GISC 2025

Global ICT Standards Conference 2025

ICT 국제표준화 전문가 성과 공유 및 활동 설명회

IEEE 802 무선 전문 네트워크 표준화

주성순 겸임교수
덕성여자대학교

ICT Standards and Intellectual Property:
AI for All

주최 과학기술정보통신부 지식재산처 주관 국립전파연구원 TTA IITP KEA kista ETRI

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Abstract

미국전기전자학회의 표준화 기구인 IEEE SA 산하 Computer Society 의 IEEE 802 표준화 활동을 소개하고, 특히 Wireless Specialty Network 표준을 다루는 IEEE 802.15 WG 의 개발 표준과 동향을 소개한다. Body Area Network 표준, UWB ranging 표준, WSN 의 정보보호 관련 표준 개발에 대하여 소개한다.

This presentation introduces the standards organization of the Institute of Electrical and Electronics Engineers (IEEE), the Computer Society standardization activities (IEEE 802), and the development standards of the IEEE 802.15 Working Group (WG), which deals with Wireless Specialty Network. It covers the development of Body Area Network standards, UWB ranging standards, and standards related to information security in WSNs.

01. IEEE, IEEE Society, Standard Committee

IEEE (Institute of Electrical and Electronics Engineers)

- formed from the American Institute of Electrical Engineers and the Institute of Radio Engineers in 1963
- publishing approximately 200 peer-reviewed journals and magazines

IEEE Society

- IEEE's 39 societies
- provide specialized publications, conferences, business networking, and
- sometimes other services (de facto standards)

Aerospace and Electronic Systems Society
Antennas and Propagation Society
Broadcast Technology Society
Circuits and Systems Society
Communications Society
Computational Intelligence Society
Computer Society
Consumer Technology Society
Control Systems Society
Dielectrics and Electrical Insulation Society
Education Society
Electromagnetic Compatibility Society
Electron Devices Society
Electronics Packaging Society
Engineering in Medicine and Biology Society
Geoscience and Remote Sensing Society
Industrial Electronics Society
Industry Applications Society
Information Theory Society
Instrumentation and Measurement Society
Intelligent Transportation Systems Society
Magnetics Society
Microwave Theory and Techniques Society
Nuclear and Plasma Sciences Society
Oceanic Engineering Society
Photonics Society
Power Electronics Society
Power & Energy Society
Product Safety Engineering Society
Professional Communication Society
Reliability Society
Robotics and Automation Society
Signal Processing Society
Society on Social Implications of Technology
Solid-State Circuits Society
Systems, Man, and Cybernetics Society
Technology and Engineering Management Society
Ultrasonics, Ferroelectrics, and Frequency Control Society
Vehicular Technology Society

IEEE
Advancing Technology for Humanity

IEEE Computer Society Standards Committees

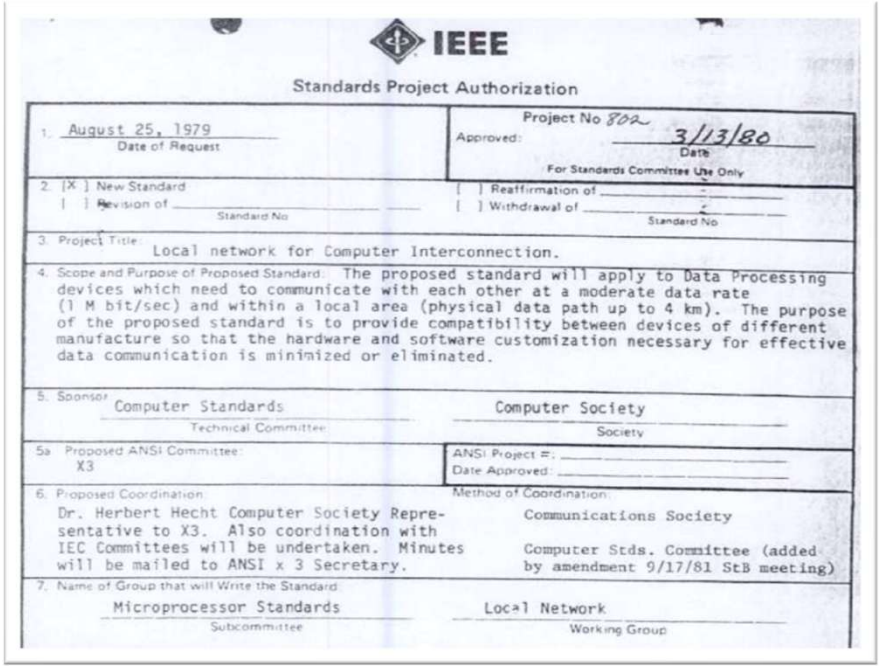
- Artificial Intelligence Standards Committee
- Blockchain and Distributed Ledgers Standards Committee
- Cloud Computing Standards Committee
- Cybersecurity & Privacy Standards Committee
- Data Compression Standards Committee
- Design Automation Standards Committee
- Functional Safety Standards Committee
- Knowledge Engineering Standards Committee (KESC)
- LAN/MAN (IEEE 802) Standards Committee
- Learning Technology Standards Committee
- Microprocessor Standards Committee
- Online Gaming Standards Committee
- Portable Applications Standards Committee
- Simulation Interoperability Standards Organization SAC
- Smart Manufacturing Standards Committee
- Software & Systems Engineering Standards Committee
- Test Technology Standards Committee

Source : https://www.ieee.org/communities/societies/index.html#ED015

02. LAN/MAN SC (IEEE 802)

The First Standard Project of LAN/MAN SC

- Local Network for Computer Interconnection
  - Date of Request : Aug. 25, 1979
  - **Approved Project No 802** : Mar. 13, 1980



IEEE

Standards Project Authorization

1. August 25, 1979 (Date of Request) — Project No 802 — Approved: 3/13/80 (Date) — For Standards Committee Use Only

2. [X] New Standard — [ ] Revision of _____ (Standard No) — [ ] Reaffirmation of _____ — [ ] Withdrawal of _____ (Standard No)

3. Project Title: Local network for Computer Interconnection.

4. Scope and Purpose of Proposed Standard: The proposed standard will apply to Data Processing devices which need to communicate with each other at a moderate data rate (1 M bit/sec) and within a local area (physical data path up to 4 km). The purpose of the proposed standard is to provide compatibility between devices of different manufacture so that the hardware and software customization necessary for effective data communication is minimized or eliminated.

5. Sponsor: Computer Standards (Technical Committee) — Computer Society (Society)

5a. Proposed ANSI Committee: X3 — ANSI Project #: _____ — Date Approved: _____

6. Proposed Coordination: Dr. Herbert Hecht Computer Society Representative to X3. Also coordination with IEC Committees will be undertaken. Minutes will be mailed to ANSI x 3 Secretary. — Method of Coordination: Communications Society; Computer Stds. Committee (added by amendment 9/17/81 StB meeting)

7. Name of Group that will Write the Standard: Microprocessor Standards (Subcommittee) — Local Network (Working Group)

IEEE 802 Standards

- **Ethernet**
  - developed at Xerox PARC around 1973
  - standardize LAN (local area networks) IEEE 802.3 in 1980

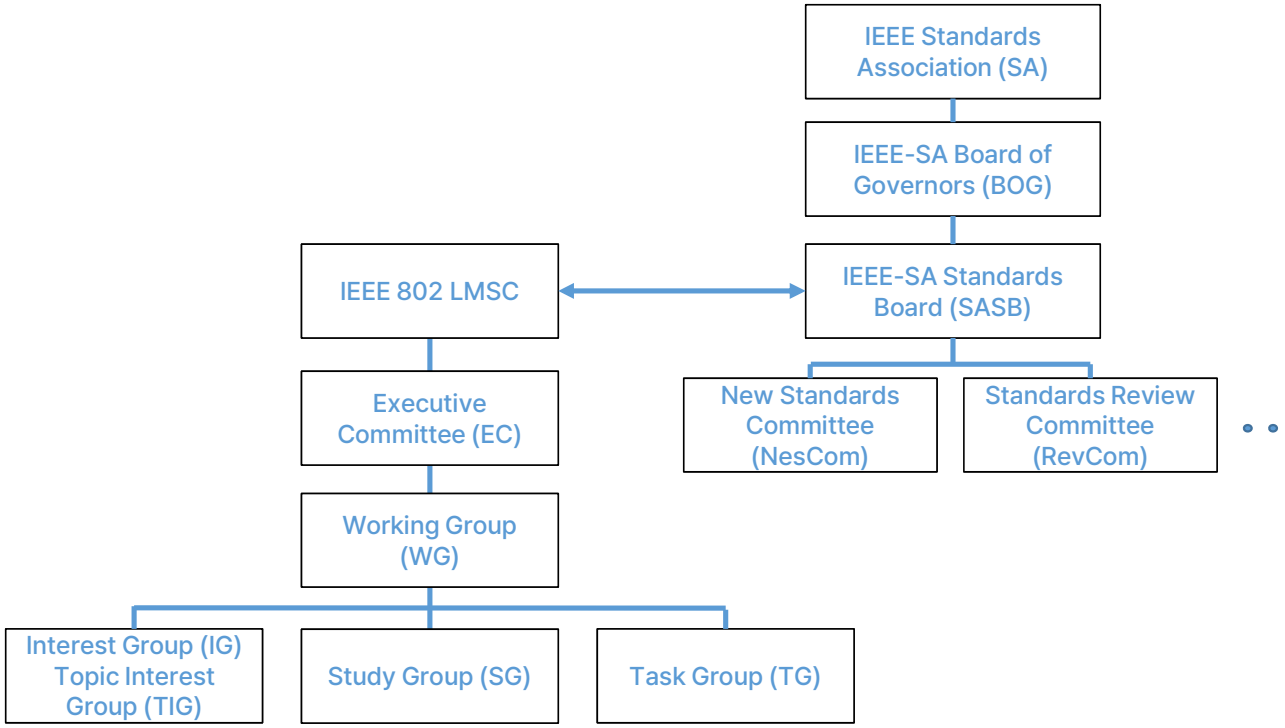
- **WiFi**
  - standardize Wireless LAN IEEE 802.11 in 1997

- **Bluetooth**
  - standardize Wireless PAN IEEE 802.15.1 in 2002

- **ZigBee**
  - standardize Wireless PAN IEEE 802.15.4 in 2003

Source : https://www.ieee802.org/30th/30thAnniversaryPanel-rev05%2016MAR2010.pdf

03. Actors on IEEE 802 Standardization



- IEEE Standards Association (SA)
- IEEE-SA Board of Governors (BOG)
- IEEE-SA Standards Board (SASB)
- New Standards Committee (NesCom)
- Standards Review Committee (RevCom)

- IEEE 802 LMSC
- 802 Executive Committee (EC)
- 802 Working Group (WG)

- Interest Group
- Study Group
  - a group formed to investigate a potential project and produce a PAR
- Task Group
  - a part of a working group which focuses on a particular project

04. IEEE Project 802 LAN/MAN Standards Committee

- Develop standards for
- Local Area Networks (LAN),
- Metropolitan Area Networks (MAN),
- Regional Area Networks (RAN),
- Personal Area Networks (PAN),
- Wireless Specialty Networks (WSN), etc.

- Mainly for link and physical layers of the OSI reference model
  - physical layer (PHY, Layer 1)
  - data link layer (DLL, Layer 2)
    - Medium Access Control (MAC)
    - Common logical link control (LLC)

CHAIR
James P.K. Gilb

Working Groups and TAGs, with Chair

802.1 WG
High Level Interface
Glenn Parsons

802.3 WG
Ethernet
David Law

802.11 WG
Wireless LAN
Robert Stacey

802.15 WG
Wireless Specialty Networks
Clint Powel

802.19 WG
Coexistence
Tuncer Baykas

802.18 TAG
Radio Regulatory
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802.24 TAG
Vertical Applications
Tim Godfrey

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WMAN
Roger Marks

802.21 WG
Media Access indep endent Services
Subir Das

802.22 WG
WRAN
Apurva Mody

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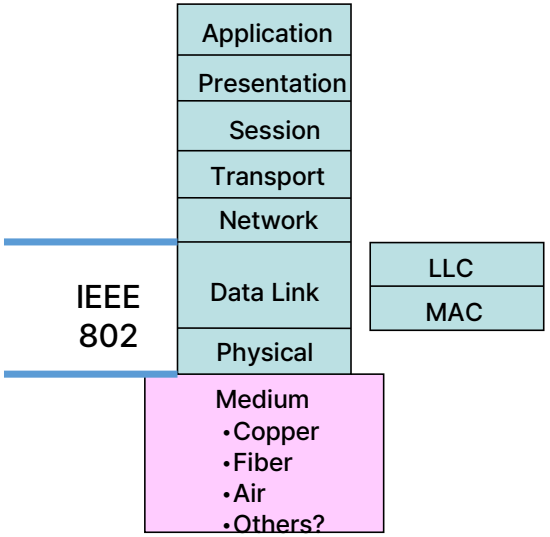
Associate Treasurer
(non-voting)
Jason Potterf

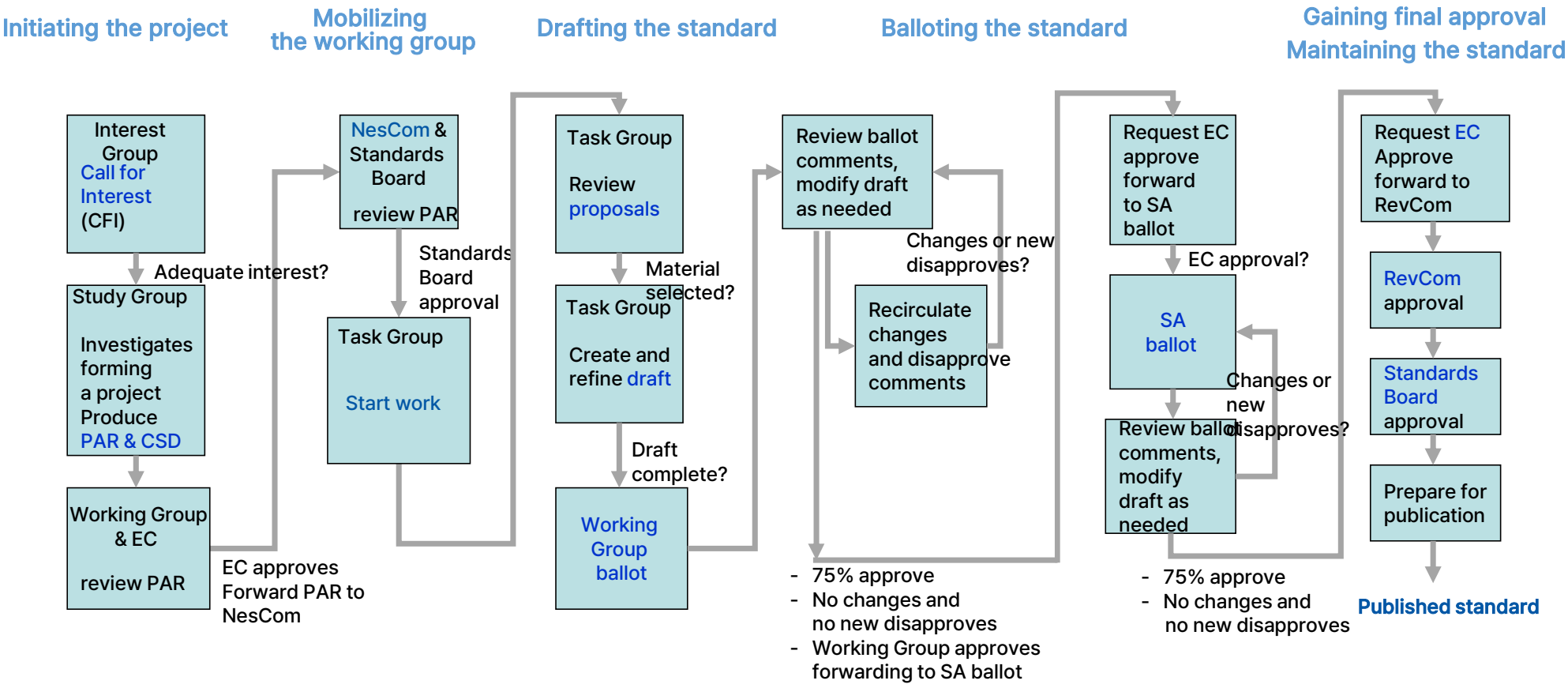
MEMBER EMERITUS
(non-voting)
Geoff Thompson
Paul Nikolich

Reference Model for End Stations



Source : https://mentor.ieee.org/802-ec/dcn/20/ec-20-0023-10-00EC-ieee-802-orientation.pptx

05. IEEE Standards Development Life Cycle



Source : https://standards.ieee.org/develop/

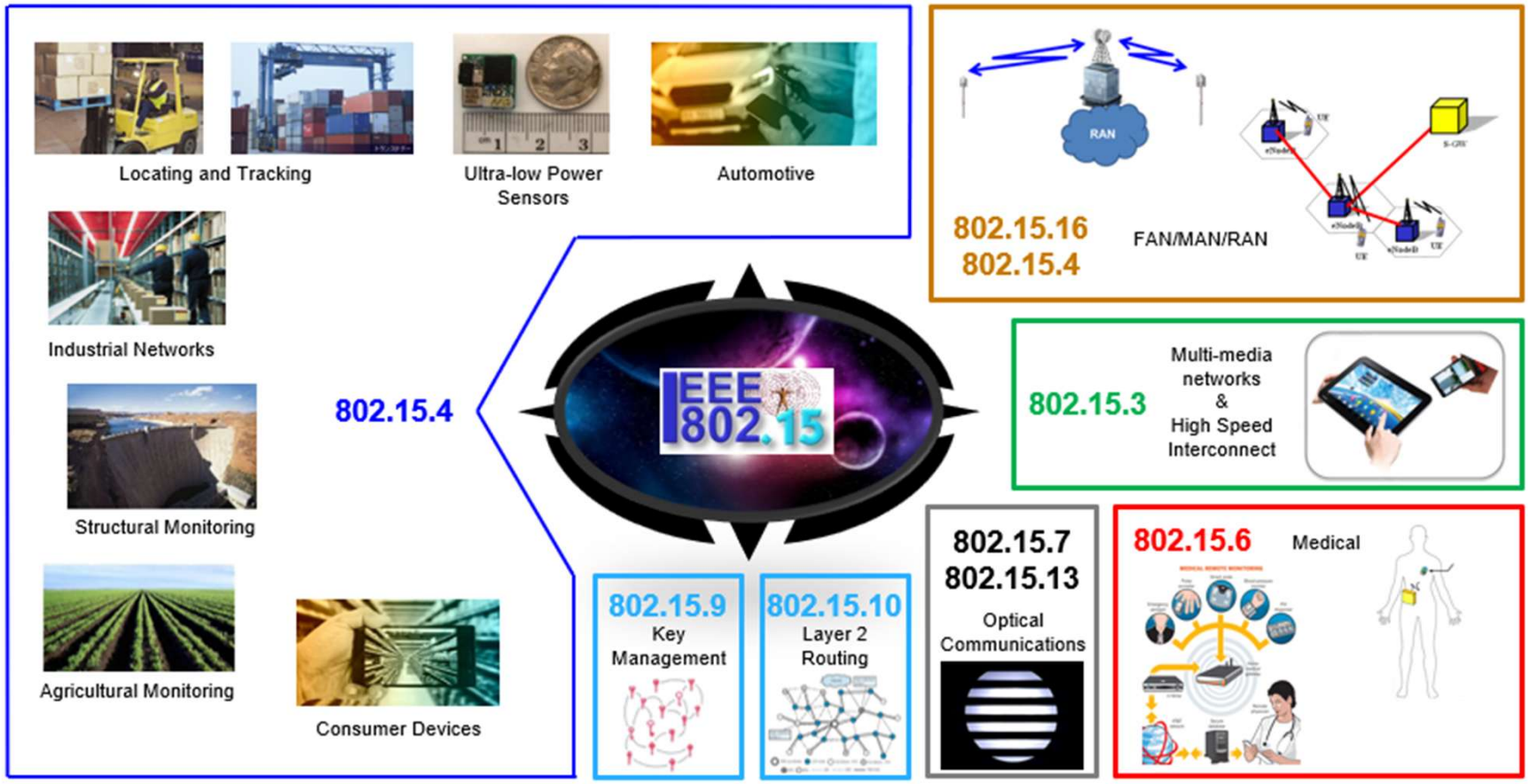
01. IEEE 802.15 WG on Wireless Specialty Networks

Wireless networking for the emerging Internet of Things (IoT)

- Wireless Body Area Network
- Wireless Personal Area Network
  - short range, low power, low cost, small network, ad-hoc network formation
- Smart Utility Network
- Railway Communication
- Critical Infra Structure Monitoring
- Low Power Wide Area Network

- Focus is on "specialty"
  - If it is wireless and not a LAN, MAN, RAN, or WAN, odds are its 802.15
  - Activities are diverse and varied
    - Data rates from 2kbps to 100gbs
    - Ranges from meters to kilometers
    - Frequencies from 400MHz to 800THz
    - Predominantly non TCP/IP applications
    - Only 802 Working Group with multiple MACs

02. IEEE 802.15 Standards & their Applications



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03. IEEE 802.15 Frequency Band Usage

Start frequency (MHz)	End frequency (MHz)	Standard-Year / Project	Clause number in standard or draft standard (if available)	PHY amendment (Date of initial approval)	PHY name (if any)	Bandwidths supported (MHz)
54	862	IEEE Std 802.15.4™-2020	24, 25, 26	IEEE Std 802.15.4m-2014		6, 7, 8
150	174	P802.15.16				
169.4	169.475	IEEE Std 802.15.4™-2020	10.1.2	IEEE Std 802.15.4g-2012		
174	216	IEEE Std 802.15.4™-2020	10.1.2	IEEE Std 802.15.4g-2012		
220		P802.15.16				
249	749	IEEE Std 802.15.4™-2020	10.1.1, 15	IEEE Std 802.15.4a-2007	HRP (High Rate Pulse) UWB sub-gigahertz	499.2, 1081.6, 1331.2, 1354.97
249	749	IEEE Std 802.15.4z™-2020	10.1.1, 15	IEEE Std 802.15.4z-2020	LRP (Low Rate Pulse) UWB	499.2, 1081.6, 1331.2, 1354.97
407	425	IEEE Std 802.15.4™-2020	29	IEEE Std 802.15.4n-2016	CMB (China Medical Band)	
433.05	434.79	IEEE Std 802.15.4™-2020	17	IEEE Std 802.15.4f-2012	MSK	
450	470	IEEE Std 802.15.4™-2020	27, 28	IEEE Std 802.15.4p-2014	RCC (Rail Control and Communications)	
450	470	P802.15.16				
470	510	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
470	512	P802.15.16				
608	630	IEEE Std 802.15.4™-2020	29	IEEE Std 802.15.4n-2016	CMB (China Medical Band)	
700		P802.15.16				
779	787	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
806	824	P802.15.16				
851	869	P802.15.16				
863	870	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
865	867	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4u-2016	SUN (Smart Utilites Networks)	
866	869	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017	SUN (Smart Utilites Networks)	
868	868.6	IEEE Std 802.15.4™-2020	13	IEEE Std 802.15.4-2003	SUN (Smart Utilites Networks)	
870	876	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
896	901	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
896	901	P802.15.16				
901	902	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
902	907.5	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v™-2017		
902	928	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4-2006		

https://mentor.ieee.org/802.15/dcn/25/15-25-0414-03-0000-sept-2025-802-15-opening-report.pptx

03. IEEE 802.15 Frequency Band Usage

Start frequency (MHz)	End frequency (MHz)	Standard-Year / Project	Clause number in standard or draft standard (if available)	PHY amendment (Date of initial approval)	PHY name (if any)	Bandwidths supported (MHz)
915	918	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
915	921	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
915	928	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
917	923.5	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
919	923	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
920	925	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
920	928	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
920.5	924.5	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4v-2017		
928	929	P802.15.16				
928	960	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
931	932	P802.15.16				
935	940	P802.15.16				
952	953	P802.15.16				
952	960	P802.15.16				
1427	1432	P802.15.16				
1427	1518	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
2360	2400	IEEE Std 802.15.4™-2020	12	IEEE Std 802.15.4j-2013	Medical BAN (Body Area Network)	
2400	2483.5	IEEE Std 802.15.3™-2016	10	IEEE Std 802.15.3-2003		
2400	2483.5	IEEE Std 802.15.4™-2020	19, 20, 21, 22, 23	IEEE Std 802.15.4g-2012		
3244	4743	IEEE Std 802.15.4™-2020	10.1.1, 16.2.3	IEEE 802.15.4a-2007	HRP (High Rate Pulse) UWB low band	499.2, 1331.2
3244	4743	IEEE Std 802.15.4z™-2020	10.1.1, 16.2.3	IEEE Std 802.15.4z-2020	HRP (High Rate Pulse) UWB low band	499.2, 1331.2
5786	8852	IEEE Std 802.15.4™-2020	10.1.1, 19		LRP (Low Rate Pulse) UWB	
5786	10370	IEEE Std 802.15.4z™-2020	10.1.1, 19	IEEE Std 802.15.4z-2020	LRP (Low Rate Pulse) UWB	
5948	10,163	IEEE Std 802.15.4™-2020	10.1.1, 16.2.3		HRP (High Rate Pulse) UWB high band	499.2, 1081.6, 1331.2, 1354.97
5948	10,163	IEEE Std 802.15.4z™-2020	10.1.1, 16.2.3	IEEE Std 802.15.4z-2020	HRP (High Rate Pulse) UWB high band	499.2, 1081.6, 1331.2, 1354.97
57,240	65,880	IEEE Std 802.15.3™-2016	11	IEEE Std 802.15.3c-2009	mmWave	
57,240	68,040	P802.15.3	11a	IEEE Std 802.15.3e-2017	HRPC	
57,240	70,200	P802.15.3	11, 11a	IEEE Std 802.15.3f-2017	mmWave	
252,000	322,000	P802.15.3	13.1.2, 13.1.3	IEEE Std 802.15.3d-2017	THZ	2160, 4320, 8640, 12,960, 17,280, 25,920, 51,840, 69,120

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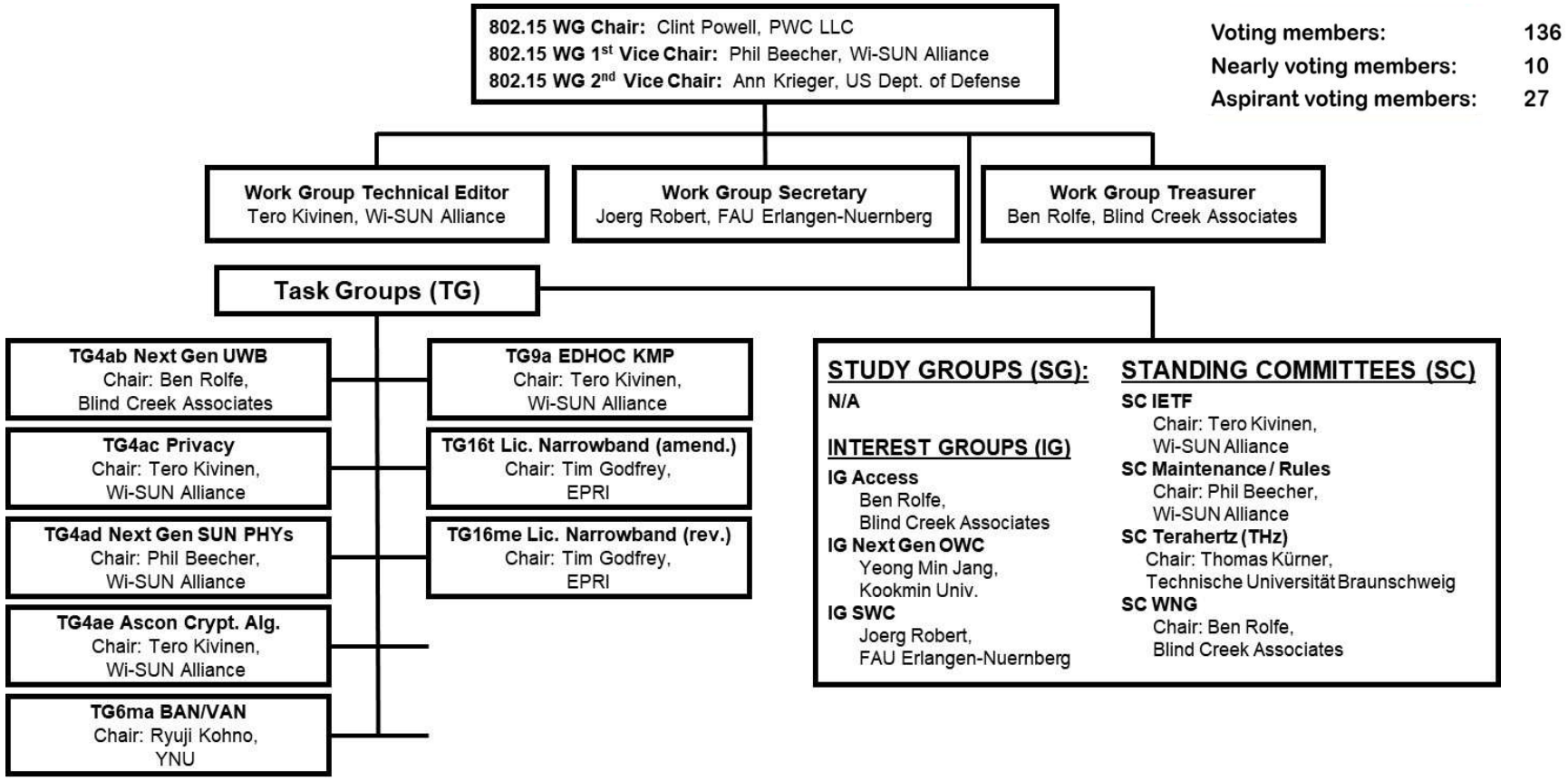
04. IEEE 802.15 Organization



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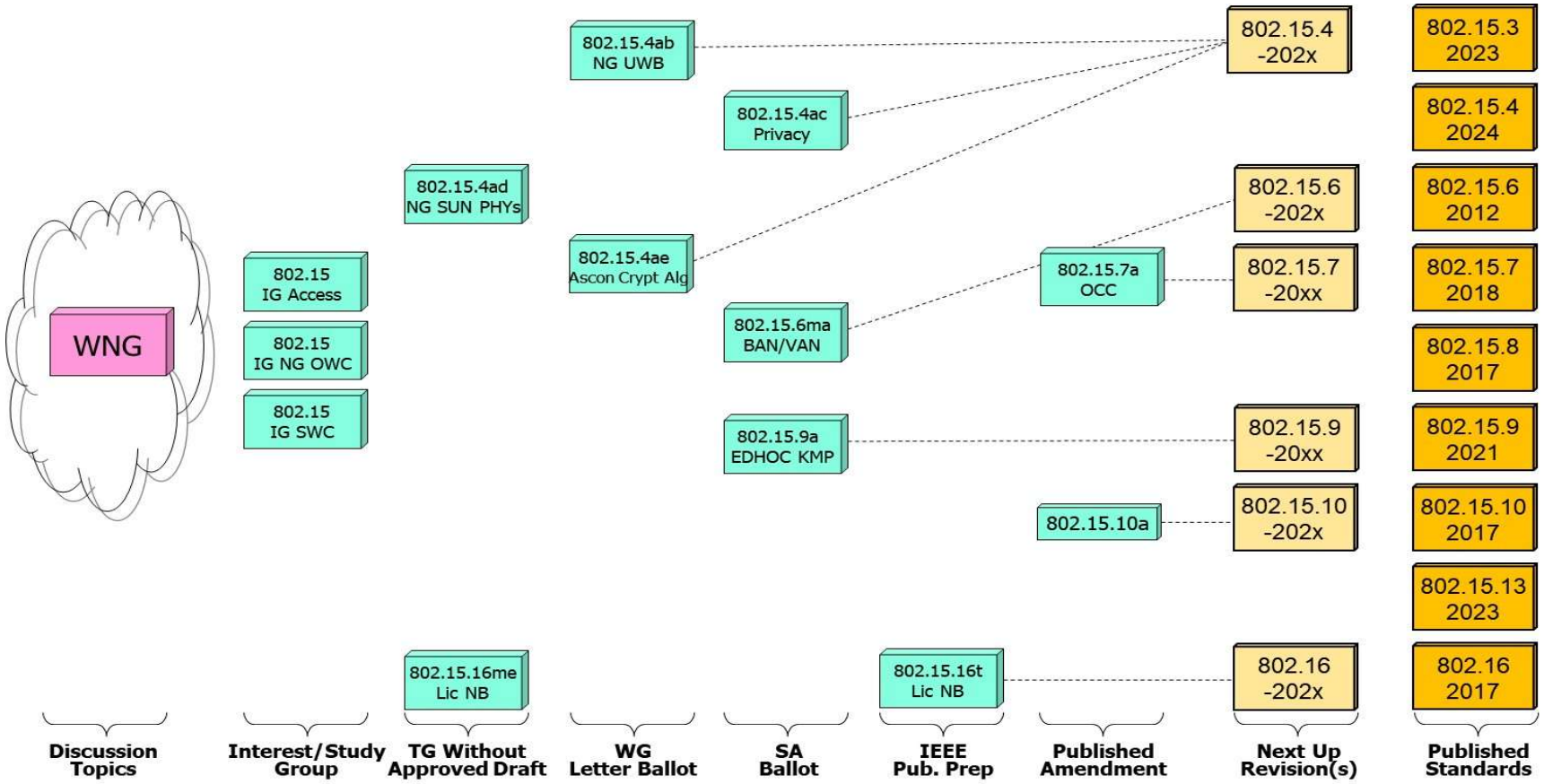
05. IEEE 802.15 Standards Pipeline



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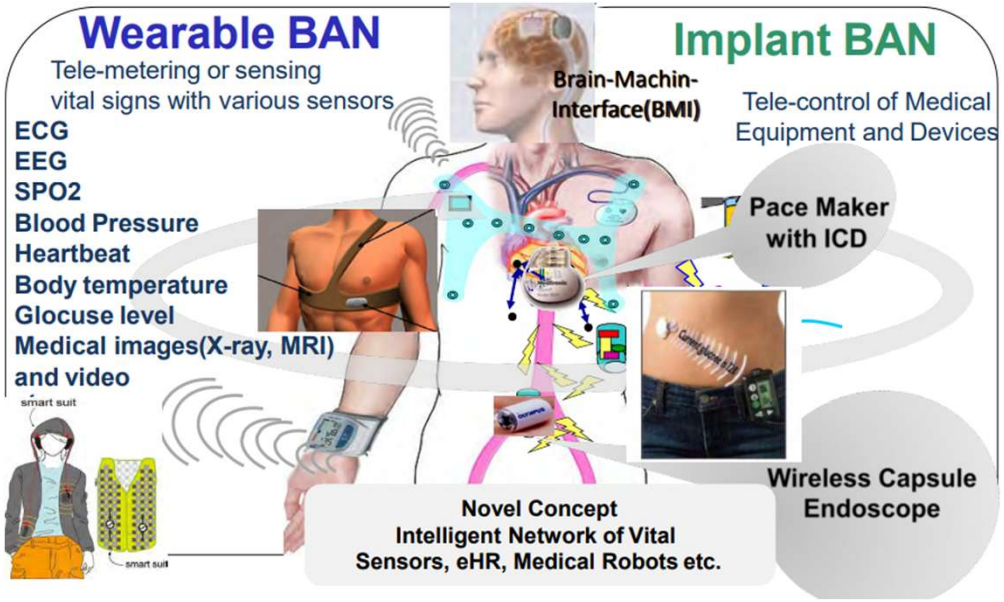
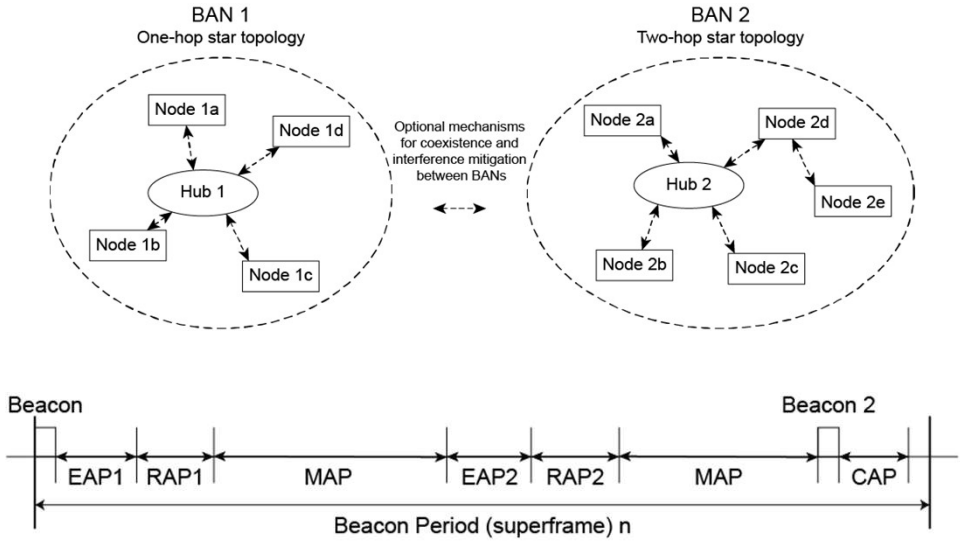
01. IEEE 802.15.6ma Dependable Body Area Network

Enhancements of IEEE 802.15.6-2012, Wireless Body Area Networks

- short-range, wireless communication in the vicinity of, or inside, a human body
  - existing industrial scientific medical (ISM) bands,
  - frequency bands approved by national medical and/or regulatory authorities



- one-hop star topology
  - Beacon mode with superframes
  - Non-beacon mode with superframes
  - Non-beacon mode without superframes

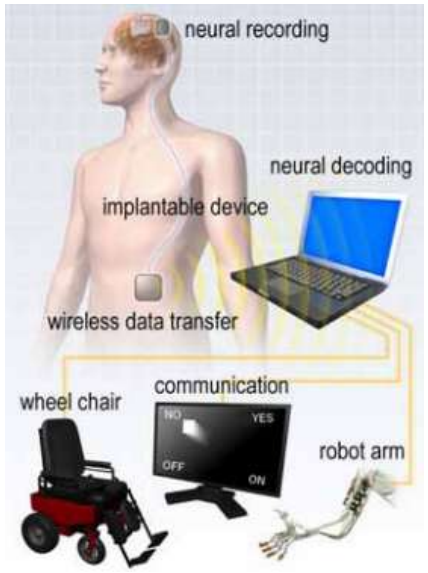


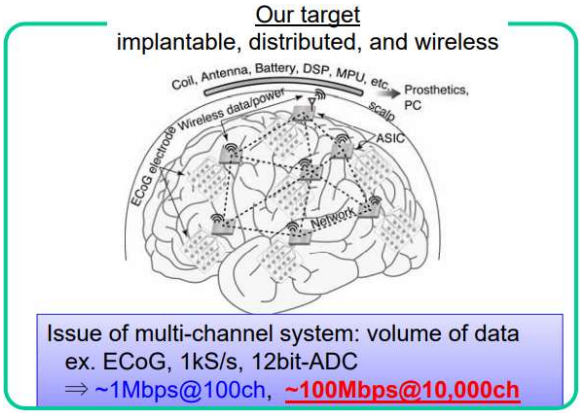
https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

01. IEEE 802.15.6ma Dependable Body Area Network

Wireless Medical BAN for Brain-Machine Interface

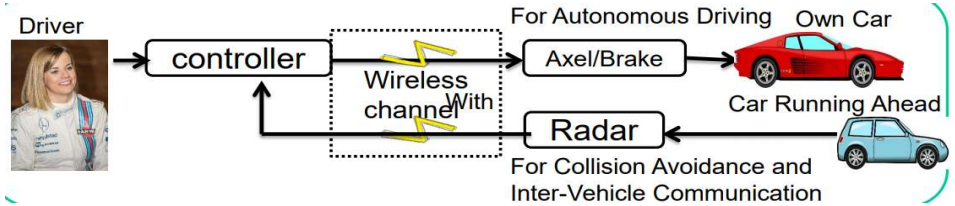
- 2nd Generation 4096ch system
  - Flexible electrode technology
  - UWB wireless technology : 12bit x 1kHz x 4096ch = 49Mbps, Distributed system

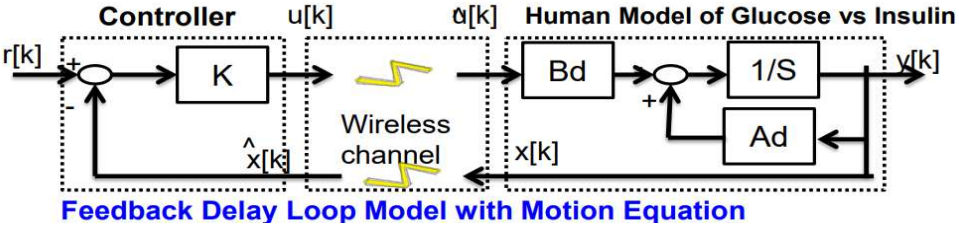




Wireless Feedback Sensing and Controlling Loop

- Vehicle Body Area Network



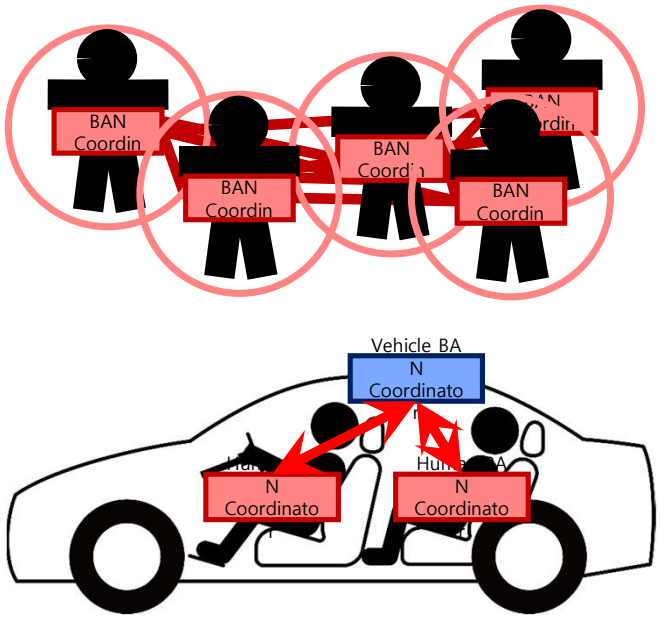


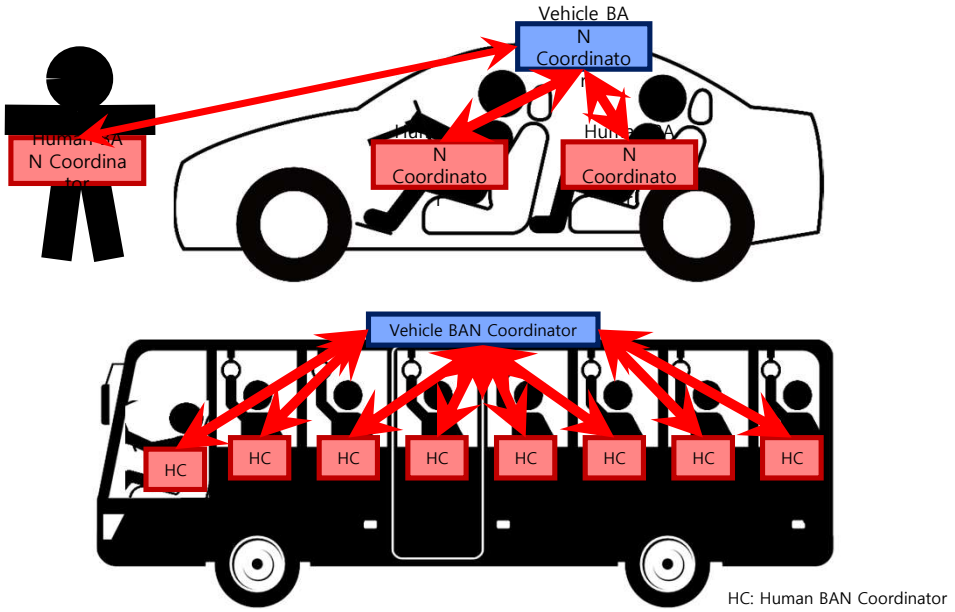
https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

01. IEEE 802.15.6ma Dependable Body Area Network

Dependable Human and Vehicle Body Area Networks

- Interference and collisions in dense situations
- Support for various use cases
- operating under strict compliance to standards and limits for electromagnetic compatibility (EMC) and electromagnetic interference (EMI)
- multiple piconets coexisting, which includes intra-BAN interference and inter-piconets interference





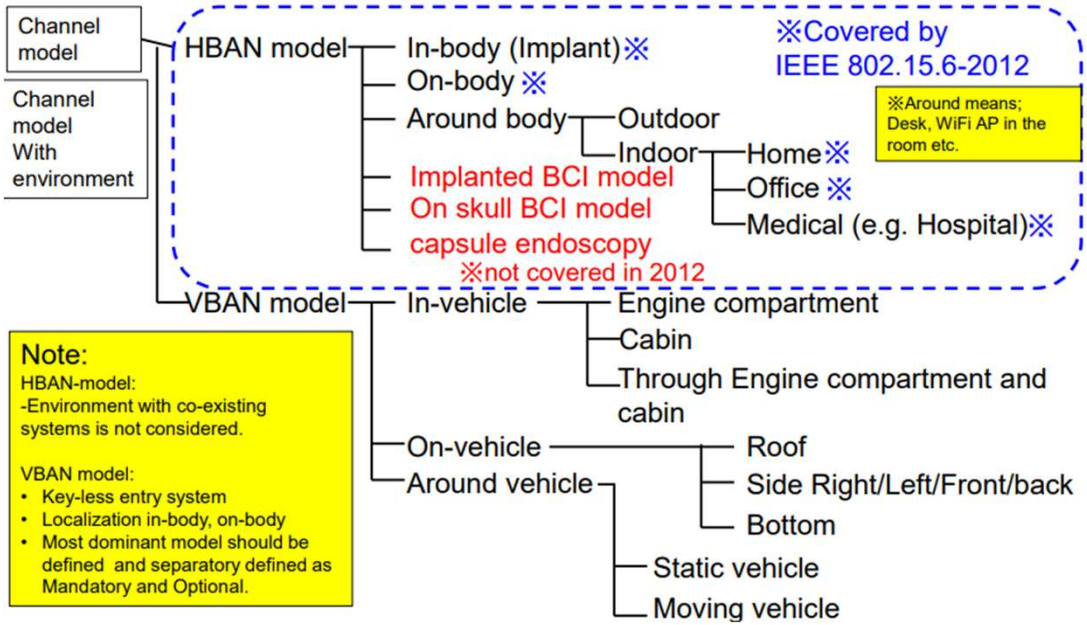
HC: Human BAN Coordinator

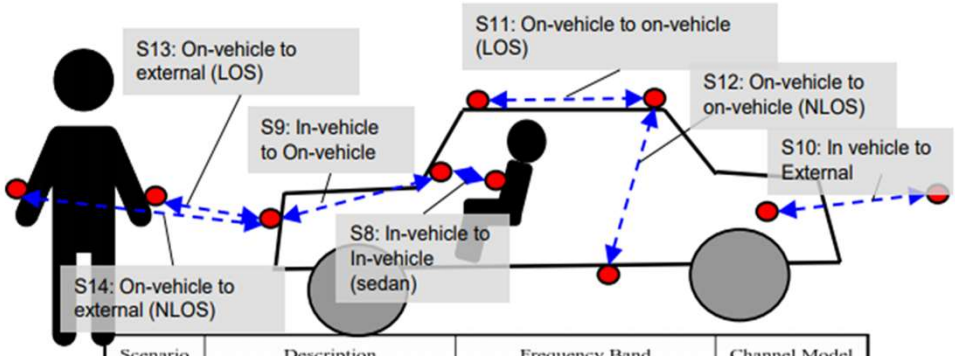
https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

01. IEEE 802.15.6ma Dependable Body Area Network

Channel and Environment Models for HBAN & VBAN

- Channel models and scenarios in IEEE802.15.6ma



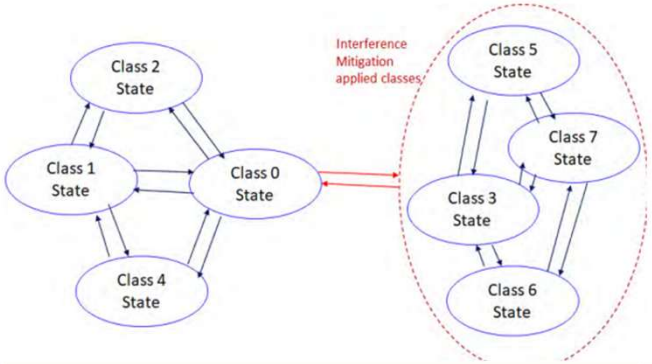


Scenario	Description	Frequency Band	Channel Model
S8	In-vehicle to In-vehicle (sedan)	2.4, 3.1-10.6 GHZ	CM8
S8.1	In-vehicle to In-vehicle (passenger bus)	2.4, 3.1-10.6 GHZ	CM8.1
S9	In-vehicle to On-vehicle	2.4, 3.1-10.6 GHZ	CM9
S10	In vehicle to External	2.4, 3.1-10.6 GHZ	CM10
S11	On-vehicle to on-vehicle (LOS)	2.4, 3.1-10.6 GHZ	CM11
S12	On-vehicle to on-vehicle (NLOS)	2.4, 3.1-10.6 GHZ	CM12
S13	On-vehicle to external (LOS)	2.4, 3.1-10.6 GHZ	CM13
S14	On-vehicle to external (NLOS)	2.4, 3.1-10.6 GHZ	CM14

https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

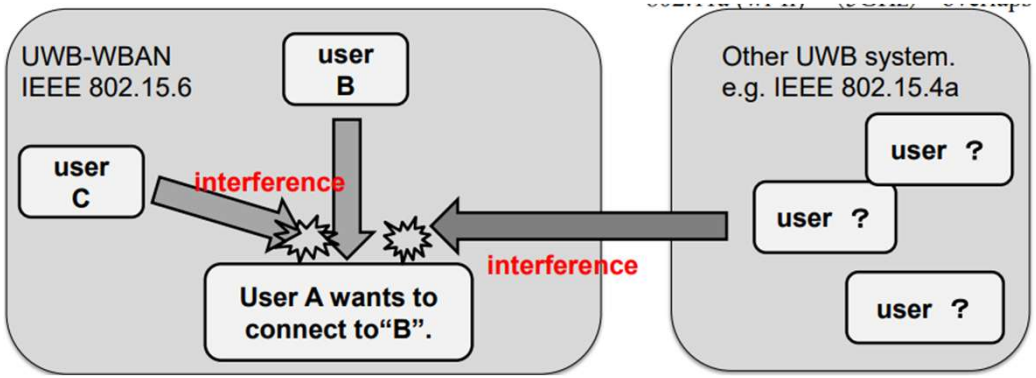
01. IEEE 802.15.6ma Dependable Body Area Network

Coexistence Environment Classes



Coexistence Class	Coexisting system(s)					Category
	802.15.6ma	802.15.6-2012	Non-UWB (ex. Wi-Fi / Unlicensed / 3GPP)	802.15 UWB (ex. 802.15.4)	Non-802.15 UWB (ex. ETSI SmartBAN)	
0	-	-	-	-	-	Single BAN
1 (1a)	✓	-	-	-	-	Multiple 15.6 BANs
2 (1b)	✓	✓	-	-	-	
3	✓	-	✓	-	-	Non-UWB
4 (2a)	✓	-	-	✓	-	Multiple UWB systems
5 (2b)	✓	-	-	-	✓	
6 (2c)	✓	-	-	✓	✓	
7	✓	✓	✓	✓	✓	Final Boss

Intra and Inter System Interference among BAN and Other PANs



Inter-user interference
"IUI" in this presentation
Interference from a system using the same pulse

known

Recognize and demodulate

Pulse shape multiple access
Multi-user detection

Inter-system interference
"ISI" in this presentation
Interference from a system using overlapped frequency

unknown

Remove

Interference canceller

https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

01. IEEE 802.15.6ma Dependable Body Area Network

Channel Coding Depending on Coexistence Class and User Priority

- Channel Coding for Class 0/1, Class 2

Common with IEEE802.15.4ab

Error-correcting codes corresponding to QoS levels

User priority	Inner code	Outer code	HARQ
0	15.4ab LDPC or BCC (R=1/2)		-
1	15.4ab LDPC or BCC (R=1/2)		-
2	15.4ab LDPC or BCC (R=1/2)		-
3	15.4ab LDPC or BCC (R=1/2)		-
4	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
5	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
6	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
7	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-

- Channel Coding for Class 5, 3/4/6/7

User priority	Inner code	Outer code	HARQ
0	15.4ab LDPC or BCC (R=1/2)		-
1	15.4ab LDPC or BCC (R=1/2)		-
2	15.4ab LDPC or BCC (R=1/2)		-
3	15.4ab LDPC or BCC (R=1/2)		-
4	15.4ab LDPC or BCC (R=1/2)		
5	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
6	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
7	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-

User priority	Inner code	Outer code	HARQ
0	15.4ab LDPC or BCC (R=1/2)		-
1	15.4ab LDPC or BCC (R=1/2)		-
2	15.4ab LDPC or BCC (R=1/2)		-
3	15.4ab LDPC or BCC (R=1/2)		-
4			o
5			o
6			o
7			o

Hybrid ARQ (HARQ) for High QoS packets

The same FEC for QoS levels 4,5,6 and 7 in Classes 0, 1, and 2

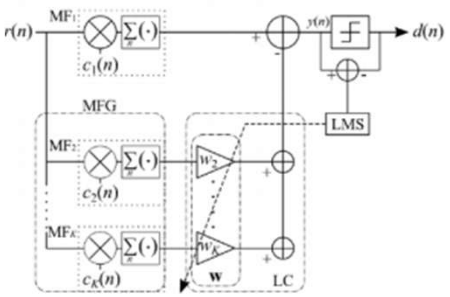
User priority	Inner code	Outer code	HARQ
0	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
1	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
2	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
3	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
4	15.4ab LDPC or BCC (R=1/2)	(200,168) shortened RS code	-
5			o
6			o
7			o

Hybrid ARQ (HARQ) for High QoS packets

Interference Mitigation

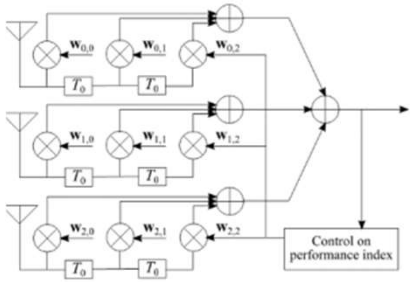
- orthogonal matched filter

Principle of OMF



- Tapped delay line array antenna

Principle of TDL-AA

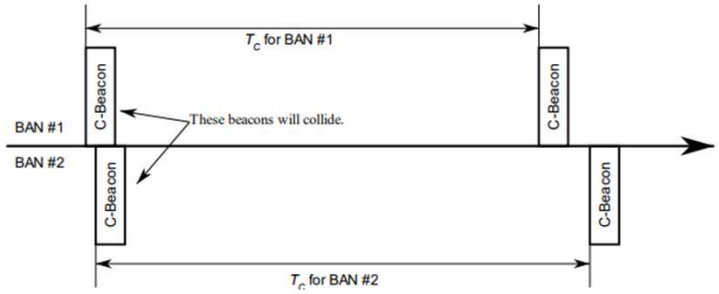


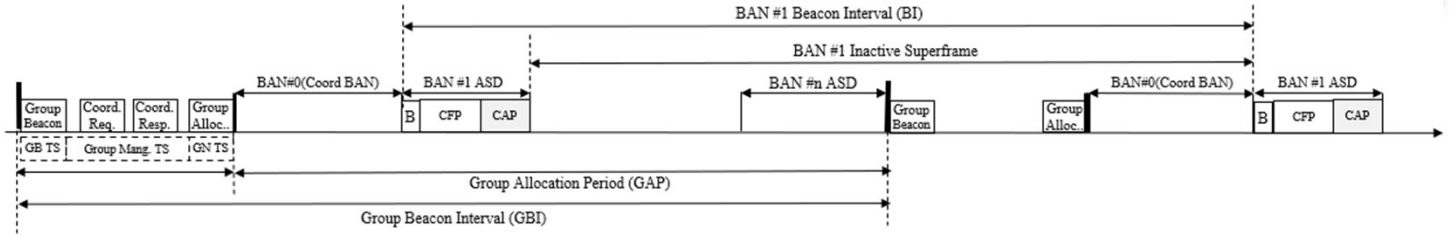
https://mentor.ieee.org/802.15/dcn/25/15-25-0033-01-006a

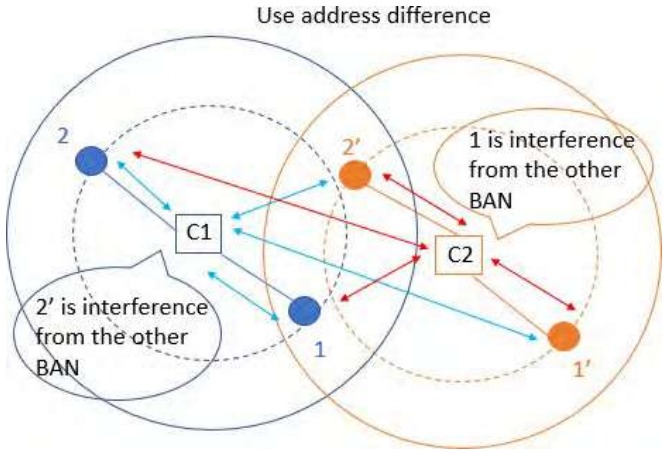
01. IEEE 802.15.6ma Dependable Body Area Network

Coexisting Dependable BANs, group BAN

- Coordinator-to-Coordinator (C2C) communication
  - mode 1 : out of band control channel
  - mode 2: in band control channel
- C2C ranging
  - detecting BAN mobility



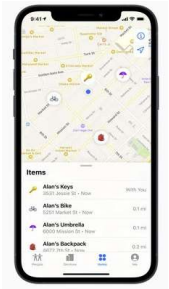




02. IEEE 802.15.4ab, Enhanced UWB amendment

UWB is being applied to an ever wider range of applications

- unique capabilities of UWB
  - very accurate ranging, localization, sensing and
  - data communication with excellent coexistence properties
- New applications require added flexibility and scalability

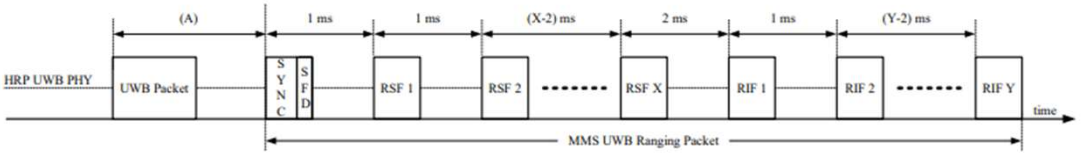


source: https://appleinsider.com/articles/20/10/18/everything-you-need-to-know-about-ultra-wideband-in-the-iphone-12-and-homepod-mini

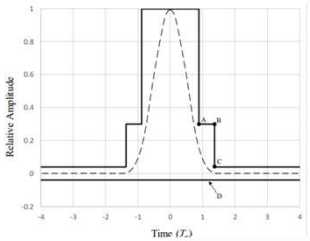
02. IEEE 802.15.4ab, Enhanced UWB amendment

Enhanced Ultra WideBand (UWB) Physical Layers (PHYs) and Associated MAC Enhancements

- Ranging
  - Link budget improvements
  - Improvements to accuracy, precision and reliability
- Sensing
  - Pulse shape improvements
  - Channel impulse response reporting to support multistatic sensing
  - To better support presence detection, environment mapping and other uses
- Data
  - Higher data rates for shorter transmission duration and power savings
  - Channel coding and packet format improvements for robustness
  - Additional options for even greater power savings
  - Protocol enhancements to support very low latency, low energy communications
- Interference mitigation techniques to support:
  - Greater device density
  - Coexistence in the presence of other users



Advanced Ranging, HRP-ARDEV : multimillisecond (MMS) ranging



UWB Sensing, HRP-SDEV : Time-bounded Kaiser window pulse shape without precursor and postcursor energy

# Pulses per data symbol	# Chips per Data symbol	Peak PRF (MHz)	Mean PRF (MHz)	Data Symbol Duration (ns)	Data Symbol Rate (MHz)	Bit Rate, RS used (Mb/s)	Bit Rate, RS not used (Mb/s)
2	4	249.6	249.6	8.01	124.8	n/a	124.8
4	8	499.2	249.6	16.03	62.4	n/a	62.4
8	16	499.2	249.6	32.05	31.2	27.24	31.2
16	64	249.6	124.8	128.21	7.8	6.81	7.8
64	256	249.6	124.8	512.82	1.95	n/a	1.95

HPRF mode modulation parameters

Enhanced Modulation : HRP-EMDEV, Low Latency data : HRP-LLDDEV

03. IEEE 802.15.4ac, Privacy Amendment

Specify mechanisms that address and improve user privacy

- 필요성
  - 스마트폰과 같이 개인의 이동과 밀접한 모바일 기기는 기기 추적 방지를 통한 개인정보보호가 요구됨
  - 고정형 장치 (조명, 스위치 등)는 정적 주소를 사용하지 않도록 보호가 필요함
  - 기기의 위치 추적을 통해 사용자의 움직임을 감시하는 행위 방지가 필요함
    - 일반적인 하드웨어를 이용한 무선 통신 범위 내에서의 기기 추적
    - 대규모 감시(Mass Surveillance) 행위
    - 국가 수준의 공격자가 전파 지문(Radio Fingerprint) 분석 등 특수 장비를 이용하는 정교한 추적 (방어 불가)

- 핵심 기능
  - 주소 익명화: 기기와 쉽게 연관되지 않는 주소를 사용
    - AAI-64를 사용하여 M/X/Y/Z 비트를 x/1/0/0으로 설정하고 나머지 60비트를 프라이버시 주소로 지정
  - 주기적 주소 변경: 추적이 불가능하도록 충분히 자주 주소를 변경하여 추적의 연결고리를 차단
    - random 하게 만들어진 다수개의 extended privacy address set 을 사용
    - address 생성 주기와 사용하는 주소의 수는 상위 계층에서 use case 에 따라 결정
  - 암호화 및 인증을 통해 메시지 교환을 보호
    - MAC 명령어: 반드시 암호화 및 인증된 프레임으로 전송

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ICT Standards and Intellectual Property:
AI for All

주최 과학기술정보통신부 지식재산처 주관 국립전파연구원 TTA IITP KEA kista ETRI