 16 kbps	up to 1,5 m	1	Real time

6.2 Fall Monitoring

Table 3

Category	Healthcare	Elderly care	Fitness		
Situations	Home	Outdoors			
Example of Use case					
Attaching patch-type sensors on an elderly adult body, an alert signal is transmitted to the data server when detecting his/her falling. This signal is in parallel transmitted to care workers immediately.					
Necessity of accurate time stamping on the sensor data		Yes			
Sensors	**Sampling rate/ quantization**	**Bit rate**	**Communication distance**	**# of Nodes**	**Real time/ Non real time**
Accelerometer/gyroscopic all-in-one sensor (multiple number of sensors are attached on a body)	10 - 16 bit, 500 Hz - 1 kHz	5 kbps - 16 kbps	up to 1,5 m	1 to 3	Real time, Near real time

6.3 Stress Monitoring

Table 4

Category	Healthcare				
Situations	Home	Outdoors	Office		
Example of Use case					
Logging daily physical and emotional stress and use the data for health management.					
Necessity of accurate time stamping on the sensor data		Yes			
Sensors	**Sampling rate/ quantization**	**Bit rate**	**Communication distance**	**# of Nodes**	**Real time/ Non real time**
pulse wave or ECG	10 - 16 bit, 64 Hz - 1 kHz	640 bps - 16 kbps	up to 1,5 m	1	Non real time