Project: P802.15 Working Group for Wireless Specialty Networks

Submission Title: ETSI TC Smart BAN Updates

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Abstract: ETSI Technical Committee on Smart BAN has been promoting research and development on dependable wireless systems for wide variety of applications of BAN, such as radio controlling, automotive control etc. by extending e-Health regarding medical BAN and so on. These slides may offer opportunity to discuss on use-cases and applications of this standard

Purpose: The discussion on use-cases and applications could lead definitions and requirements of current ongoing research and development on dependable wireless networks

Content

- Motivation
- SmartBAN in brief
- Use-cases
- Summary
- List of published ETSI documents

Motivation

- IoT utilization is spreading fast in modern home and industrial automation, but it can also be utilized in healthcare domain.
  - Wearables and other health and wellbeing related personal devices carried by humans, or even implanted inside a human, are being more popular in healthcare.
  - Low power consumption devices could enable seamless 24/7 monitoring, control and actuation functions for various use-cases to assist healthcare professionals and patients.

Motivation

- The ETSI SmartBAN is a European initiative towards wider wireless body area networks (WBAN) utilization.
- This presentation summaries shortly the SmartBAN standard and its utilization in medical IoT (mIoT) applications in heterogeneous radio environment.
- The ETSI SmartBAN standard is defining physical and medium access control layers (PHY/MAC), as well as semantic interoperability mechanisms, heterogeneity management and security for smart WBAN.

Motivation

- The work towards smart BAN standardization under the ETSI Technical Committee (TC) SmartBAN started in 2013.
- Our goal is to have a reliable, low-power and interoperable standard to boost WBAN technology development and adaptation to global mIoT markets.

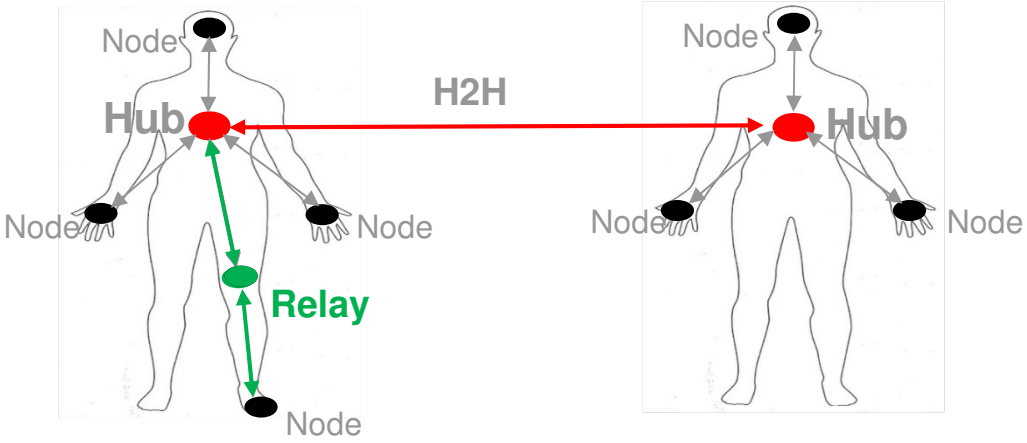
SmartBAN in brief – Architecture

- The SmartBAN network is controlled by the network coordinator, called as a Hub, which is the most powerful device associated to the network.
- The SmartBAN sensor nodes connected to the Hub can consist of reduced functionalities and thus they could consume much less energy and be cheaper.
  - Maximum number of nodes is 16, being typically < 8
- The maximum range is less than 2 m.
  - Based on the human's dimensions

SmartBAN in brief – Architecture

- The current SmartBAN system model is based on a one-hop star network topology.
  - Ongoing revision work to support relay functionality
  - and Hub-to-Hub (H2H) communications

H2H: e.g.,
patient <–> doctor
patient <-> medical device



SmartBAN in brief – Operational assumptions

- SmartBAN devices need to be energy efficient.
- They need to co-exist with the other radio systems sharing the same space and frequency band.
- System needs to fulfil pre-defined quality of service (QoS) requirements.

Smart Body Area Networks (SmartBAN); System Description. ETSI TR 103 394.

- SmartBAN is providing fast channel access mechanism and supports prioritized traffic for nodes to communicate with the hub.

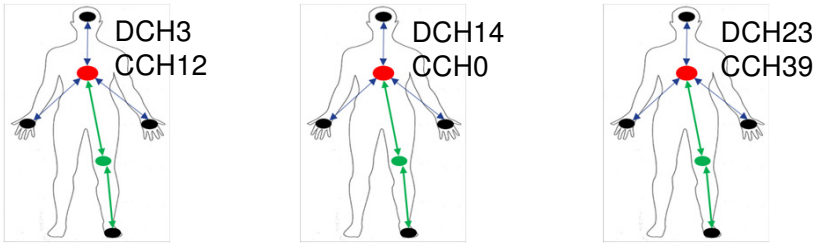
SmartBAN in brief – Physical layer

- SmartBAN is operating at unlicensed 2.4 GHz ISM band consisting of forty 2 MHz physical channels at the frequency band from 2401 MHz to 2481 MHz with center frequencies of

  $f_c = 2402 \text{ MHz} + 2*n \text{ MHz}, n = 0 \ldots 39.$
- Channels Ch0, Ch12 and Ch39 are dedicated to control information, and they are named as Control Channels (CCH).
- The other 37 channels are reserved for data payload and those are called as Data Channels (DCH).

SmartBAN in brief – Physical layer

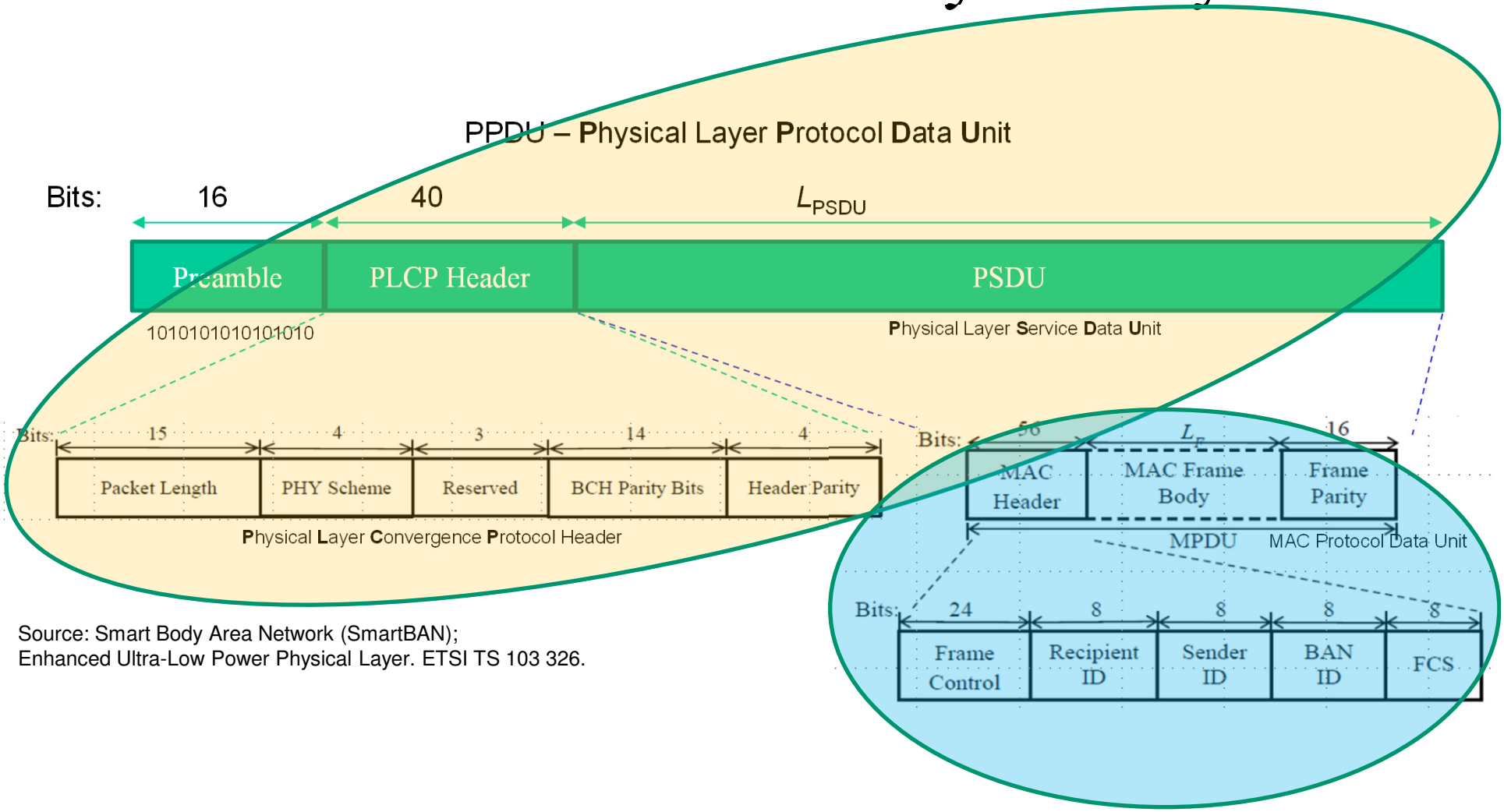
- Hub is using CCH to broadcast control channel beacon (C-Beacon) with essential network information.
  - hub address, slot length, time slots, interference mitigation mechanism, duty cycling, DCH channel number, initial state for scrambling, and time stamp
- All data, as well as control and management information, is transmitted using bidirectional DCH.
- One established SmartBAN is using only one CCH and DCH.
  - frequency hopping, like BLE does, is not supported
  - hub decides the channels to be used
- Interference mitigation and coexistence managements with adjacent SmartBAN networks are handled using different CCHs and DCHs per each network.



SmartBAN in brief – Physical layer

- Data modulation is Gaussian frequency shift keying (GFSK)
  - modulation index $h = 0.5$ and bandwidth-bit period product $BT = 0.5$.
- Data rate is nominally 1 kbps to 100 kbps, but it is scalable up to 1 Mbps.
- **Forward error control** (FEC) and **repetition coding** are used to improve a transmission quality.
  - instead of using bit-vice repetition coding (like e.g., IEEE802.15.6), repetition is done packet-vice by sending Physical Layer Protocol Data Unit (PPDU) either 2 or 4 times, or just only once.

SmartBAN in brief – Physical layer

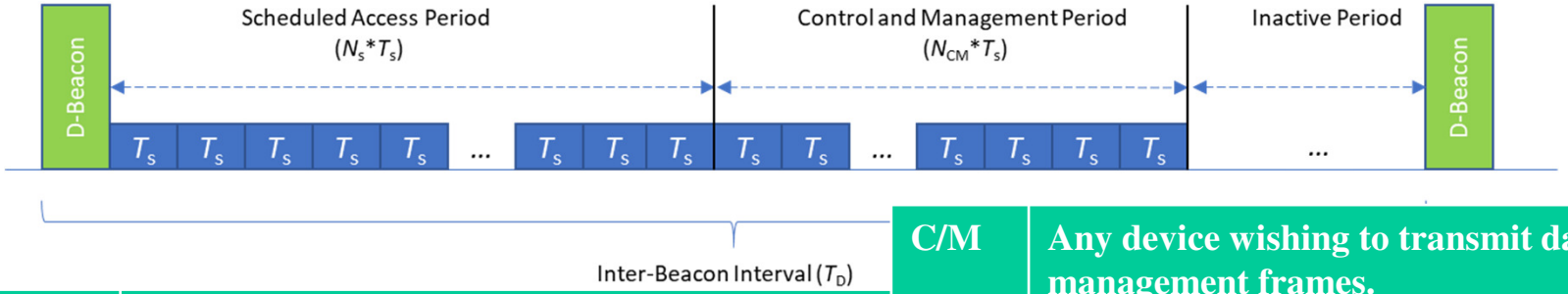


Source: Smart Body Area Network (SmartBAN);
Enhanced Ultra-Low Power Physical Layer. ETSI TS 103 326.

Source: Smart Body Area Network (SmartBAN);
Low Complexity Medium Access Control (MAC) for SmartBAN. ETSI TS 103 325.

SmartBAN in brief – MAC layer

- One of the goals in SmartBAN was to define a simple MAC, which still enables efficient functionalities.
- The main block in MAC layer is a superframe called as an *Inter-Beacon Interval* (IBI).
- IBI is divided into three parts: *scheduled access period* (SAP), *control and management period* (C/M) and *inactive period*.



SAP	**For data transmission. Each node has its own reserved slot**
C/M	**Any device wishing to transmit data or management frames. Slotted-Aloha, if enough resources were not granted during SAP.**

SmartBAN in brief – MAC layer

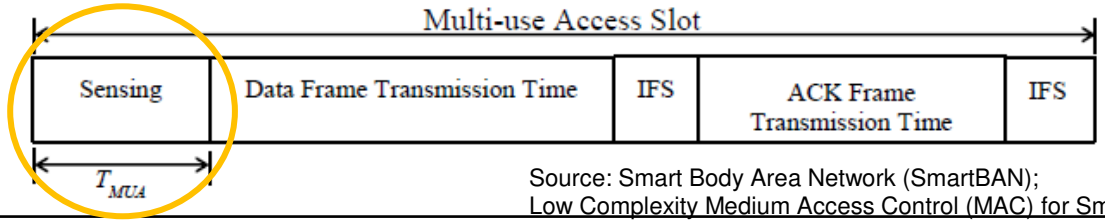
- SmartBAN introduces a novel channel access method called as a Multi-use Channel Access (MCA).
- Very-low latency (about ms) emergency/highest priority transmissions using Priority Channel Access (PCA).
  - order of slot time instead of frame as typically in other Standards
  - 4 user priority classes

User Priority	Data Type
0	Low priority
1	Mid priority
2	High priority
3	Very High (Emergency)

- Can be used in both Scheduled Access, and Control and Management Periods
- Utilization of scheduled but unused time slots by secondary users is to improve channel usage.

SmartBAN in brief – MAC layer

- *Multi-use Channel Access* is an optional feature.
  - Mandatory: Hubs **need** always to support MCA!
  - Nodes, on the other hand, **shall** always support Scheduled Channel Access and Slotted Aloha Channel Access, and they **may** support MCA.
  - MCA may only be used when **every** node in the network supports it
- Nodes need to perform two clear channel assessments (CCA) to detect a) possible emergency or b) slot owner transmissions.



Source: Smart Body Area Network (SmartBAN); Low Complexity Medium Access Control (MAC) for SmartBAN. ETSI TS 103 325.

SmartBAN in brief – Interoperability

- TC SmartBAN has defined mechanisms for interoperability and heterogeneity management.
  - SmartBAN is providing data-level, semantic and technical interoperability
- SmartBAN utilizes an open data reference semantic model, which can be associated with metadata.
  - The functionalities are supporting both measurements and control
- Due to the harmonized data presentation, SmartBAN provides also semantic analysis, which enables automated monitoring and controlling.
- SmartBAN is able to coexist and share data between multi-technology wireless medical devices independently of vendors!

SmartBAN in brief – Use-cases

- The potential use-cases are dealing with person's safety and health monitoring, when vital signs can be automatically collected, analyzed and transmitted to electrical health records from where the data can be accessed by the authorized health professionals.
  - uses-cases are such as stress, sleep, safety, and fall monitoring, etc.
- As WBANs support mobility and wearables, SmartBAN is also suitable for various sports and welfare applications to collect human's physical information during their daily activities.

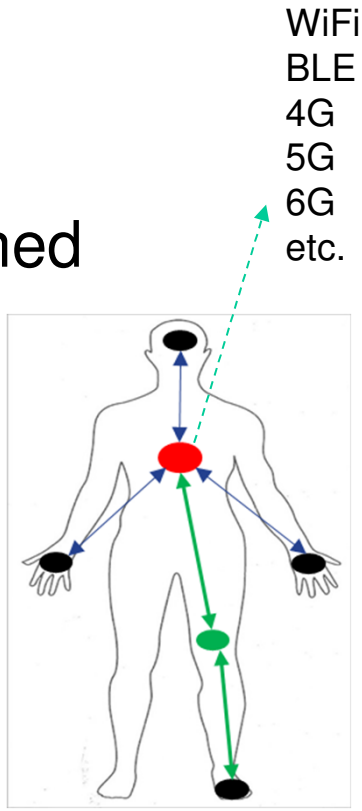
* Smart Body Area Networks (SmartBAN); System Description. ETSI TR 103 394.
* Smart Body Area Network (SmartBAN); Applying SmartBAN MAC (ETSI TS 103 325) for various use-cases. ETSI TR 103 711.

SmartBAN in brief – Use-cases

- In assisted living environments, SmartBAN is a potential technology for smart living and smart home solutions to provide additional information of the person's wellbeing and lifestyle.
- Due to the various needs for quality-of-service different applications have, the SmartBAN system is scalable in the means of data rates, latency requirements, allowed errors, and so on.
- SmartBAN is also future-proof WBAN technology.
  - Smart Coordinator will be a bridge outside of SmartBAN

Smart Coordinator

- We envision that Smart Coordinator (SC) can act as a **bridge** between the human centric measurements and a wider, ubiquitous medical access network.
  - Security and heterogeneity management
  - Smart Coordinator specifications will be defined by ETSI TC SmartBAN!
- Smart Coordinator enables future proof operation as the smartness is in the Smart Coordinator, not in the nodes.
  - New functionalities can be adopted via SC



Conclusion

PARAMETER	SmartBAN REQUIREMENTS
Frequency band	2.4 GHz ISM band
Channel bandwidth	2 MHz
Number of channels	40
Data rate (sensors)	nominally < 100 kbps/node (vital sign monitoring)
Transmission data rata (PHY)	up to 1 Mbps
Network topology	Star network
QoS control	Priority based control and cross layer optimization. Emergency signal transmission supported.
Reliability	Robust to multipath interference, FEC (BCH code) and repetition coding.
Max. node capacity	up to 16 nodes (typically 8)
Range	< 1.5 m
Latency	< 125 ms (high sampling applications, e.g., EEG, ECG)
Security / privacy	TBD (nominally AES-128)
Coexistence / robustness	Good (high tolerance, low interference to other systems)
Implant communications	IR-UWB at low-band, 3.4 – 4.8 GHz
Modulation	PPM

amendments to relay and H2H are coming

List of published TS

- Smart Body Area Network (SmartBAN); Enhanced Ultra-Low Power Physical Layer. ETSI TS 103 326.
- Smart Body Area Network (SmartBAN); Low Complexity Medium Access Control (MAC) for SmartBAN. ETSI TS 103 325.
- Smart Body Area Networks (SmartBAN); Unified data representation formats, semantic and open data model. ETSI TS 103 378.
- Smart Body Area Networks (SmartBAN); Service and application standardized enablers and interfaces, APIs and infrastructure for interoperability management. ETSI TS 103 327.

https://www.etsi.org/committee/1413-smartban

List of published TR

- Smart Body Area Networks (SmartBAN); System Description. ETSI TR 103 394.
- Smart Body Area Network (SmartBAN); Measurements and modelling of SmartBAN Radio Frequency (RF) environment. ETSI TR 103 395.
- Smart Body Area Networks (SmartBAN); Implant communications. ETSI TR 103 751.
- Smart Body Area Network (SmartBAN); Applying SmartBAN MAC (ETSI TS 103 325) for various use-cases. ETSI TR 103 711.

Summary article:

- M. Hämäläinen, L. Mucchi, M. Girod-Genet, T. Paso, J. Farserotu, H. Tanaka, D. Anzai, L. Pierucci, R. Khan, Md M. Alam, P. Dallemagne, "ETSI SmartBAN Architecture: the Global Vision for Smart Body Area Networks", IEEE Access, Vol. 8, pp. 150611 - 150625, 2020.

If you are interested in contributing to the ETSI SmartBAN, please join us!

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