Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title:[SmartBAN: ETSI standard for smart body area networks]
Date Submitted: [12 November 2019]
Source: [1:Matti Hämäläinen] [CWC University of Oulu] [2:John R. Farserotu] [CSEM]
Address [1: Linnanmaa, P.O. Box 4500, FIN-90570 Oulu,
Finland FI-90014, 2:Jaquet-Droz 1 Case Postale CH-2002 Neuchatel, Switzerland]
Voice:[1: +358 40 5243813, 2:+41-7935-66816],
Email:[1:matti.hamalainen@oulu.fi 2:john.farserotu@csem.ch]

Re: []

Abstract: [In order to collaborate with IEEE802.15 IG-DEP, activities of ETSI SmartBAN will be introduced. This slides are copies of presentation in 2019 IEEE international symposium on medical ICT (ISMICT2019) in Oslo, Norway on May 9, 2019.]

Purpose: [information]

Notice: This document has been prepared to assist the IEEE P802.15. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release: The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.

SmartBAN
ETSI standard for smart body area networks

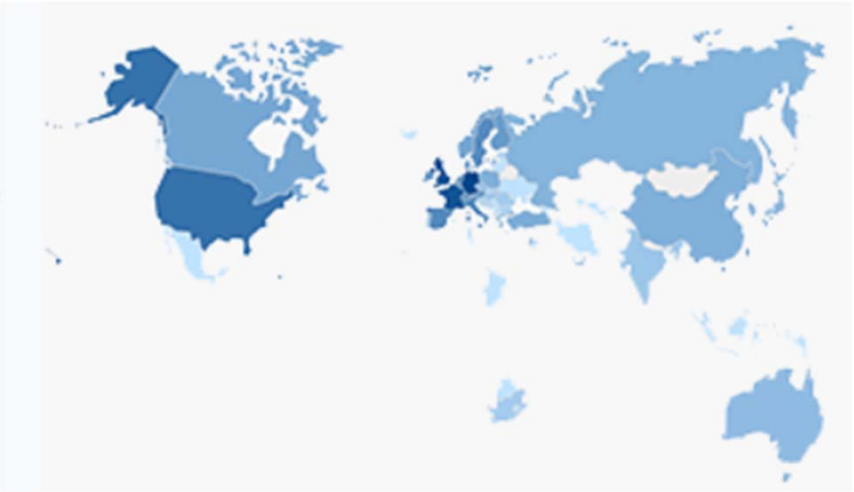
Adj.Prof. Matti Hämäläinen[1], Dr. John Farserotu[2]

[1]Centre for Wireless Communications, University of Oulu, Finland
[2]Swiss Center for Electronics and Microtechnology, Switzerland

This slides are copies of presentation in 2019 IEEE International Symposium on Medical ICT (ISMICT'2019), Oslo, Norway May 9, 2019

Introduction

- European Telecommunications Standards Institute (ETSI) is a non-profit European Standards Organization (ESO)
- It provides standards for telecommunication broadcasting and other electronic communications networks and services
- ETSI has members from more than 60 countries and five continents
- Various number of active Technical Committees



BOARD	FC	GA	IPR	OCG	3GPP
CYBER	DECT	EE	eHEALTH	EMTEL	ERM
MSG	MTS	NTECH	RRS	RT	SAFETY
STQ	TCCE	USER	ARF	CDM	CDP
NFV	NGP	OEU	PDL	QKD	ZSM

oneM2M	ATTM	BRAN	BROADCAST	CABLE
ESI	HF	INT	ITS	LI
SAGE	SCP	SES	SmartBAN	SmartM2M
CIM	ENI	IP6	MEC	mWT
OSM	NSO	STF	WORKSHOP	

Standization Principle

- Openness
  - ETSI standards and technical specifications are developed on the basis of open decision-making accessible to all interested parties in the market or markets affected by those ETSI standards and technical specifications.
- Consensus
  - The decision-making process is collaborative and consensus based and does not favor any particular stakeholder.
- Transparency
  - All information concerning technical discussions and decision making is archived and identified.
  - Information on new standardization activities is publicly and widely announced through suitable and accessible means.
  - Participation of all relevant categories of interested parties is sought with a view to achieving balance.
  - Consideration and response are given to comments by interested parties.

Introduction

- The use of wearables and body sensor devices is rapidly growing in the Internet of Things (IoT).
- At the same time, digital health, a convergence of digital technologies and health is emerging
- Wireless Body Area Networks (WBAN) offer a means of connectivity, facilitating the sharing of data, interaction and interoperability in smart environments (e.g., smart homes, living environments, smart environment, automotive, aerospace, etc.)
- SmartBAN activities started as academic research by European researchers.
- ETSI TC SmartBAN was approved in March 2013.
  - preparation meeting was organized in September 2012 in conjunction with Bodynets conference held at Oslo University Hospital
- SmartBAN aims at a "smart" solution for BAN with improved and dedicated performance for medical & health improvement and sport and leisure applications, further to existing BAN standards.
  - refer to IEEE802.15.6: in addition to medical & welfare, different kinds of consumer applications are included
    - Further IEEE802.15 IGDEP for M2M
- SmartBAN covers:
  - wireless communications and the associated physical layer (PHY) and the medium access control (MAC) layer
  - network layer, security, Quality-of-Service (QoS) and provision of generic applications and services,
  - a star network around a "smart" hub such as a handset or a watch, with the option for a multi-hop relay.

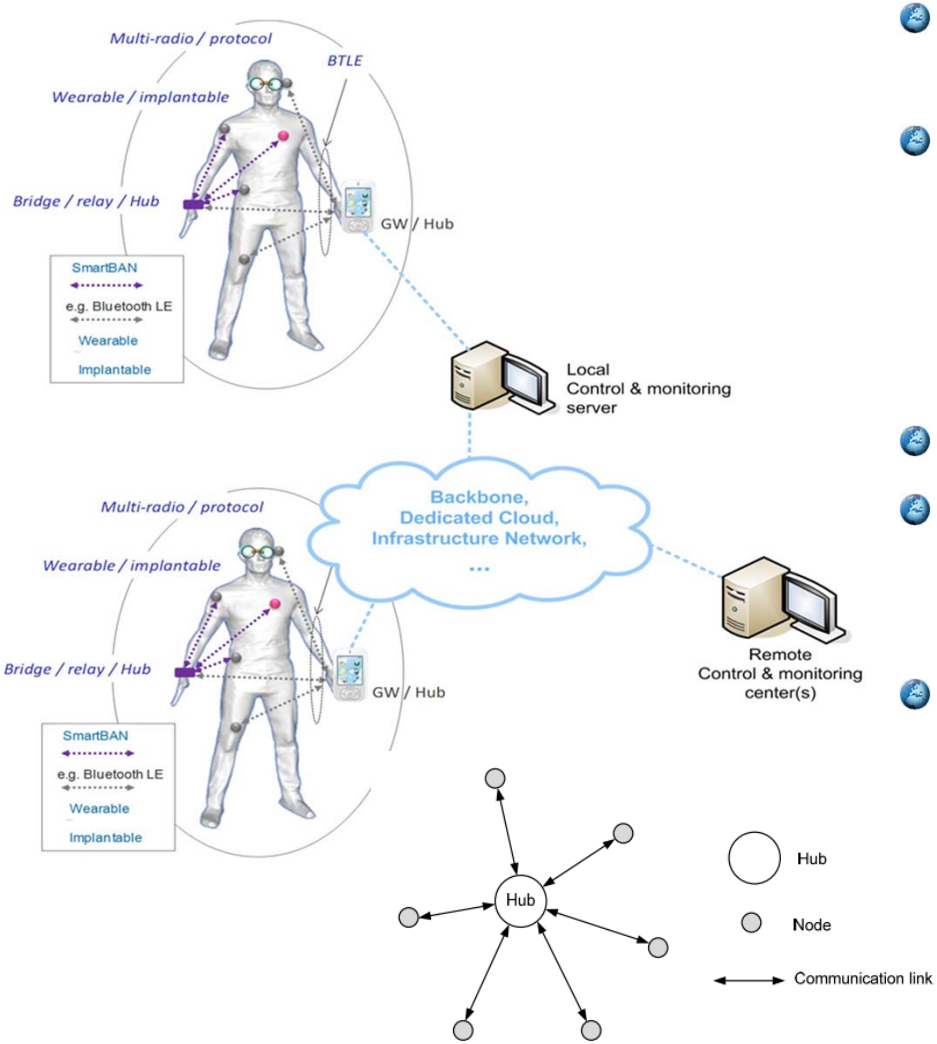
The Challenge

- The challenges for BAN include interoperability in heterogeneous use cases, low power, low latency, security, robust operation and the ability to interact with embedded intelligence in smart environments.
- To address these challenges, ETSI TC SmartBAN
  - targets a more efficient MAC and PHY, tailored to health and medical applications (e.g., low power).
  - provides additional semantic and data analytic enablers (e.g., semantic discovery, reasoning / rules) and automatic node discovery, such as semantic discovery of nodes or composition.
    - a semantic representation of the information and semantic interoperability strategies are also the key issues to manage the interoperability between different vendors and applications
  - provides added robustness via forward error correction.
  - computationally light security
  - supports operation across heterogeneous networks with enhanced interoperability / connectivity options, including data, network and semantic interoperability.
    - co-existence

SmartBAN applications

- The target applications for the TC SmartBAN are
  - medical and other health applications, wellness, leisure and sport with the following use case examples:
    - safety monitoring
    - health monitoring
      - fall monitoring
      - stress monitoring
      - sleep monitoring
      - blood pressure fluctuation monitoring
      - abnormal cardiac rhythm monitoring
      - apnea monitoring
    - sports monitoring
    - smart living
    - smart spaces

SmartBAN network and features



- **Network topology**: Star topology
  - NWIs for relay and hub-to-hub communications
- **PHY-MAC**: Efficient PHY + MAC, yielding very low latency emergency messaging, very low energy consumption, very fast initial set up time & channel reassignment, heterogeneous NTW
- **Secure** data transmission and storage
- **Channel assignment**: Real-time radio channel assignment (subject of further research)
- **Smart**: semantic approach, semantic interoperablity, heterogeneity management, IoT compliance, automatic node discovery (e.g., semantic discovery of nodes), coordinator, …

Timeline, progress and milestones achieved

- The group has released the following specifications and reports:

Status	Number	Title	Date
Published	**TS 103 326 Ver. 1.1.1**	**Smart Body Area Network (SmartBAN), Enhanced Ultra-Low Power Physical Layer**	**April 2015**
	TS 103 325 Ver. 1.1.1	**Smart Body Area Network (SmartBAN), Low Complexity Medium Access Control (MAC) for SmartBAN**	**April 2015**
	TS 103 378 Ver. 1.1.1	**Smart Body Area Networks (SmartBAN), Unified data representation formats, semantic and open data model**	**December 2015**
	TR103 395 Ver. 1.1.1	Smart Body Area Network (SmartBAN); Measurements and modelling of SmartBAN Radio Frequency (RF) environment	December 2016
	TR103 394 Ver.1.1.1	Smart Body Area Networks (SmartBAN); System Description	January 2018
	TS103 327 Ver.1.1.1	**Smart Body Area Networks (SmartBAN); Service and application standardized enablers and interfaces, APIs and infrastructure for interoperability management**	**April 2019**

Timeline, progress and milestones achieved

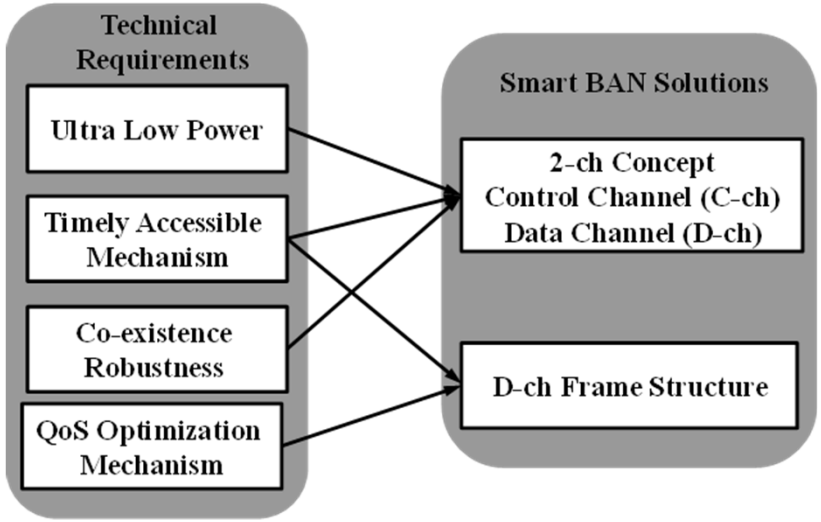
- In progress there are the following specifications and reports:

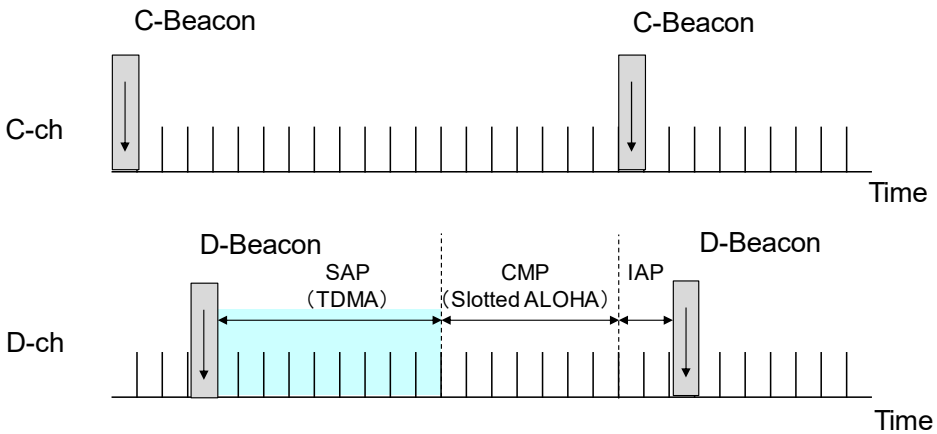
Status	Number	Title	Date
Ongoing work	DTR/SmartBAN-001 – TR106 671	Smart Body Area Networks (SmartBAN); Comparative analysis between SmartBAN and other short-range standards	Q2 2019 (draft), Q3 2019 (approval)
	DTR/SmartBAN-003	Smart Body Area Networks (SmartBAN); Implant communications	Q1 2020 (draft), Q1 2020 (approval)
	DTR/SmartBAN-0010	Smart Body Area Networks (SmartBAN); Security, privacy and trust; state of the art, use cases treats and requirements analysis	Q2 2020 (draft), Q2 2020 (approval)
	DTR/SmartBAN-0014	Applying SmartBAN MAC (TS 103 325) for various use cases	Q1 2020 (draft), Q1 2020 (approval)
	RTS/SmartBAN-005r1 – TS 103 325	**Low complexity MAC and routing for SmartBAN, Draft started (TS 103 325)**	**Q4 2019 (draft), Q1 2020 (approval)**
	RTS/SmartBAN-009r1 - TS 103 378	**SmartBAN unified data representation formats, semantic open data model and corresponding ontology**	**Q4 2019 (draft), Q1 2020 (approval)**
	DTS/SmartBAN-002	**Smart Body Area Networks (SmartBAN); System level description and requirements**	**Q4 2019 (draft), Q1 2020 (approval)**

New documents (DTR/DTS) and revisions to the existing ones (RTS).

PHY-MAC technical requirements

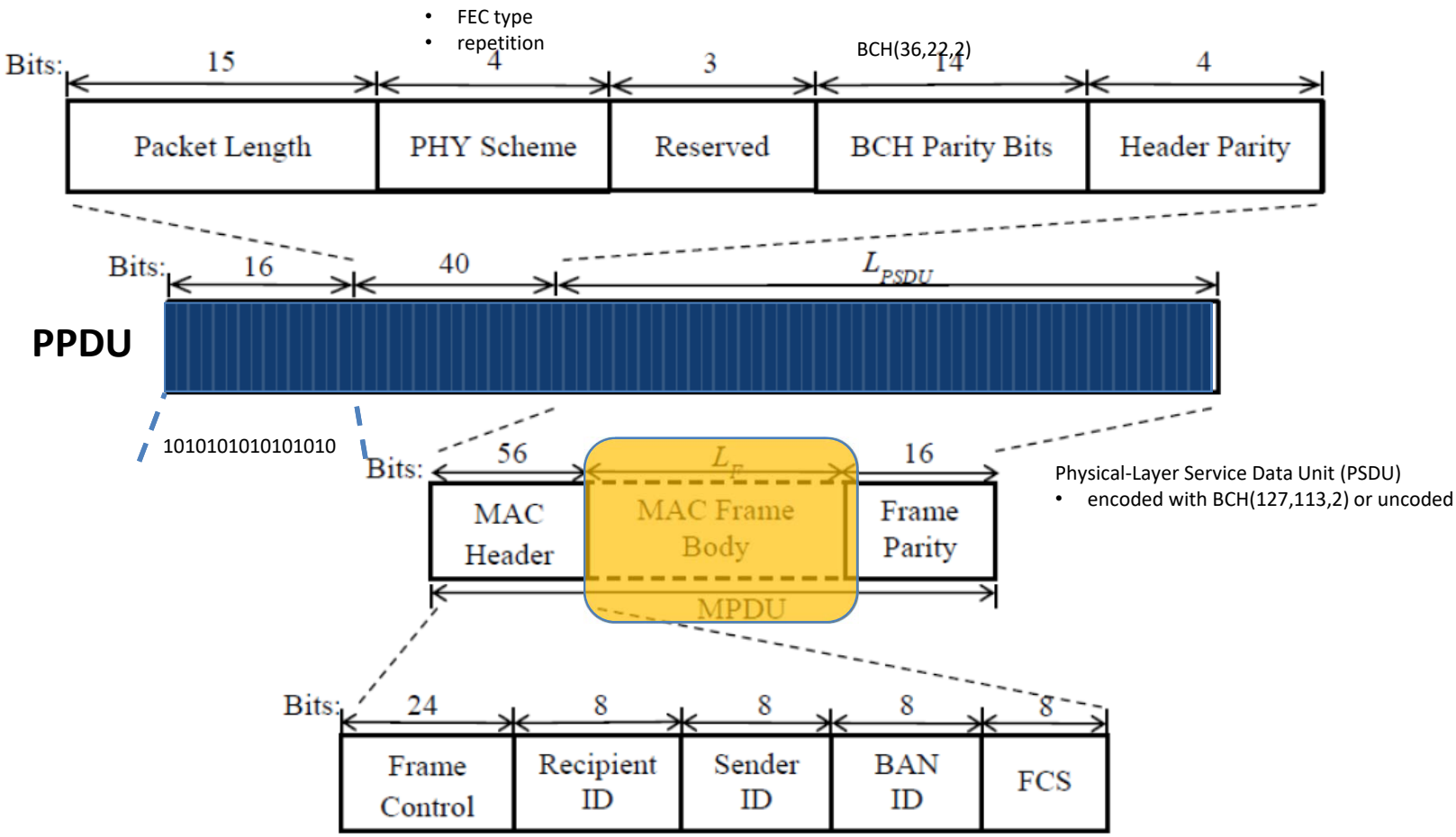
1. Ultra Low Power Design
   - HUB/Node Role Sharing
     - HUB takes care of MAC operation functionality as much as possible. Node operation is designed to be minimum.
     - Low complexity/low energy is maintained by exploiting the two-channel approach
2. Timely Accessible Mechanism
   - Node needs to connect to an intended hub within a short time
   - Emergency Signal Transmission
3. Co-existence / Robustness
   - Co-existence between HUBs
   - Automatic interference avoidance between BANs using the same D-ch
4. QoS Optimization Mechanism
   - Transmission (re-transmission) at the required level of BER, latency, etc.
   - Priority traffic





2-ch Concept and Access Schemes

Physical layer protocol data unit (PPDU)



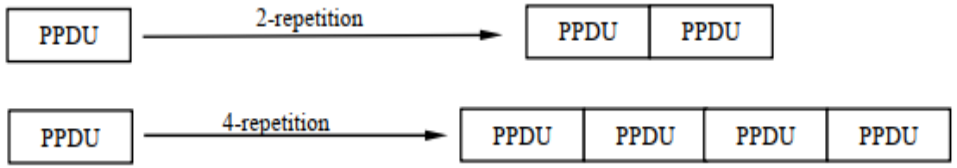
Physical-Layer Service Data Unit (PSDU)
- encoded with BCH(127,113,2) or uncoded

Physical layer convergence protocol (PLCP)
Frame check sequency (FCS)

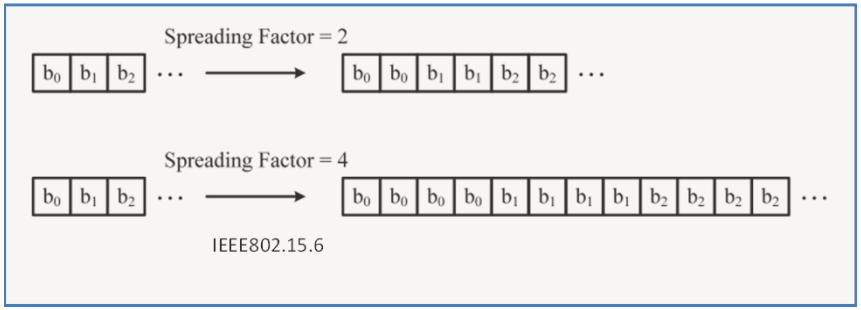
PHY-MAC solutions

- Each channel has a bandwidth of 2 MHz
- Centre frequencies
  - f_c = 2402 + 2*n MHz, n = 0 … 39
  - 40 channels
- Modulation is Gaussian Frequency Shift Keying (GSFK) with a bandwidth-bit period product BT = 0.5 and modulation index h = 0.5
- BCH (127,113,t=2) Encoding
- BCH (36,22,t=2) for PLCP header
  - Physical Layer Convergence Protocol
- Repetition of 1, 2 or 4

Channel Number	Centre Frequency (MHz)	Channel Type	Data Channel Number	Control Channel Number
0	2 402	Control		0
1	2 404	Data	0	
...		Data		
11	2 424	Data	10	
12	2 426	Control		1
13	2 428	Data	11	
...		Data		
38	2 478	Data	36	
39	2 480	Control		2



Physical-Layer Protocol Data Unit (PPDU)



PHY-MAC solutions

Supported data rates

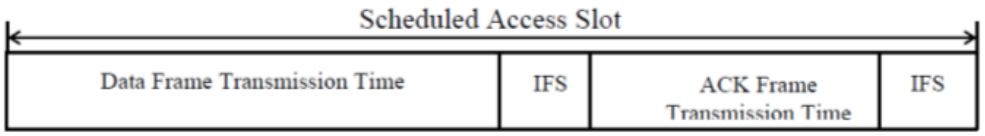
Channel (Data/Control)	Information Flow	Symbol Rate (MSymbols/s)	Code Rate	Repetition	Information Rate (Mbps)
Data/Control	Downlink/Uplink	1,0	1	1	1,0
Data/Control	Downlink/Uplink	1,0	1	2	0,5
Data/Control	Downlink/Uplink	1,0	1	4	0,25
Data/Control	Downlink/Uplink	1,0	113/127	1	0,89
Data/Control	Downlink/Uplink	1,0	113/127	2	0,44
Data/Control	Downlink/Uplink	1,0	113/127	4	0,22

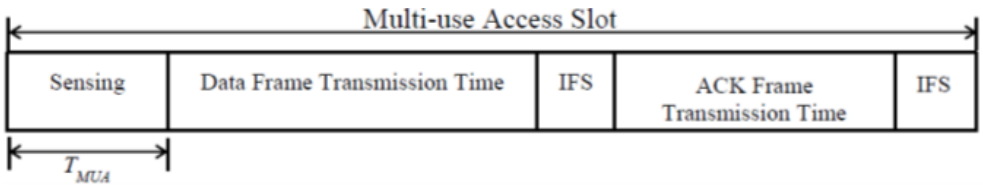
Four user priorities

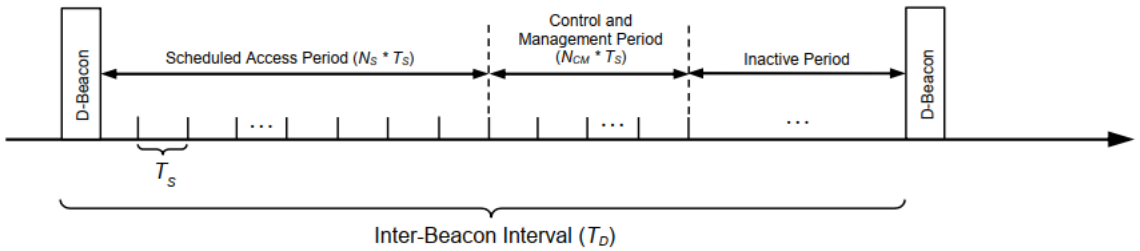
User Priority	Data Type
0	Low priority
1	Mid priority
2	High priority
3	Very High (Emergency)

PHY-MAC solutions

- Three channel access mechanisms
  - Scheduled channel access
  - Slotted Aloha channel access
    - Management frames
    - Data, when no sufficient resources in scheduled period available
  - Multi-use channel access
    - Sensing period for clear channel assessment (CCA)
    - Data transmission if sl is free
    - Re-use of an empty slo of other user







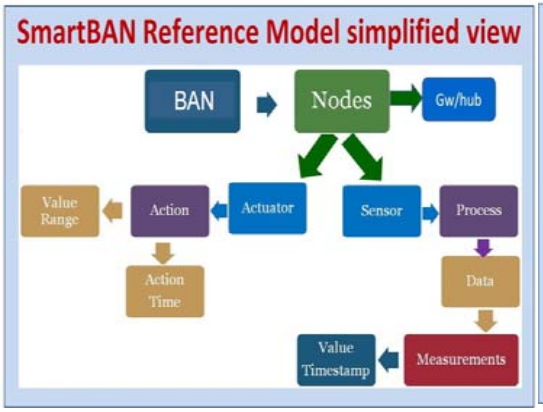
Data representation and interoperability management

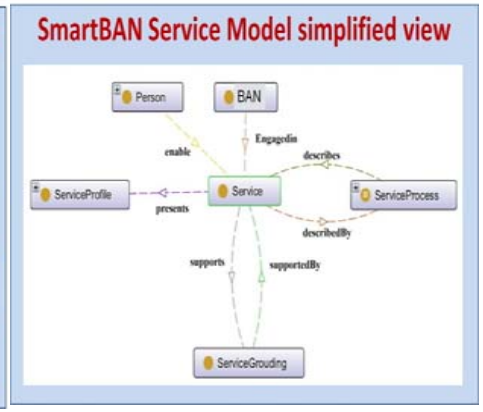
- A BAN (*SmartBAN*) – data, device, service/application – unified semantic and open reference model, with corresponding modular ontology:
  - ⇒ key element for BANs data/device interoperability,
  - ⇒ coupled with a XaaS (Everything as a Service)/WoT (Web of Things) strategy for semantic interoperability handling, device discovery and composition facilities, data sharing at application level and cross domain use cases handling,
  - ⇒ eases implementation of automated monitoring/control strategies.

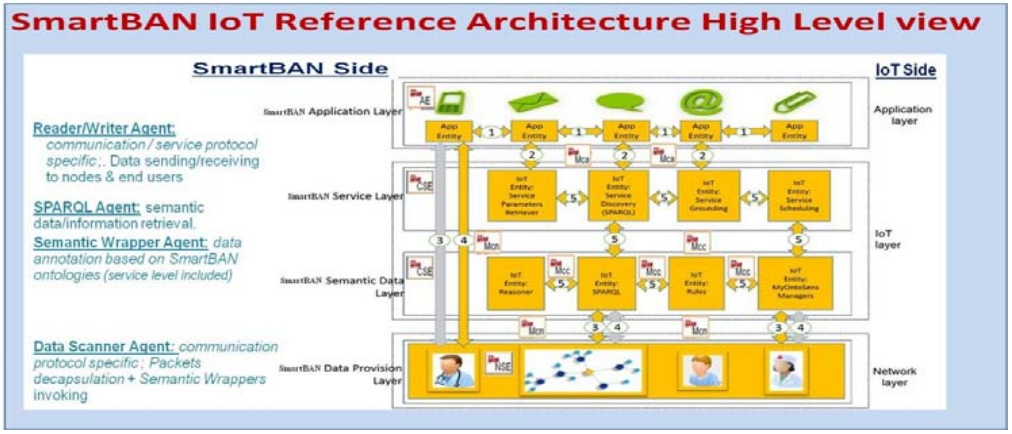
- A BAN (*SmartBAN*) global and more integrated IoT reference architecture for secure interaction and access to BAN data & entities:
  - ⇒ specified on top of the SmartBAN reference model,
  - ⇒ oneM2M and Multi-Agent based,
  - ⇒ addresses network/syntactic/semantic interoperability,
  - ⇒ provides in particular generic service enablers for semantic data sharing/management, embedded semantic analytics (*device/edge/fog levels*), and distributed monitoring/control operations.

Data representation and interoperability management

- In addition to PHY/MAC layers' specifications, the scope is to cover also higher OSI-layers
  - from the networking level up to the service and application levels
  - specification and formalization of a SmartBAN unified data representation formats, semantic open data model and corresponding ontology are covered
    - specification of a standardized end-to-end architecture (up to the remote control and monitoring servers of, e.g., caregivers or healthcare centers) for SmartBAN entities' generic interactions, data access, control and monitoring, <u>irrespective of whatever lower layers and radio technologies are used</u>







A comparison with other standards

Parameter		SmartBAN	BTLE	IEEE 802.15.6™
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

Cooperation with other bodies and demonstration of the technology

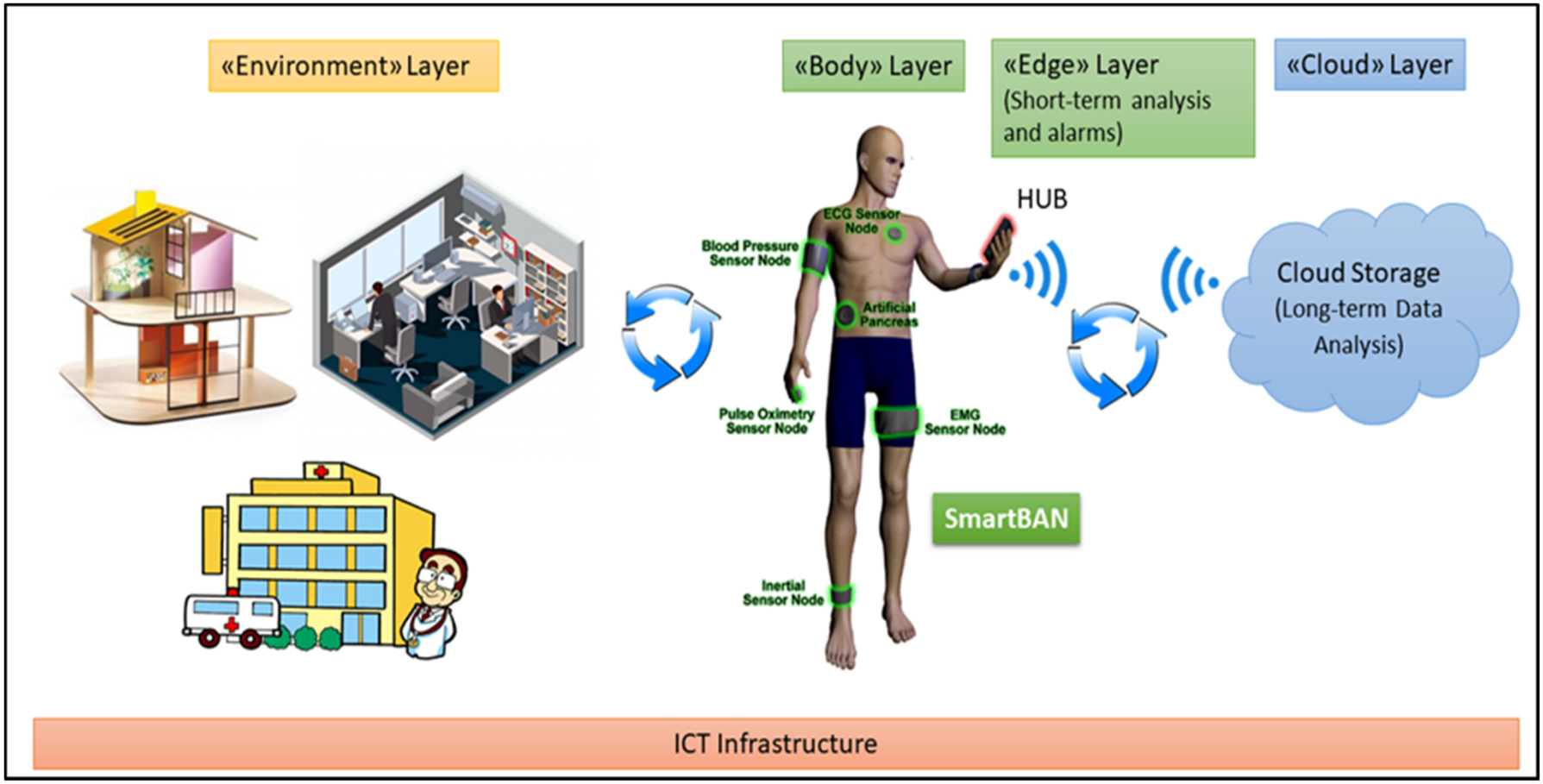
- Cooperation
  - SmartBAN has collaborated with oneM2M and namely contributed to the ITEA3 CareWare project demonstrator (elderly at home support)
  - Clinical tests in partnership with OHS – Office d'Hygiène Sociale – Nancy.
  - TC SmartBAN's work continues to be promoted via contributions to various bodies both within ETSI and wider, e.g.:
    - oneM2M/SmartM2M, ERM TG 30, AIOTI, IEC (official liaison to IEC systems committee, active assisted living (AAL)), BT SIG, H2020 ACTIVAGE, …
- Demonstration of SmartBAN technology was held at ETSI IoT Week 2018 including:
  - Semantic interoperability and SmartBAN reference IoT/oneM2M platform for remote monitoring and control applications
  - SmartBAN 2.4 GHz PHY

Moving forward – near term

- New Work Item (NWI) on implant communication was initiated in 2018, in cooperation with ETSI ERM TG 30.
- NWI on security, privacy and trust for SmartBAN was initiated in 2018
- NWI on applying SmartBAN MAC (TS 103 325) for various use cases, Feb 2019
- Joint group between ETSI TC SmartBAN and ETSI TC SmartM2M was envisioned for merging and/or aligning the SmartBAN ontology with SAREF* and oneM2M ontologies.

*SAREF: Smart Appliances REFerence ontology

SmartBAN in the IoT – a view to the future



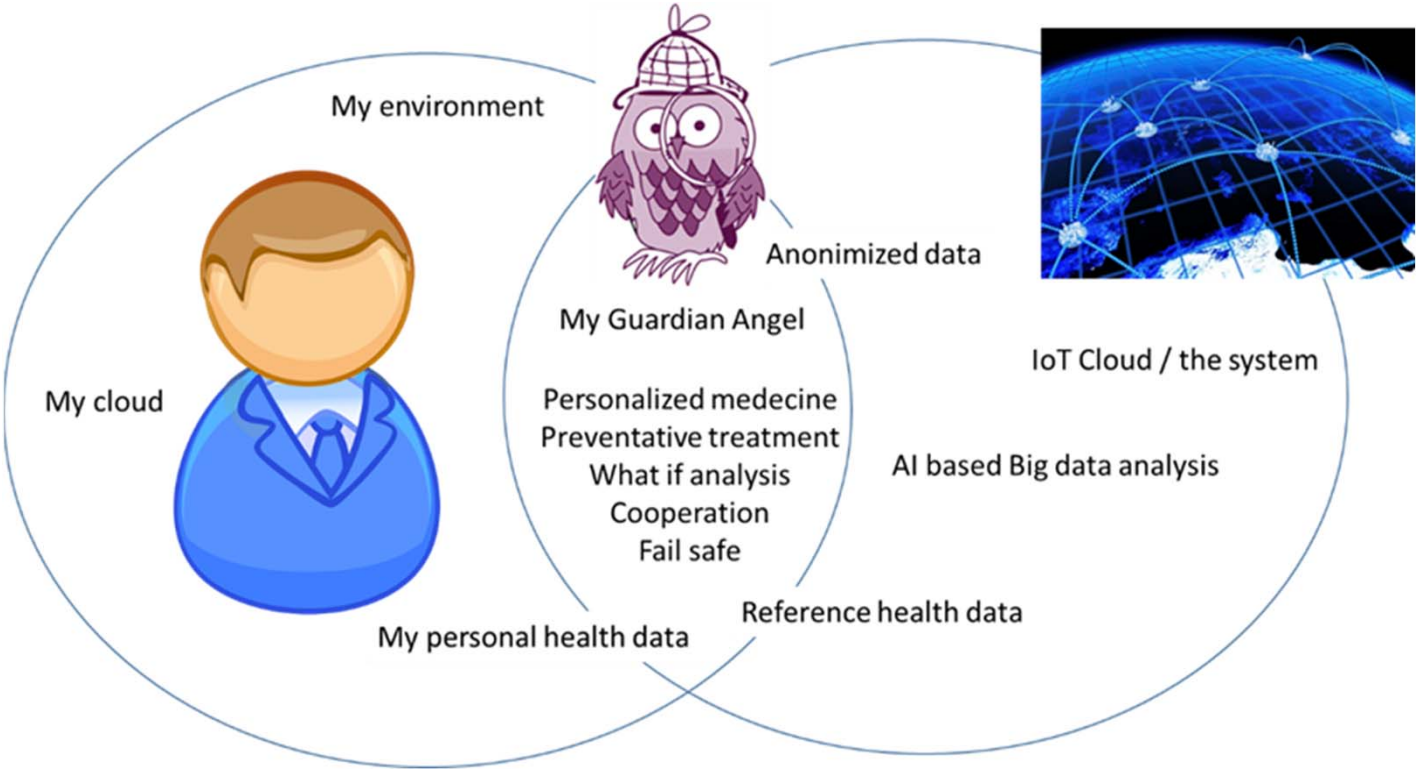
Digital society and the rise of pervasive cognitive computing

- The IoT is rapidly emerging and the number of connected devices is expanding exponentially.
- More and more, we are evolving towards a hyper-connected world in which almost unimaginable numbers of devices, sensors and smart objects may be connected 24/7.
- Staggering amounts of data may be fed into the cloud where it is stored and searchable.
- Ordinary, everyday objects are becoming cognitive computing agents.
- ULP technologies and new computing paradigms are required to support cognitive computing for all kinds of applications, from the IoT, health and medical to automotive, smart homes, factories, security and data analysis.

- *Smart Everything Everywhere (SEE)*
- *Smarter wireless sensors, (local processing / ML inside)*
- *Ultra low power (ULP) energy autonomous wireless sensors*

SmartBAN and Digital Health - a vision for the digital future

SmartBAN Digital Health



SmartBAN, our personal interface to the digital healthcare system of the future and guardian in a complex Digital Society!

Sources:

- Future Health: https://ec.europa.eu/futurium/en/system/files/ged/futurehealth_white_paper.pdf, Health EU, https://www.health-eu.eu/
- Digi Twins: http://www.engineersjournal.ie/2018/06/12/revolutionary-healthcare-proposal-digitwins-seeking-eu-flagship-success/

Finally, who are SmartBAN?

- The most active partners in ETSI TC SmartBAN are

- Chair: CSEM
- Vice Chair: Toshiba Europe
- University of Oulu
- Cnit: Consorzio nazional interuniversitario per le telecomunicazioni
- Intitit-Mines-Telecom
- FAU: Friedrich-ale Universitat Erlangen-Nur
- Tallinn University of Technology

Concluding remarks on SmartBAN for Digital Health

- SmartBAN can not only provide connectivity for our portable and wearable devices in the IoT, it can serve as our personal interface to the digital world, in particular, the healthcare system of the future
- To do so, new solutions are needed both technically, as well as, with respect to interoperablity:
  - Intelligent and autonomous solutions (HW /SW)
  - Protecting and ensuring our security and privacy, learning and maintaining our trust
  - Ensuring interoperability across systems and environments (e.g. semantic interoperability)
  - Low power, yet high performance, smart edge devices (wearable and sensor nodes)
  - Dependable, robust QoS, with high coexistence

SmartBAN for Digital Health - towards a personal, trusted platform and interface to the healthcare system of the future, helping us in our daily lives, challenging us to live better, healthier and longer!

Thank you for your attention!

From CSEM side, SmartBAN is supported by the Hermes Partnership (www.hermes-europe.net/), a network of leading European organizations in wireless and mobile communication, the European H2020 ACTIVAGE project (http://www.activageproject.eu/) and H2020

From University of Oulu side, SmartBAN is supported by the Academy of Finland 6Genesis Flagship (grant no. 318927).

- **And finally question to the panelists:**

How do you see the role of standardization in the development of future medical devices for digital health?

Thank you!