

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

Submission Title: [DCN 15-16-02xx-00-0wng Tutorial presentation for IETF 95, April 2016]

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Re: [Tutorial presentation for IETF 95, April 2016]

Abstract: [802.15 and 802.24 summary and descriptions for task groups, study groups, and interest groups]

Purpose: [802.15 tutorial materials targeted towards presentation at IETF 95]

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IEEE-SA Standards Board Operation Manual (subclause 5.9.3)

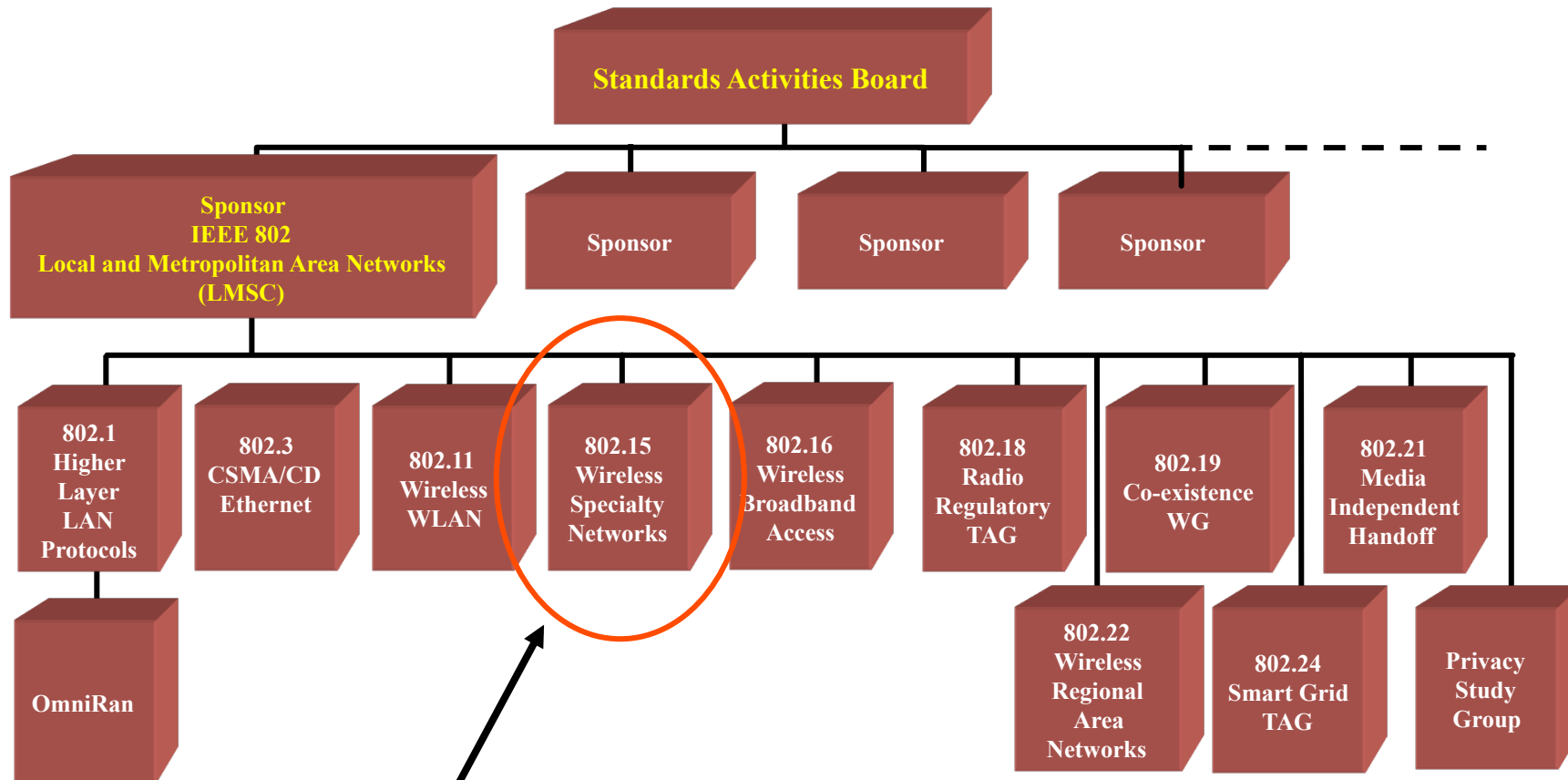
Outline of Presentation

Adapting materials from *Bob Heile*
and *Pat Kinney* (many thanks!)

- Introduction to 802.15
- History and market focus
- 802.15 task groups
- Interest Groups, Study Groups
- 802.15.11c (ULI) description

IEEE 802 Organization

IEEE Standards Association



Voting Members ~102

www.ieee802.org/15

802.15 Scope and Purpose

- Initial activities focused on wearable devices - hence “personal area networks”
- Activities have proven to be much more diverse
 - Data rates from 2kbps to 2gbs
 - Ranges from meters to kilometers
 - Frequencies from 400MHz to 800THz
 - Predominantly non TCP/IP applications
 - Shipping over 1 million devices per day
- Focus is on “specialty”, typically short range, communications. If it is wireless and not a LAN, MAN, RAN, or WAN, odds are its 802.15
- 802.15 is only 802 group with multiple MACs

802.15 Completed Projects

- 802.15.1 Original Bluetooth (standards in 2002 and 2005)
- 802.15.2 Coexistence Recommended Practice Bluetooth/802.11 (standard in 2003) (in hibernation)
- 802.15.3 High Rate (55 Mbps) Multimedia WPAN (standard in 2003) (in hibernation). *15.3 amendments:*
 - 802.15.3c High Rate (>1Gbps) mmWave 15.3 PHY
- 802.15.4-Low Rate (250kbps). Energy Efficient WPAN for WSN type applications
15.4 amendments:
 - 802.15.4a Higher data rate 15.4 UWB PHY
 - 802.15.4c Sub 1 GHz 15.4 PHY for China
 - 802.15.4d Sub 1 GHz 15.4 PHY for Japan

802.15.4: Standard for Low-Rate Wireless Networks

- Very low complexity
- Broadly used in IoT
- Location based services
- Standard issued with 2015 date

802.15 Completed Projects

15.4 Amendments (cont):

- 802.15.4e 15.4 MAC Enhancements (GTS among others)
- 802.15.4f 15.4 PHY for Active RFID
- 802.15.4g 15.4 PHY for Field Area Smart Utility Networks
- 802.15.4-2011: 15.4 Roll-up to include 15.4a,c & d
- 802.15.4j 15.4 PHY using US dedicated medical band
- 802.15.4k 15.4 PHY for Low Energy Critical Infrastructure Monitoring (LCIM)
- 802.15.4m 15.4 PHY for operation in TV White Spaces
- 802.15.4n 15.4 PHY for Chinese Medical Applications
- 802.15.4p 15.4 PHY for Rail Communications and Control
- 802.15.4q Ultra Low Power 15.4 PHY
- 802.15.4-2015 Revision C (bug fixes and roll-up of amendments e,f,g,j,k,m, and p)

802.15 Completed Projects

- 802.15.5: Mesh Networking Recommended Practice
- 802.15.6: Body Area Networking for medical and entertainment applications
- 802.15.7: Visible Light Communications using structured lighting

802.15 Active Projects/Status

IEEE802.15.3 Amendments:

- 802.15.3d THz band 100Gb/s PHY layer for point to point applications (e.g., data center, 5G)
 - *centimeters* \leq *Range* $<$ *kilometer*
 - *STATUS: reviewing proposals, starting draft*
- 802.15.3e High Rate (100Gb/s), Close Proximity Communications using mmWave for 4k HD MPEG file transfers in <250 ms total transaction time
 - *STATUS: in WG Letter Ballot.*

IEEE802.15.3 Revision A [802.15.3-2015]:

- Roll-up of amendments b and c plus conversion from 64 bit to 48 bit MAC addressing
 - *STATUS: On the May 2016 Stds Board agenda for approval*

802.15 Active Projects/Status (cont)

IEEE802.15.4 Amendments/Projects:

- 802.15.4r Common 15.4 ranging protocol for Location Based Services indoors or out
 - *STATUS: on hold*
- 802.15.4s Spectrum Resource Utilization(SRU): MAC enhancement for improvements to utilization
 - *STATUS: working on draft*
- 802.15.4t Higher Rate PHY (HRP): PHY capable of 2 Mb/s data rates, utilizing the 2.4 GHz ISM band (250 kb/s data rate), having backwards-compatibility to, and the same occupied bandwidth as, the present 2.4 GHz O-QPSK PHY, and be simple to implement.
 - *STATUS: CFP issued*

802.15 Active Projects/Status (cont)

- IEEE802.15.4 Amendments/Projects (cont):
 - 802.15.4u India Sub 1 GHz PHY (ISB): PHY for 865-867 MHz band in India.
 - *STATUS: In Working Group Letter Ballot*
 - 802.15.4v Regional Sub 1GHz Band (RSB):
 - Define 15.4 PHY clause changes to use 870-876 MHz & 915-921 MHz bands in Europe, 902-928 MHz band in Mexico, 902-907.5 MHz & 915-928 MHz bands in Brazil, 915-928 MHz band in Australia/New Zealand that are not in 15.4-2015
 - Update the channel parameters for the 470-510 MHz band in China and the 863-870 MHz band in Europe to align them with current requirements.
 - *STATUS: On the May 2016 Stds Board agenda for approval*

Active Projects/Status 802.15.7a

- Revision to IEEE802.15.7-2012, Standard for Visible Light Communications.
 - Extend spectral range include near UV and near IR
 - Renamed “Optical Wireless Communications” (OWC)
 - Considers mobility of the optical link, compatibility with various light infrastructures, impairments due to noise and interference, e.g. from ambient light
 - Add capability to specifically to address Optical Camera Communications for use with existing as well as future smart mobile devices
 - *STATUS: Developed TRD, issued CFP and are reviewing proposals*

New Standards Work: 802.15.8 (PAC)

- 802.15.8 Peer Aware Communications (PAC)
 - Infrastructure-less PAC among Mobile Devices
 - data rates from 10 Kbps to 55 Mbps
 - multiple channels, dynamic grouping, multiple peer-to-peer communications, location of devices, multicasting, coverage extension, low latency, fast synchronization and association of devices, low power consumption, and enhanced security
 - *STATUS: near completion first ballotable draft*

New Standards Work: 802.15.9 (KMP)

- 802.15.8 Recommended Practice for a 15.4 Key Management Protocol (KMP)
 - Specifies containers for Key Management Protocols (KMPs)
 - Clarifies fragmentation
 - *STATUS: Complete, awaiting publication*

New Standards Work: 802.15.10 L2R (Layer 2 Routing Mesh):

- Recommended Practice for Layer 2 Routing (Mesh Under) for 802.15.4
- Handles all MAC and PHY layers
- Handles multi-PAN networks, short addressing, peer-to-peer routing
- STATUS: Completing WG Letter Ballot. To seek approval to start sponsor ballot at next opportunity

New Standards Work: 802.15.12

- 802.15.12 Upper Layer Interface (ULI) for 15.4:
 - Make IEEE 802.15.4 easier to use, like 802.11 and 802.3
 - Enable the use of many of the higher layer protocol stacks used by 802.11 and 802.3 without changes
 - Allow 15.4 to address new applications, yet maintain backward compatibility with existing devices and applications
 - Potentially consolidate L2R, KMP, 6T, & 6lowpan in one ULI
 - Will need tight coordination with 802.1 and IETF
 - *STATUS: On May 2016 Stds Board agenda for approval*

802.15 Active Project Status

802.15 Interest Groups:

- Dependability IG (IG DEP): seeking to identify non implementation based strategies, which could be standardized, that inherently improve wireless link reliability.
- High Rate Rail Communications IG (HRRC)
- THz IG: Review and discuss the latest advances for using THz bands for wireless data applications

802.15 Other Activity

Joint effort with IETF:

- 6Tisch Interest Group-formed to support collaboration and coordination of 802.15 activities/positions with IETF on an activity to utilize capabilities in 15.4e in conjunction with IPv6, specifically time slotted channel hopping (TSCH).
- Approaches to support 15.12 were discussed in March
- Looking to broaden the liaison relationship with IETF

Partner Projects for ISO / IEC PSDO process

- 802.15.3 High Rate Wireless Multimedia Communications
 - STATUS: Completed review period with no comments
- 802.15.4-2015 Low Rate Wireless Networks
 - Submitted to JTC1/SC6 for information prior to formally submitting the Standard
- 802.15.6 Body Area Networking
 - Submitted to JTC1/SC6 for information prior to formally submitting the Standard

IEEE 802.15.12 (Upper Layer Interface)

- New IEEE 802.15 project has progressed to:
 - Make IEEE 802.15.4 easier to use, similar to IEEE 802.11 (WiFi) and IEEE 802.3 (Ethernet)
 - Enable IEEE 802.15.4 to use many of the higher layer protocol stacks used by IEEE 802.11 and IEEE 802.3 without changes
 - Allow IEEE 802.15.4 to address new applications yet maintain backward compatibility with existing devices and applications

Target Applications for 802.15.12

- Deterministic
 - ISA100.11a
 - IETF 6TiSCH
 - Industrial Internet of Things (IIoT)
- Non-Deterministic (best effort)
 - Smart Grid (e.g. WiSUN™)
 - Internet of Things (IoT)
 - Long Range Infrastructure
 - e.g., LECIM (Low energy critical infrastructure monitoring)

General Concept

Create a Data Link sublayer above the MAC that adapts and configures the 802.15.4 MAC for desired operation, and contains existing and soon to be released sub-layers for 802.15.4 such as 6LoWPAN, Key Management Protocol (KMP), Layer 2 Routing Mesh (L2R), 6top (IETF 6TiSCH)

Protocol Layers

Transport Layer

- UDP, TCP, ICMP

Network Layer

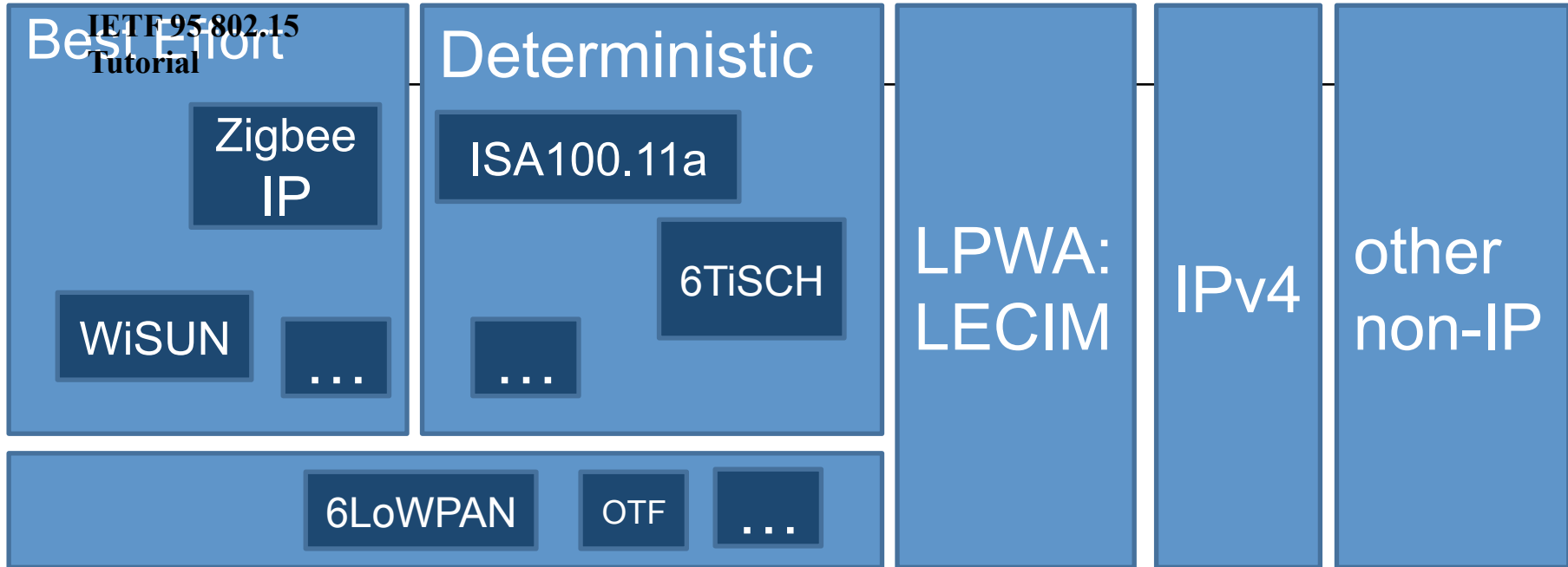
- IPv6 (IPv4 with adapter)

Data Link Layer

- **LLC (802.15.12)**
- MAC (802.15.4)

Physical Layer

- 802.15.4 Modulations: O-QPSK, BFSK, FSK, OFDM
- 802.15.4 Frequency Bands: (433, 890, 915, 2450, et al)



New LLC work

IEEE 802.15.4 MAC

- CSMA
- TSCH
- ...

IEEE 802.15.4 PHY

- 2003
- 4g
- 4k
- ...

Conclusions and final words

- 802.15 is very active and dominant for IoT-style applications
 - Low-power
 - Range of bandwidths
 - Interesting for IETF working groups
6TiSch, 6lo, roll
- Participates in IEEE/IETF coordination
- Looking for liaison, similar to 802.11