IEEE 802 LAN/MAN Standards Enabling Future Networks

Prepared for 23 October 2018 IEEE Workshop on 5G Technologies for Tactical and First Responder Networks

by

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IEEE Overview

- IEEE mission: ‘Advancing Technology for Humanity’
- Core activity: Collect, vet and publish/distribute high quality technical information
- 430,000+ members, 45 societies, 190+ countries
- Members host conferences, produce documents and develop technical standards
- The IEEE Standards Association is the IEEE Organizational Unit responsible for oversight of the IEEE’s standards development process
- IEEE 802 LAN/MAN Standards is a Sponsor in the IEEE Computer Society
  - 8 Working Groups, 2 Technical Advisory Groups
  - 750+ active participants, individual based, global, IEEE membership is not required
  - 6 week long face-to-face sessions per year held throughout the world
  - Hundreds of electronic meetings held per year
  - Estimated time/expertise value of volunteer participation north of $250mm per year

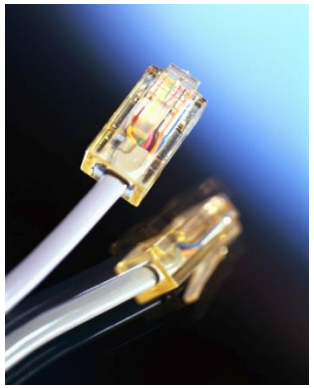
802 Impact Over the Decades

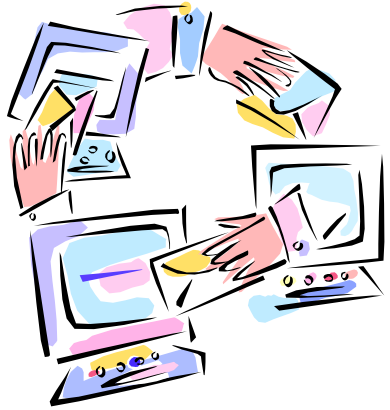
enabled markets/technologies

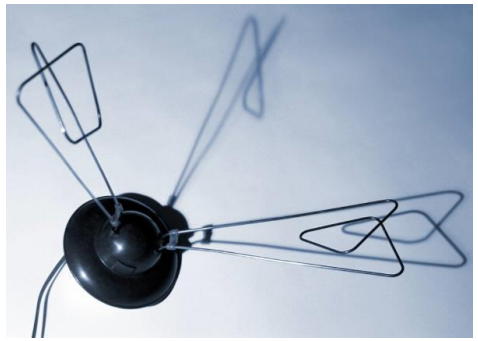
1970 to 1980 (pre IEEE 802)	Mainframe and Mini Computers (100s of thousands) Proprietary LANs and WANs (sub 10Mbps)
1980 to 1990 802 began March 1980	Mini and Personal Computers (millions) Enterprise LANs (802.1 Bridges, 802.3 Ethernet, 802.5 Token Ring) Proprietary Leased Line WANs
1990 to 2000 802.11 WLAN began March 1990	PCs, Tablets, (100s of millions) Enterprise and Home LANs—wired and wireless (802.11) Broadband Access—cable modems and Ethernet PONs (802.3) Fiber based Metro and Wide-Area Networks
2000 to 2010 802.23 Emergency Services Study Group formed Sept 2009	Tablets, Smart Phones (billions) Ubiquitous wireless (802.11, portability, mobility) Faster fiber and broadband access (EPONs)
2010 to 2020 802.23 Emergency Services Working Group disbanded Nov 2011	IoT/IoE (100s of billions) Automotive Networks (802.1, 802.3, 802.11) IoT, M2M, faster/slower, low latency, low power, more reliable, more secure, more private, higher density, sensor networks (802.15.4), ubiquitous connectivity…..

802 LAN/MAN Standards Description

- Interoperability Specifications
  - specify methods for **reliable** and **secure** information movement from one point to another
  - **Physical Layer** focus
    - Copper, Fiber, Wireless, Optical
- Dynamic and adaptive







Markets relying on 802 Standards

- Internet Infrastructure (core, regional, metro, local)
- Data Center Networks
- Enterprise and Home Networks

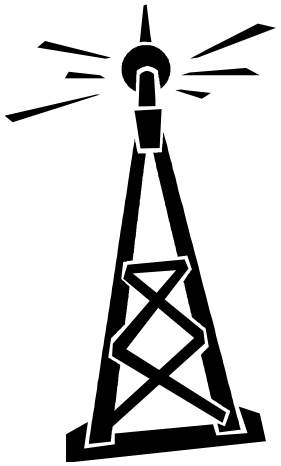
Traditional

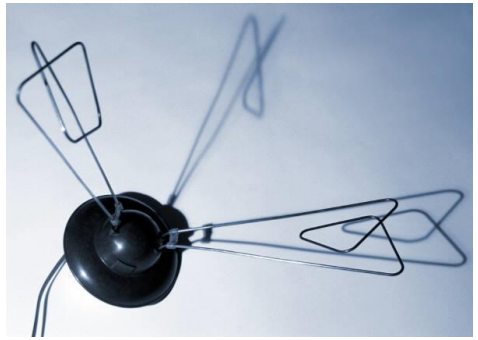
- Sensor Networks
- Intra and Inter Vehicle Networks
- Manufacturing Networks
- Gaming, Entertainment and Media Networks

Emerging

802 LMSC technologies

- Wireless
  - License Exempt (802.11, 802.15, 802.22)
    - Sub 1 GHz, 2.4 GHz, 5 GHz, 60 GHz
    - TV Whitespace (VHF/UHF)
    - Tera Hertz
  - Licensed (802.16)
    - Cellular bands
    - UHF bands
    - Microwave bands
    - MMwave bands
  - Lightwave (802.11bb, 802.15.7)
    - Visible light band





Evolving 802 Activities

- 802.3 Ethernet
  - Copper and Fiber media
  - Reduced Rates (2.5Gb/s, 5Gb/s 25Gb/s)
  - Higher Rates (400GB/s)
  - Next Gen EPON
  - Reduced Pair
    - Vehicular/Factory applications
  - More DC Power

- 802.11 Wireless LAN
  - High Efficiency WLAN
  - Accurate Position Estimation
  - Real Time Applications
  - Next Gen V2X
  - Extremely High Throughput
  - Broadcast Services

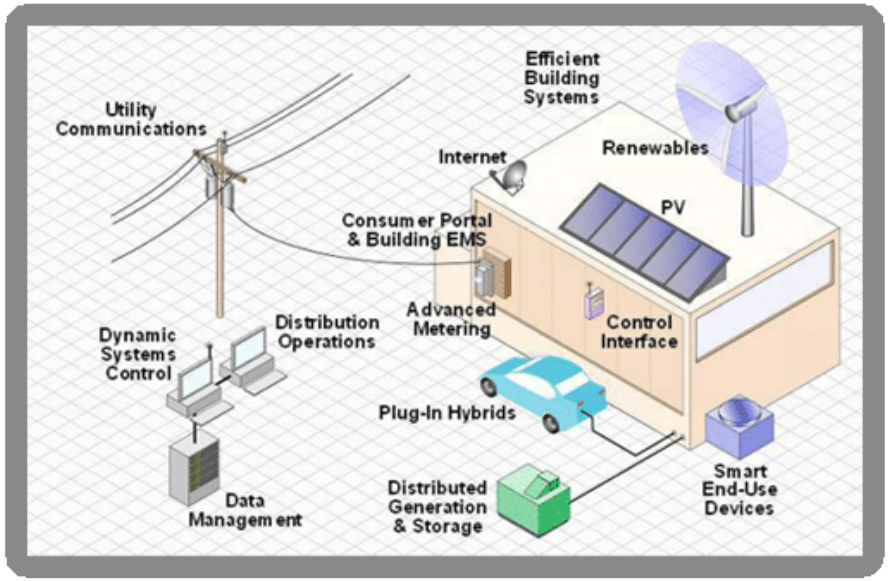
- 802.15.4 Wide Area Networks
  - Mesh
  - Sensor applications
  - Long Range Low Power
  - UWB ranging

- 802.15.8 Peer Aware Communicat
  - ‘crowd networking’

Evolving 802 Activities

- Low Power Sensor Networks (IoT)
  - 802.15, 802.11

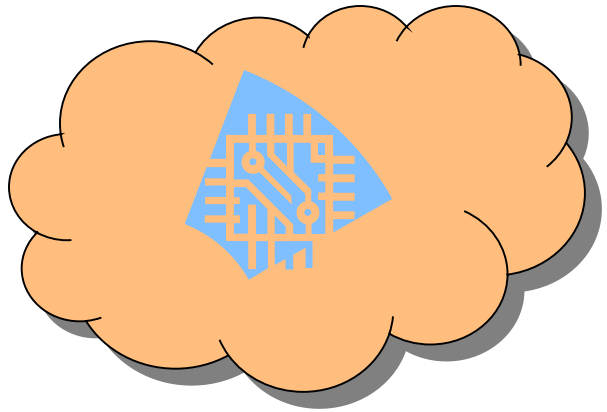
- 802.24 Technical Advisory Group on Vertical Network Applications (Smart Grid, IoT, etc.)



Evolving 802 Activities

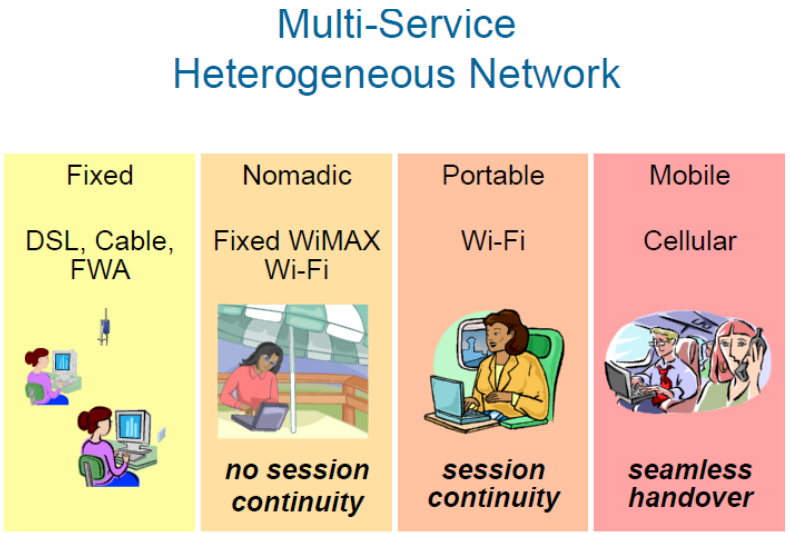
- 802.1 Time Sensitive Networking
  - Low latency/jitter
  - Deterministic
  - Factory Automation

- 802.1 Data Center Bridging
  - Support of virtual machines enabling cloud computing

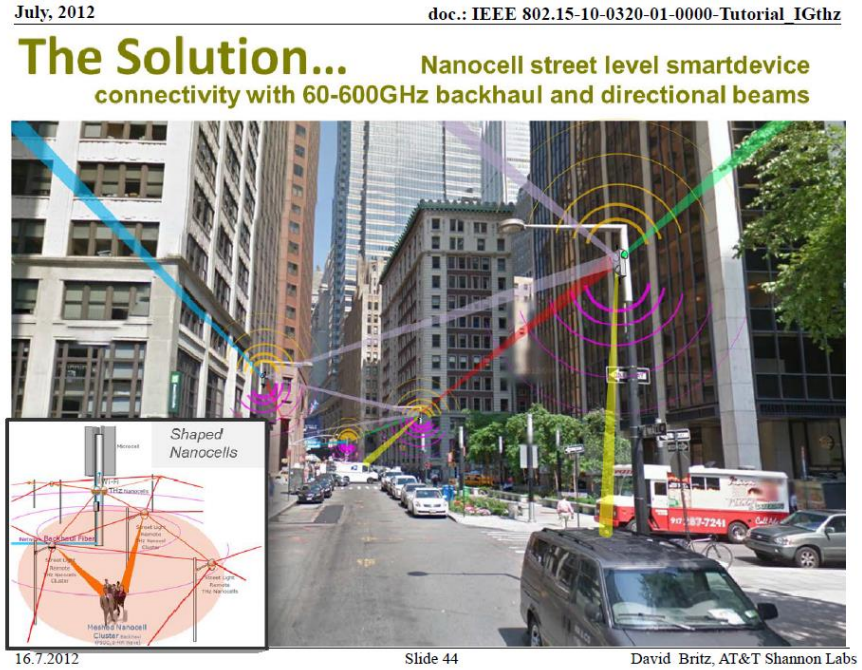


Evolving 802 Activities

- 802.1CF OmniRAN Reference Architecture

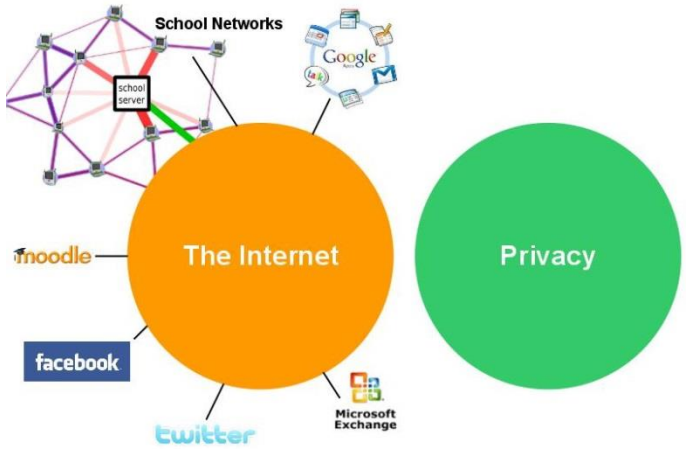


- 802.15 100Gbps Wireless Networks at Terahertz Frequencies

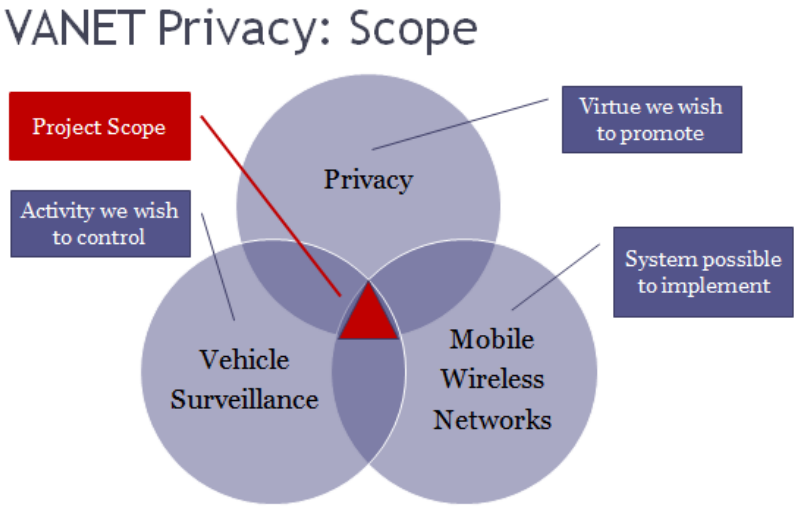


Evolving 802 Activities

- 802C Privacy Recommended Practice Project
  - network protocol vulnerabilities make it difficult to control access to personal information (e.g., Privacy, location, etc.)
  - Identify threats and possible remedies



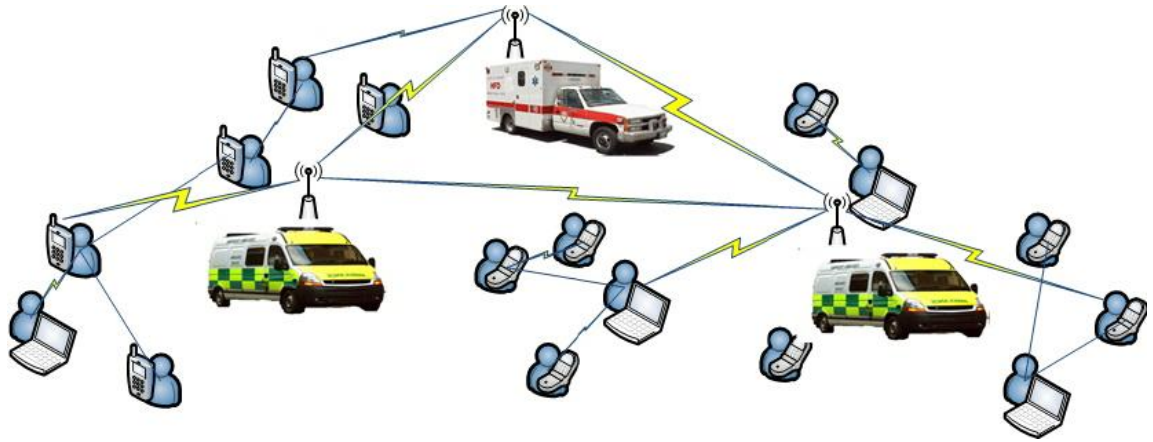
A Useful Venn Diagram



Source: Oakland University - School of Engineering and Computer Science - CSE Department Research Experience for Undergraduates - REU 2013

Emergency Services 802 Activity (terminated 2011)

- 802.23 Emergency Services Working Group
  - Formed September 2009, Disbanded November 2011
    - Inadequate participation
  - 5.4 Purpose: To support civil authority requirements complementary to IETF ECRIT specifications for citizen to authority emergency services functionality. This standard intends to encompass voice, data and multi-media requests across IEEE 802 using a new Layer 2 entity and associated behaviors and provide a uniform Structure of Management Information (SMI) for transferring required data for emergency services requests
  - Document archive at https://mentor.ieee.org/802.23/documents



Source: https://www.researchgate.net/publication/257923906_A_framework_supporting_extreme_emergency_services

802.23 Emergency Services Project Objectives (terminated)

What can IEEE 802 provide to meet ECRIT* requirements?

- Provide better location than just the router location (e.g., end points)
- Emergency calls should be given priority in the 802 network
- Callback is currently a problem
- Spoofing and security are issues
- Prefer LOCAL connection (e.g. bypass various tunneling schemes)
- Provide service to unauthenticated user

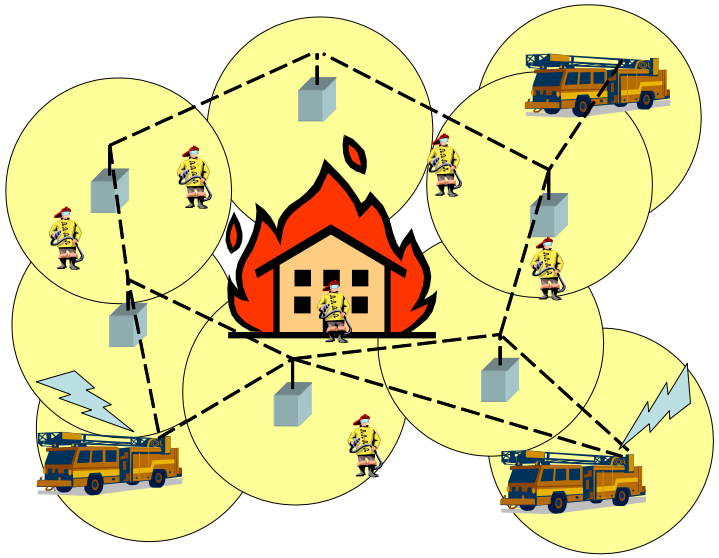
*IETF Emergency Context Resolution with Internet Technologies = ECRIT

From 802.11-04/662r16 Mesh Usage Models: Public Safety

Public safety mesh networks provide wireless network access to emergency and municipal safety personnel such as fire, police, and emergency workers responding to an incident scene. The network may be used for video surveillance, tracking emergency workers with bio-sensors, voice and data communication between emergency workers, uploading images, downloading hazmat information, tracking air status, etc.

Public safety networks may be deployed over a wide range of scales, with respect to both the physical dimensions of the network and the number of Mesh Points/Mesh APs. Public safety mesh network deployments may consist of a combination of semi-permanent infrastructure installation (e.g. radios installed on poll tops) as well as mobile mesh points and mesh APs deployed at a scene during an emergency. While many mesh points in a public safety network may be mobile during the operation of the network, many back haul links are expected to be from fire trucks or other vehicles that are less mobile, more secure, and have better power.

Communications for public safety networks are mostly outdoors, but may include communicating with first responders inside buildings (potentially deep inside with contact only by multi-hop relaying). The number of forwarding nodes may naturally exceed 32, which may require some ability for automatic partitioning into clusters, each of which uses 802.11s. Node mobility, dynamic variations in radio propagation, equipment/power failures, etc. make network self-configuration and self-management essential in these scenarios.

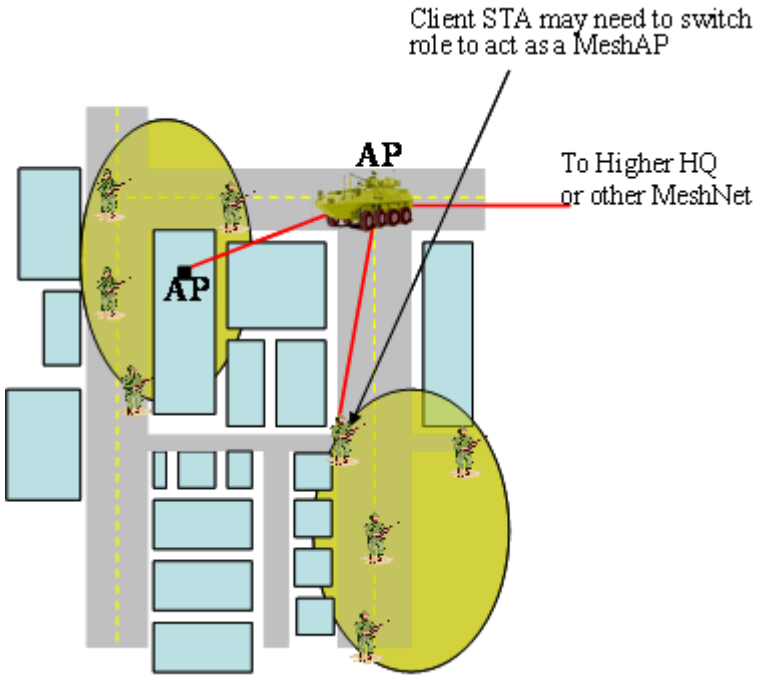


From 802.11-04/662r16 Mesh Usage Models: Military Combat Operational Useage

Military usage of mesh networks can be classified into two categories. The first category, non-combat usage, is adequately represented by the usage cases previously described in this document. The second category, combat operational usage, is distinguished by node mobility, a heavy reliance on fully automated network management and, for disadvantaged nodes, e.g., dismounted troops, sensitivity to energy conservation.

Combat operations may occur both indoors and outdoors. The accompanying graphic illustrates an outdoor scenario with combat units clearing areas in an urban neighbourhood. This scenario can easily be extended to include indoor operations as troops enter buildings to clear them of enemy combatants. A key element of this scenario is the requirement for client STAs to temporarily switch roles to become mesh APs in order to relay traffic for troops that are at the forward point of the operation and, consequently, out of range of a mesh AP. When the former client STA is no longer needed as a critical relay, it may revert to its more energy conservative client STA role. The AP can be installed on a vehicle, inside a ship or on the backpack of dismounted military personnel. Power conservation is important for the latter AP deployment scenario.

Situational awareness (SA) and voice communications are primary applications of interest to the military. SA traffic may include short, periodic packet transmissions to report troop positions and conditions to a combat operations center. SA traffic could also be real-time video feeds from individual troops or automated surveillance devices, e.g., UAVs. Moreover, the combat operations center may broadcast a common tactical picture back to the troops engaged in operations. Typically, military applications rely heavily on broadcast/multicast in addition to unicast traffic delivery.



Standards Applicable to Future Networks

Computer Society:

IEEE 802.1 - Higher Layer LAN Protocols Working Group

- IEEE P802.1CM Time Sensitive Networking
- IEEE P802.1CF Network Reference Model of the Radio Access Network (omniRAN)
- IEEE P802E Privacy

IEEE 802.3 - Ethernet Working Group

- IEEE P802.3bs 200 Gb/s and 400 Gb/s Ethernet
- IEEE P802.3ca 25 Gb/s, 50 Gb/s, and 100 Gb/s Ethernet Passive Optical Networks (EPON)
- IEEE P802.3cc 25 Gb/s Ethernet over Single-Mode Fiber
- IEEE P802.3cd 50Gb/s, 100 Gb/s, and 200 Gb/s Ethernet

IEEE 802.11 - Wireless LAN (aka Wi-Fi) Working Group

- IEEE 802.11ac-2013 Up to 7 Gbps in 5 GHz
- IEEE 802.11ad-2012 Up to 7 Gbps in 60 GHz
- IEEE P802.11ax Up to 10 Gbps in the 5 GHz
- IEEE P802.11ay Up to 20 Gbps in the 60 GHz band
- IEEE 802.11ah-2016 “HaLow”: Massive Machine Type Communications

Standards Applicable to Future Networks (Cont'd)

Computer Society:

IEEE 802.15 - Wireless Personal Area Network (WPAN) Working Group

- IEEE 802.15.6 Wireless Body Area Networks (BAN)
- IEEE 802.15.7 Visible Light Communications
- IEEE 802.15.12 Upper Layer Interface (ULI)

IEEE 802.16 - Broadband Wireless Access Working Group

IEEE 802.18 - Radio Regulatory Technical Advisory Group

IEEE 802.19 - Wireless Coexistence Working Group

- IEEE 802.19.1 TV White Space Coexistence Methods

IEEE 802.21 - Media Independent Handover Services Working Group

IEEE 802.22 Point-to-Multipoint Wireless Broadband

For details on IEEE 802 LAN MAN Standards Groups

Please see www.ieee802.org

No charge access to 802 standards 6 months after publication at the IEEE Get 802 Program (https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=68)

Next plenary session: 11-16 November in Bangkok Thailand

Supplemental slides

802 Organizational Characteristics

- Market Relevant--Industry Driven by 1000s of individual volunteers and hundreds of companies seeking consensus to satisfy demands of their respective markets
- High Quality--Broad and deep technical ‘hyper-peer review’ by 1000s of individual world experts
- Performance Requirements defined by producers and users—Market Driven
- High Volumes and Multi-Vendor result in very low fixed and operational costs: components, systems and services
- Dynamic and adaptive, rapidly responding to changing markets
- Collaborative – close relationships with SDOs and Alliances
- **Highly respected and used world-wide**

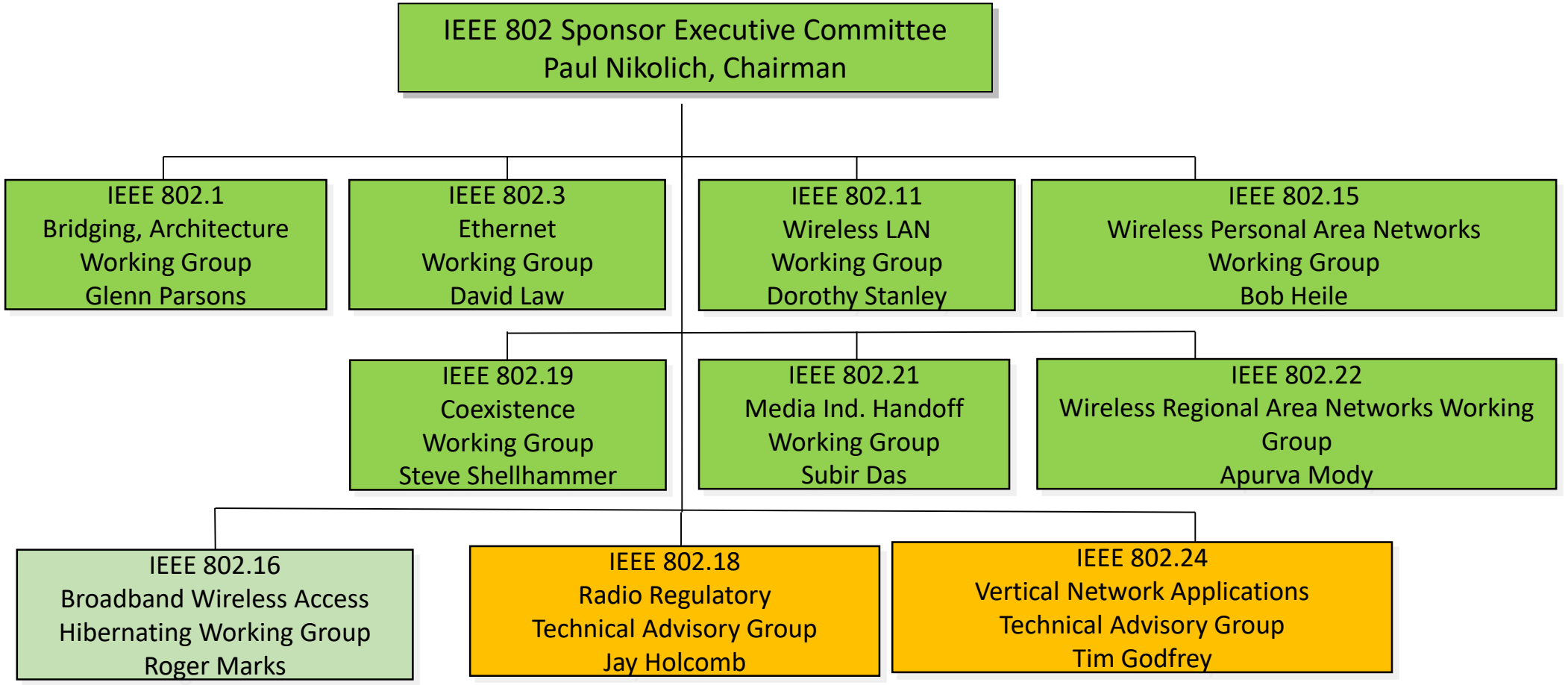
802 Activity

- 3 plenary sessions per year (MAR, JUL, NOV)
- 3 interim sessions per year (JAN, MAY, SEP)
- Innumerable conference calls between sessions
- ~50 activities ranging in size from 6 to 200 participants
- ~75 active standards
- ~750 active individual participants affiliated with 100s of companies and dozens of countries

Impact of the 802 Community

- Over 100 network interfaces based on 802 standards are put into service every SECOND.
  - That is well over 3 billion each year
  - …and it is growing
- A robust 802 community is a fundamental building block in the continued growth of ubiquitous connectivity worldwide

IEEE 802 Organization



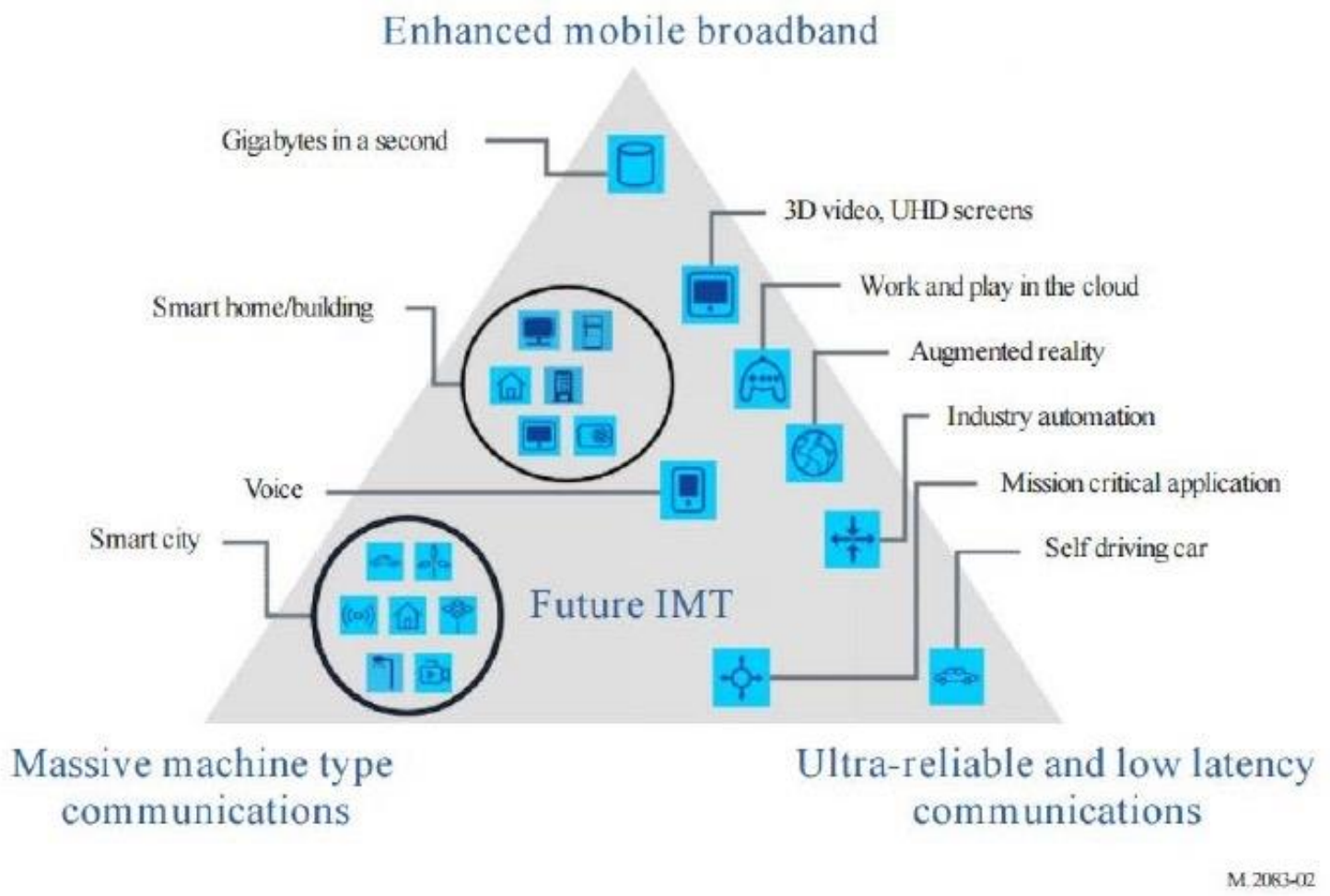
Appointed Executive Committee members:
Executive Secretary Jon Rosdahl
Recording Secretary John D'Ambrosia
Treasurer George Zimmerman

1st Vice Chair James Gilb
2nd Vice Chair Roger Marks
Member Emeriti Geoff Thompson, Clint Chaplin

Disbanded Groups: 802.2 Logical Link Control
802.4 Token Bus, 802.5 Token Ring, 802.6 Metro Area Network
802.7 Broadband TAG, 802.8 Fiber TAG, 802.9 Integrated Svcs LAN
802.10 Security, 802.12 Demand Priority, 802.14 CATV Broadband,
802.17 Resilient Packet Ring,
802.23 Emergency Services

IMT-2020 (per ITU-R M.2083 Vision document)

"Framework and overall objectives of the future development of IMT for 2020 and beyond"



Standards Applicable to 5G (Cont'd)

IEEE Vehicular Technology Society/ Intelligent Transportation Systems:

- 1609 Series - IEEE Wireless Access in Vehicular Environments (WAVE)

IEEE Antennas and Propagation Society/Antennas and Propagation:

- P211 - Standard Definitions of Terms for Radio Wave Propagation
- P149 - Recommended Practice for Antenna Measurements
- 1720-2012 - IEEE Recommended Practice for Near-Field Antenna Measurements

SASB/SCC39-SCC39 - International Committee on Electromagnetic Safety:

- 1528-2013 - IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

Instruments & Measurements:

- 1451 Series - Smart Transducer Interface for Sensors and Actuator Wireless Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats

Audio Video Coding Working Group:

- IEEE P1857.6™ - Standard for Digital Media Content
- IEEE P1857.9™ - Standard for Immersive Visual Content Coding

3D Based Medical Application Working Group:

- IEEE P3333.2.4™ - Standard for Three-Dimensional (3D) Medical Simulation

Standards in Development Applicable to 5G (Cont'd)

IEEE SA Design Automation Standards Committee (DASC)

- IEEE 1666 (SystemC) Modeling of 5G designs at a pre-implementation level
- IEEE 1666.1 SystemC AMS)
- IEEE 1800 (SystemVerilog) Design/Verification of 5G devices
- IEEE 1076 (VHDL)
- IEEE 1076.1.1 (VHDL AMS)
- IEEE 1647 (the e language)
- IEEE P1800.2 (UVM)
- IEEE 1801 (UPF) Low power hardware analysis 5G hardware designs
- IEEE 1685 (IPXACT) 5G Semiconductor IP design
- IEEE 1734 (IP quality)
- IEEE 1735 (IP encryption)

Standards in Development Applicable to 5G (Cont'd)

Communications Society

- IEEE P1903.1 Content Delivery Protocols of Next Generation Service Overlay Network (NGSON)
- IEEE P1903.2 Service Composition Protocols of NGSON
- IEEE P1903.3 Self-Organizing Management Protocols of NGSON
- IEEE P2413 Architectural Framework for the Internet of Things
- IEEE P1914.1 Standard for Packet-based Fronthaul Transport Networks
- IEEE P1915.1 SDN and NFV Security
- IEEE P1916.1 SDN and NFV Performance
- IEEE P1917.1 SDN and NFV Reliability
- IEEE P1918.1 Tactile Internet
- IEEE P1918.1.1 Haptic Codecs for the Tactile Internet
- IEEE P1921.1 SDN Bootstrapping Procedures
- IEEE P1930.1 Recommended Practice for (SDN) Middleware
- IEEE 1931.1 Architectural "ROOF "Framework for the IoT

Standards in Development Applicable to 5G (Cont'd)

IEEE Microwave Theory and Techniques:

- IEEE P1765 Recommended Practice for Estimating the Uncertainty In Measurements of Modulated Signals for Wireless Communications with Application to Error Vector Magnitude and Other System-Level Distortion Metrics
- IEEE P1770 Recommended Practice for The Usage of Terms Commonly Employed In the Field of Large-Signal Vector Network Analysis
- IEEE P1785 IEEE Frequency Bands and Waveguide Dimensions

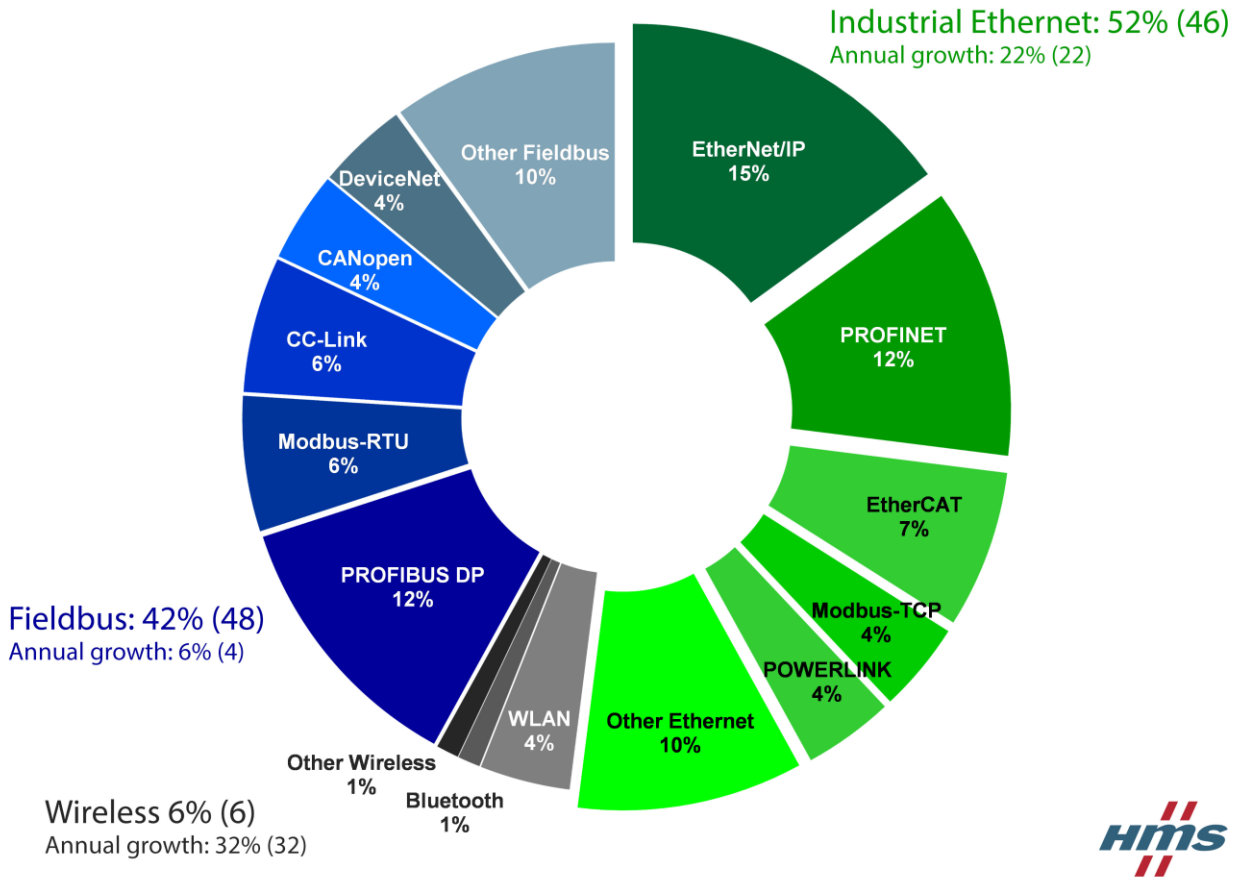
IEEE Instrumentation and Measurement Society:

- IEEE P287 Standard for Precision Coaxial Connectors at RF, Microwave and Millimeter-wave Frequencies
- IEEE P1415-99 Harmonization of Internet of Things (IoT) Devices and Systems

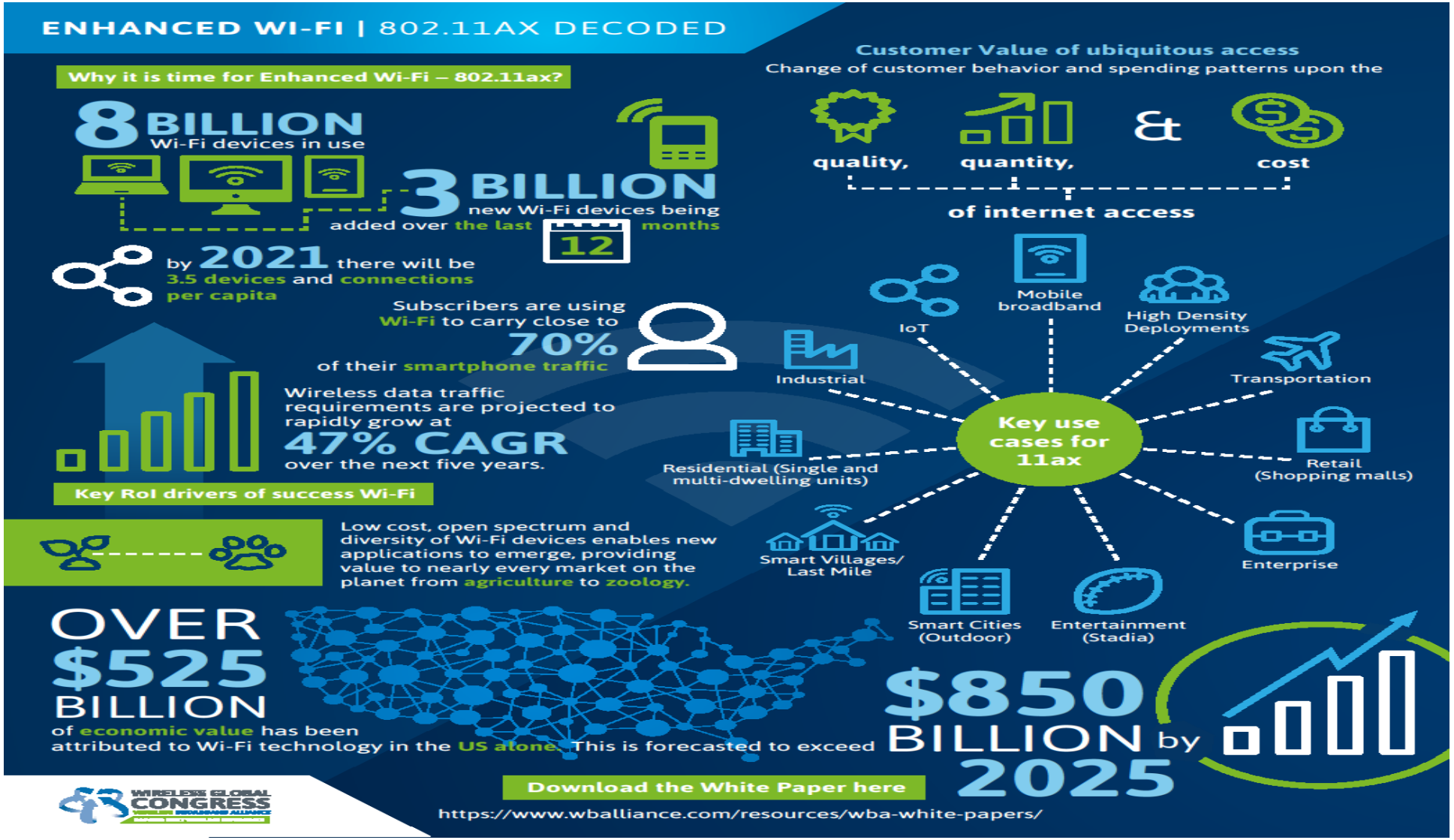
Augmented Reality Learning Experience Model:

- IEEE P1589 Standard for an Augmented Reality Learning Experience Model

Industrial Ethernet

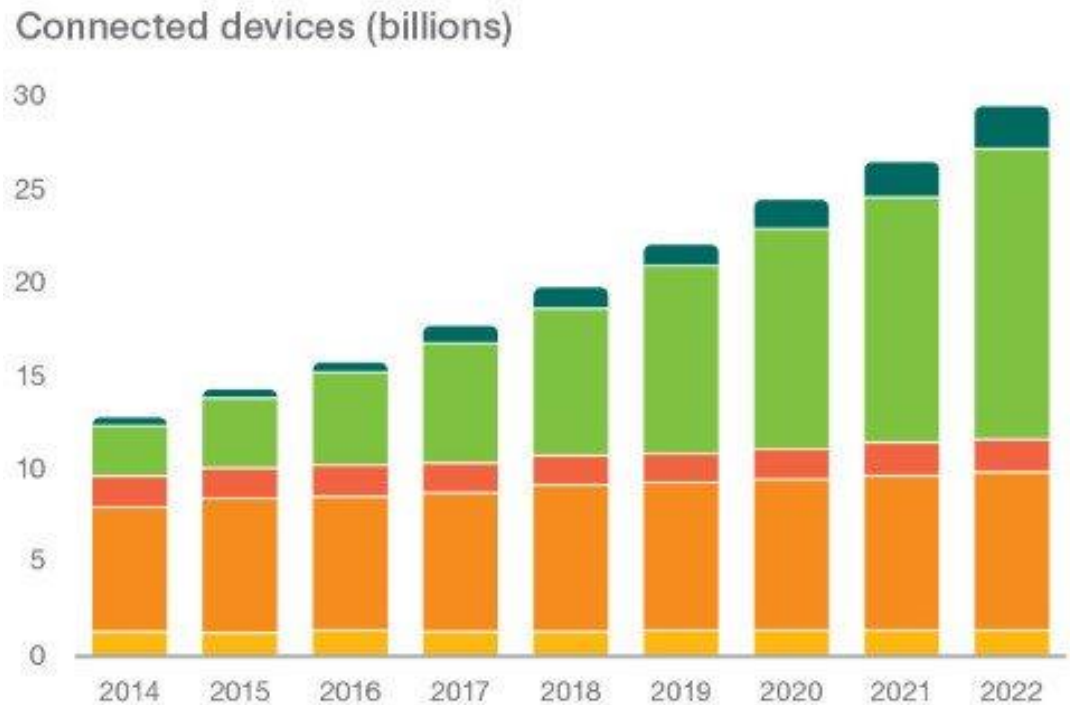


https://www.anybus.com/about-us/news/2018/02/16/industrial-ethernet-is-now-bigger-than-fieldbuses
HMS Industrial Networks' annual study of the industrial network market



- over 3 billion new Wi-Fi devices deployed in 2017, 8 billion currently in use
  https://www.wi-fi.org/news-events/newsroom/wi-fi-alliance-publishes-7-for-17-wi-fi-predictions

https://www.ericsson.com/en/mobility-report/internet-of-things-forecast



	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	16	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	10%

Unlicensed Use of the 6 GHz Band ET Docket No. 18-295 misc notes

- The fixed service is used for highly reliable point-to-point microwave links that support a variety of critical services such as public safety (including backhaul for police and fire vehicle dispatch), coordination of railroad train movements, control of natural gas and oil pipelines, management of electric grids, long-distance telephone service, and backhaul for commercial wireless providers such as traffic between commercial wireless base stations and wireline networks. 21 The 5.925-6.425 GHz (U-NII-5) and 6.525-6.875 GHz (U-NII-7) bands are the most heavily used by the common carrier fixed point-to-point microwave service and private operational fixed point-to-point microwave service. 22 In the 6.875-7.125 GHz (U-NII-8) band, fixed service links are restricted from intersecting with the service areas of television pick up stations which effectively limits the use of the band by common carrier and operational fixed point-to-point microwave services.23