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About

Welcome to the twenty-first issue of Smart Grid Communications ("Comms") Intelligencer, a triannual newsletter published by EPRI's Information and Communication Technology (ICT) Program. Our mission is to highlight issues of relevance and interest to utility communications engineers and managers. Our focus is on developments in communication technologies and standards, and business issues that can affect the design, deployment, or operation of utility communications infrastructure.

This newsletter tracks standards development activities that continue over an extended period of time. To make the material understandable without requiring reference to previous issues, some text is retained from issue to issue to provide a context for the topic. To make it easier to find updates, new text is formatted with this shade of purple.

Communications technology continues to evolve at a rapid pace, and the demand for wireless connectivity in all industries is growing exponentially. Utility telecommunications networks use a variety of technologies out of necessity, since no single technology is able to meet all requirements. Many networks use a combination of wireless, copper, and fiber media, and operate wireless networks in both licensed and unlicensed spectrum. The licensed spectrum may be utility-owned, or accessed through a commercial cellular operator. Standards-based communications technologies enable interoperability, vendor choice, a broader product ecosystem, and ultimately lower costs. Many of the wide range of wireless communications technologies that are deployed today, or may be deployed in the future, originate from the standards development activities that are covered in this newsletter.

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IEEE 802 Communications Standards

How to apply this information

As a utility communications manager or engineer, you may wonder why new communications standards matter to you, since the timeframe for the development of new standards may be measured in years. The primary value is in providing you with knowledge of what is coming, and what will be possible. As you discuss your utility's plans and requirements with vendors today, awareness of emerging standards gives you insights into the roadmap presented by vendors. If a vendor is proposing a proprietary communications protocol, you can ask how an upcoming standard fits into their roadmap. If a vendor indicates they are committed to supporting that standard, then asking the same questions to other vendors can put you on the path toward

alternate sources. A secondary benefit is the opportunity to contribute or influence standards during development. IEEE standards follow an open process with voting for approval. EPRI's Information & Communications Technology (ICT) staff is actively involved in many standardization activities. The IEEE 802 standards represent many of the core communications technologies, both wired and wireless. EPRI leads and contributes to projects in IEEE 802 that are relevant to the utility industry.

If you are unfamiliar with the seemingly cryptic numbering system used for IEEE 802 standards, there is a rational explanation behind them. An explanation was presented in the first issue of the Comms Intelligencer [1] in the section titled "IEEE 802 Working and Task Group Naming Conventions."

IEEE 802.11 Wireless LAN Working Group

The 802.11 working group has multiple task groups concurrently working on amendments and revisions. These are ranked in terms of relevance to utility applications:

- ○ Limited utility relevance, or unknown at this time
- ◑ Possibly relevant – certain aspects could be applied
- ◕ Likely relevant – identified utility application
- ● Very relevant – expected to have a major impact

TGak	802.11ak	Transit Links (Bridging between networks)	◕
TGaq	802.11aq	Pre-Association Service Discovery	◑
TGax	802.11ax	High Efficiency WLAN	●
TGay	802.11ay	Next Generation 60 GHz	◑
TGaz	802.11az	Next Generation Positioning	◕
TGba	802.11ba	Low Power Wake Up Receiver	◑
TGbb	802.11bb	Light Communications	○
SG	BCS-SG	Broadcast Services Study Group	◑
SG	NGV-SG	Next Generation Vehicle (V2X) Study Group	○
TIG	FD-TIG	Full Duplex Topic Information Group	◑
TIG	EHT-TIG	Extreme High Throughput Topic Information Group	●

IEEE Std 802.11ak is an amendment for standardizing the use of 802.11 to link two networks. The official title is "Enhancements for transit links within bridged networks". Today, the 802.11 standard only specifies the operation of an 802.11 device as a network endpoint. The addition of inter-network bridging will enable new options for linking groups of devices and networks in a variety of utility applications where copper or fiber are not cost effective.

The amendment is completed and was published June 15, 2018. It will be available for free after 6 months, around December 15, 2018. Devices supporting 802.11ak are not yet available commercially.

Task Group TGax (High Efficiency Wireless - HEW) has been active since the May 2014 meeting. This amendment is the next "big thing" for 802.11, with hundreds of people participating. Instead of focusing only on the raw data rate, development effort is now focusing on improving spectrum efficiency (users per unit of area) and improving performance in dense deployments through more effective spatial re-use. This will be

accomplished while maintaining or improving power efficiency. Some of the use cases involve outdoor applications. While TGax isn't specifically chartered to focus on grid-centric applications, support for IoT devices is a consideration. The requirements for IoT communication are aligned with utility applications in sensors, DER, DR, and other customer-premises applications. 802.11ax defines new modes of operation derived from LTE, such as multi-user MIMO and OFDMA[1] (Orthogonal Frequency Division Multiple Access). It also defines new enhancements for Single User (SU) operation, including the Extended Range SU format. The ER_SU implements a 3dB power boost in the packet preamble for range extension. A side benefit of OFDMA is the ability to allocate smaller units of RF bandwidth (down to 8 MHz), which can also improve range. The benefits of 802.11ax will affect utility users of 802.11 from the enterprise to field and sensor applications. This standard will define the next generation of 802.11 devices that are widely used for both IT and operational purposes.

The task group modified the PAR in September 2017, to "raise the top end of the frequency band from 6 GHz to 7.125 GHz, and indicate that new Operating Classes will be required to support the new channels."[2] This spectrum has not yet been allocated by the FCC, but is one of the bands identified in the Mid Band Spectrum Notice of Inquiry[3] (NOI) released by the FCC in October 2017. The expectation is that the FCC's eventual rules will treat some (or all) of the 6 GHz band as unlicensed, much like the 5 GHz band already widely used for 802.11. Within IEEE 802, the 802.15 working group has identified a potential coexistence problem with 802.15.4a ultrawideband ranging devices[4] that have been widely used in industry. They operate in the 6 GHz band at very low power and would be unable to operate in the presence of 802.11 with higher power levels. A new activity has been started in the 802.19 coexistence working group to study the issues.

The previous six months have been spent on comment resolution on Draft 2.0, which did not pass. After the May 2018 meeting, Draft 3.0 was balloted. It is the first 802.11ax draft to pass the 75% threshold, with an approval of 87%. That means subsequent drafts will use recirculation ballots, where only changes from the previous draft are open for comment. This is intended to bring closure. The next draft, D4.0, is scheduled for November 2018, with Sponsor Ballot in July 2019. Final approval is still shown as December 2019, but the expectation is that it will slip to early 2020.

Task Group TGay - Next Generation 60 GHz. The objective of the amendment is to increase the data rates of the existing 802.11ad standard in unlicensed bands above 45 GHz. (57.05 to 64 GHz in the USA, up to 66 GHz in Europe and Japan). From a utility perspective, the 60 GHz band is differentiated from the (typically) 4 to 40 GHz bands used for point-to-point outdoor microwave links. The 60 GHz band is unlicensed globally, but more importantly, it falls in a frequency range where atmospheric absorption (primarily Oxygen) is at a maximum. So, it isn't usable for traditional microwave links with a range of kilometers. The expected application is shorter range links, such as wireless HDMI video, and high-data-rate cable replacement in data centers. These bands are also expected to play a major role in future "5G" mobile cellular systems, as a basis for femtocell technology. Some use cases envisioned for TGay are related to short range (10 cm) and high rate (10 Gb/s) data transfer. For example, moving 5 GB of data to a portable device in under 6 seconds. Utility applications could include Augmented Reality, Virtual Reality, download of maps, GIS, and other equipment data for field workers operating in areas that are lacking wireless data coverage, or providing bulk data downloads to workers in mutual aid scenarios.

The group conducted its first letter ballot on Draft 1.0 following the November 2017 meeting. The ballot barely missed the threshold, with an approval of 74%. The task group resolved the 1343 comments during the January through July 2018 meetings. Draft 2.0 will be prepared and sent for letter ballot in early August 2018.

Task Group TGaz (Next Generation Positioning - NGP). The project objective is to define a mechanism to locate 802.11 devices with a precision of 0.1m. This technology could have immediate utility applications in generation and other indoor facilities where both data communication as well as asset location and tracking

[1] http://www.ni.com/white-paper/53150/en/
[2] https://mentor.ieee.org/802.11/dcn/17/11-17-0913-02-00ax-par-modification-to-support-6-ghz-band.docx
[3] https://www.fcc.gov/document/fcc-opens-inquiry-new-opportunities-mid-band-spectrum-0
[4] https://www.decawave.com/products/overview

are required, and GPS is not available. Potentially, it could complement GPS in outdoor applications, either by reducing cost for the localization (eliminating the need for a GPS system if Wi-Fi is already present for communications needs), or providing a redundant location mechanism.

During the first half of 2018, the group continued development of the Specification Framework Document (SFD) and continued to receive contributions. The SFD was frozen at revision 15 during the July 2018 meeting[5]. The NGP amendment will support the VHT (802.11ac), DMG (802.11ad), EDMG (802.11ay), and HE (802.11ax) PHYs. In July, pre-draft D0.3 was approved. The current timeline calls for a first draft (D1.0) in November 2018, and final approval in early 2021.

Task Group TGba (Low Power Wake Up Receiver - LP-WUR)

The Low Power Wake Up Receiver enables lower power operation by reducing receiver standby power. The normal 802.11 receiver requires significant power to execute the complex signal processing required to decode the data. The LP-WUR defines a simpler receiver (optimized for low power) to operate in parallel. When a special wake-up signal is received by the WUR, the normal 802.11 receiver is activated. This approach does not save any power during normal receiver or transmitter operation, or provide any capability for longer range. It allows devices to consume less power while passively sleeping and waiting for a signal to wake up.

During the May and July 2018 meetings, the group continued to review contributions for the draft. Pre-draft D0.3 has been completed. The group has experienced some “scope creep”, and the specification is becoming more complex than initially envisioned. In July, the 802.11 Architecture committee reviewed the implications of the new power save states and interactions introduced by TGba[6]. The schedule has slipped another two months, and Draft 1.0 is now planned for September 2018. Final approval moves to September 2020.

Task Group TGbb - Light Communications

The Light Communications Task Group met for the first time in May 2018. The concept is to transmit data over light from LED fixtures. The concept has been called “Li-Fi.” It is unclear what utility applications would be a good fit for light communication. The short range and line of sight requirement limits the use cases. There may be potential applications in some plant environments where radio frequency energy must be limited. Li-Fi may be able to leverage the Power over Ethernet[7] LED Lighting technology, to provide a data communications capability at a small incremental cost. The overall objective is to provide additional network capacity by offloading data transfer out of the crowded RF bands into visible light.

The PAR and CSD were approved in March 2018. The TGbb task group will develop an amendment to 802.11, which will be referred to as 802.11bb. In July 2018, the task group developed and approved a usage model[8], focusing on indoor connectivity. The group also approved their functional requirements document[9], defining a wide range of throughput: “a minimum single-link throughput of 10 Mb/s and at least one mode of operation of achieving single-link throughput of at least 5 Gb/s”. The schedule anticipates final approval in July 2021.

Task Group TGmd (Maintenance)

Because of the pace of amendments in 802.11, the Maintenance Task Group is always working on the next revision of the base standard. The Maintenance task group is always designated TGm, unlike other task groups that select incrementing letter pairs from the same pool. The fourth character increments for each revision. TGmd will develop the fourth revision to the 802.11 standard. The revision is based on IEEE Std

[5] https://mentor.ieee.org/802.11/dcn/17/11-17-0462-15-00az-11-az-tg-sfd.doc
[6] https://mentor.ieee.org/802.11/dcn/18/11-18-1020-04-0arc-discussion-on-wur-802-11ba-states.pptx
[7] IEEE 802.3af-2003 and IEEE 802.3bu-2016
[8] https://mentor.ieee.org/802.11/dcn/18/11-18-1109-05-00bb-lc-usage-model-document.pptx
[9] https://mentor.ieee.org/802.11/dcn/18/11-18-1309-00-00bb-802-11bb-functional-requirements.docx

802.11-2016 and incorporates amendments 802.11ai, 11ah, 11aq, 11ak, 11aj, and 11ax. A recirculation letter ballot will be conducted on D2.0 following the September 2018 meeting. Assuming the revision is completed on schedule (Fall 2020), it will be published as IEEE 802.11-2020.

Broadcast Services Study Group

The Broadcast Services (BCS) Study Group met for the first time in May 2018. The SG is exploring new use cases for 802.11 broadcast information. While IEEE 802.11 already supports the networking concepts of broadcast and multicast to associated and authenticated devices, this SG will explore use cases for public broadcast to non-associated, non-authenticated devices. Example use cases could include local and area-specific information, indoor maps in a shopping mall, menus in restaurants, flight information at an airport, traffic information for vehicles (already present to some extent in 802.11p - see NGV below), and emergency related information. Utility-focused applications could be identified and included, although the public nature of the proposed Broadcast Services may limit the applicability. Although the purpose of BCS is the provide information to un-associated, and un-authenticated devices, it will implement a security mechanism for origin authenticity protection for broadcast data.

The group plans to complete its PAR[10] and CSD in September 2018, submit for approval in November 2018, and initiate the task group in January 2019.

Next Generation V2X (NGV) Study Group

The Next Generation V2X (Vehicle to Anything) Study Group (NGV) met for the first time in May 2018. It will develop a new amendment the 802.11p[11] standard also known as Dedicated Short-Range Communication[12] (DSRC) to better align with newer 802.11 physical layers. One interesting aspect of 802.11p (and its potential successor from NGV) is the availability of dedicated spectrum[13] at 5.9 GHz that can be used by vehicles.

In July 2018, the NGV SG developed a PAR and CSD. An initial set of use cases were developed[14], including safety messages, sensor sharing, vehicular position, and automated driving. The group plans to complete its PAR and CSD in September 2018, submit for approval in November 2018, and initiate the task group in January 2019.

Full Duplex Topic Interest Group

The Full Duplex Topic Interest Group met for the first time in March 2018. Full Duplex operation of 802.11 could enable simultaneous uplink and downlink in the same spectrum, providing benefits in higher throughput and lower latency. The use of full duplex in mobile phones is well established and mature, using separated frequency channels for uplink and downlink. The proposed 802.11 full duplex would transmit and receive concurrently in the same frequency channel. This is a significant unsolved technical challenge, analogous to a person listening for a pin drop while shouting, but research in this area has progressed to the point where considering a standard is appealing.

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[10] https://mentor.ieee.org/802.11/dcn/18/11-18-0825-06-0bcs-a-par-proposal-for-bcs.docx
[11] http://www.eenewsautomotive.com/design-center/why-80211p-beats-lte-and-5g-v2x
[12] US Dept of Transportation, Intelligent Transportation Systems Office https://www.its.dot.gov/factsheets/dsrc_factsheet.htm
[13] FCC: “Dedicated Short Range Communications (DSRC) Service” https://www.fcc.gov/wireless/bureau-divisions/mobility-division/dedicated-short-range-communications-dsrc-service
[14] https://mentor.ieee.org/802.11/dcn/18/11-18-1323-00-0ngv-ngv-sg-use-cases.pptx

The group has been developing a technical report describing use cases and architecture, and expects to complete it in the September meeting.

Extreme High Throughput Topic Interest Group

The Extreme High Throughput Topic Interest Group met for the first time in July 2018. This project will be the next major generation of 802.11 after 802.11ax. Due to the level of interest and potential impact of the work, the group passed a motion to form a Study Group at its first session. The Study Group will begin in September. The scope includes operation from 1 GHz to 7.125 GHz (notably avoiding the 915 MHz unlicensed bands, but perhaps anticipating favorable regulatory outcomes regarding unlicensed use of the 6 GHz band). The goal is "increasing throughput to support high throughput applications such as video-over-WLAN, AR and VR".

IEEE 802.15 Working Group

The 802.15 Working Group is officially the working group for Wireless Personal Area Networks (WPAN), but the WG has taken on a variety of projects. The working group has started to refer to itself as Wireless Sensor Networks (WSN), since WPAN is less descriptive. In some ways, it can be thought of as a home for wireless standards that don't clearly fit elsewhere. The first standard in 802.15 was Bluetooth (802.15.1) which is a "personal area network", but since that initial version, the Bluetooth SIG has developed the spec independently from IEEE 802.15. The 802.15.4 family has been the mostly widely adopted, and serves as the basis for ZigBee and the newer Wi-SUN specification for utility field area networks. Standards have been developed in 802.15 that are related to 802.15.4, but have a unique number since they are independent documents, and not an amendment. Examples include 802.15.9, 802.15.10, and 802.15.12.

802.15.4s "Spectrum Resource Utilization" (SRU) Task Group (TG4s)

The TG4s amendment defines the Spectrum Resource Measurement (SRM) capability, which consists of measurements, and messages to communicate spectrum measurements. The measurements include energy detection, noise measurements, link quality metrics, and MAC layer statistics on failed and deferred transmissions. IEEE Std 802.15.4s-2018 was published June 28, 2018 and will be available for free 6 months after that date.

802.15.4w "Low Power Wide Area" (LPWA) Task Group

The LPWA Task Group TG4w held its first meeting in May 2018. The group is investigating how 802.15 standards can address the types of low power sensor networks that are targeted by systems such as LoRa, SigFox, and NB-IoT. As an amendment to 802.15.4, it would integrate with the existing MAC and set of PHYs. It is anticipated to be an extension to the Low Energy Critical Infrastructure Monitoring (LECIM) PHY that was defined in 802.15.4k. Products from Ingenu (formerly OnRamp) are loosely based on 802.15.4k, but their implementation is proprietary. Their systems have been deployed by some utilities. The study group developed a developed a Technical Guidance Document in March 2018.

In the May and July 2018 meetings, the task group reviewed submitted proposals. Completion is projected for early 2020.

802.15.4x "FAN Enhancements" (FANE) Task Group

The FAN Enhancements Task Group (TG4x) held its first meeting in May 2018. It is developing an amendment to the Smart Utility Network (SUN) PHY (originally specified in the 802.15.4g amendment) to define modes with higher data rates, and modes with longer range. This is an important amendment for utility field area networks. These improvements are likely to be referenced in future versions of the Wi-SUN FAN specification.

The project is not complex or controversial, and the work has moved quickly. The project introduces new OFDM data rates up to 2.4 Mb/s for higher throughput. It also defines lower rates for FSK modes down to 10 kb/s for longer range. In the May and July 2018 meetings, proposals of draft text were submitted and

accepted. Draft D0 was completed in the July 2018 meeting, and a letter ballot will complete before the September 2018 meeting.

802.15.4y "Security Next Generation" (SECN) Task Group

The Security Next Generation Task Group (TG4y) held its first meeting in May 2018. It is defining support for Advanced Encryption Standard (AES)-256 encryption and other security extensions and additional algorithms. This is an important amendment for utility field area networks. The intention is to keep ahead of advances in computing power, and corresponding best practices in security that are continually evolving. The amendment will define mechanisms to improve extensibility, to simplify adding additional security algorithms in the future. These improvements are likely to be referenced in future versions of the Wi-SUN FAN specification.

In the May and July 2018 meetings, the task group reviewed proposals for methods to support agility of multiple security algorithms without changing the existing over the air protocols. The task group will create a new Annex to 802.15.4 for AES-256 CCM and other new cipher suites. The task group will also work with the TG4m maintenance task group to change the term "CCM*"[15] to "AEAD"[16] to generalize the reference to the security model. The project has also identified a need to update 802.15.9 (Key Management Protocol) to define handling of the larger keys specified in TG4y.

802.15.4z "Enhancements in Ranging" (EIR) Task Group

The Enhancements in Ranging task group for the first time in May 2018. It is developing an amendment to enhance the High Rate Pulse (HRP) and Low Rate Pulse (LRP) Ultra-Wide-Band (UWB) Physical Layers (PHYs) and their associated ranging techniques. These were first introduced in the 802.15.4a amendment that was completed in 2007. These PHYs are used in industrial applications for asset tracking and location.

In May and July 2018, the group reviewed and adopted contributions, and merged proposals. They anticipate a first draft and ballot following the November 2018 meeting.

802.15.4md "Maintenance Revision 4" Task Group (TG4m)

The TG4m Maintenance Task Group is responsible for revisions of the 802.15.4 standard. The most recent revision is 802.15.4-2015. An errata document was published in July 2016 that changed the standard title from "IEEE Standard for Low-Rate Wireless Personal Area Networks (WPANs)" to "IEEE Standard for Low-Rate Wireless Networks". Subsequently, a corrigendum project was initiated to correct errors and ambiguities in the transmission order of addresses. IEEE 802.15.4-2015/Cor 1-2018 was published in January 2018.

Currently, TGmd is developing the fourth revision of 802.15.4, which will merge the 802.15.4n, 802.15.4q, 802.15.4u, 802.15.4t, 802.15.4v, and 802.15.4s amendments (described in previous issues) and the 802.15.4-2015/Cor 1-2018 corrigendum into the base standard (802.15.4-2015). As with all revision projects, the entire standard is open to change, so it is possible that features could be added or removed, based on the votes of the Task Group members.

The TGmd task group initiated a letter ballot on P802.15.4-REVd draft D01 following the July 2018 meeting. Sponsor ballot is planned after the March 2019 meeting, with final approval and publication at the end of 2019 or early 2020.

15 CCM*: "Extension of Counter mode encryption and Cipher block chaining Message authentication code"

16 AEAD: Authenticated Encryption with Associated Data

802.15.12 "Upper Layer Interface (ULI) for 15.4" (TG12)

This project is addressing some long-standing gaps in IEEE 802.15.4, making it easier to use in mixed network environments. Other IEEE 802 networks such as 802.3 and 802.11 use a special field to identify the type of protocol that is encapsulated in the frame. Because this approach dates to the time when Ethernet was young, the field is called an EtherType[17] Protocol Discrimination (EPD). For example, the EPD can distinguish between a packet containing IPv4 (0x0800) and a packet containing an IEC 61850 GOOSE[18] message (0x88b8). The IEEE 802.15.4 standard has not yet defined an analogous identifier. As higher layer protocols and applications operating over 802.15.4 devices began to proliferate, support for multiple protocols was proprietary, or did not exist at all. This new standard is intended to enable 802.15.4 networks to use many of the higher layer protocol stacks used by 802.11 and 802.3 without changes.

The 802.15.12 standard will allow IEEE 802.15.4 based networks to address new applications, yet maintain backward compatibility with existing devices and applications. It intends to provide an integration framework for L2R (802.15.10), KMP (802.15.9), 6TSCH (IETF), and 6lowpan (RFC 4944) into one Upper Layer Interface (ULI). This task group is based in IEEE 802.15, but will rely on tight coordination with 802.1 and IETF.

The task group has continued to update the conceptual overview[19]. See **[19]** for further details.

In May and July 2018, the task group continued to work on specific features and functions. The ULI Mandatory Elements Operation document[20] was updated. The first letter ballot on Draft 1.0 is scheduled for November 2019, with final publication at the end of 2021.

802.15.13 "Multi-Gbit Optical Wireless Communication" TG13

The differentiation of this Light Communications group from 802.11bb Light Communications task group remains unclear. 802.15.13 appears to be primarily targeting higher rates and shorter ranges.

In May and July 2018, the group resolved comments collected on Draft 2.0. The task group initiated a comment collection on draft D3 after the July 2018 meeting. They plan a first letter ballot after the September 2018 meeting.

IEEE 802.16 Working Group

IEEE 802.16 has been used in the utility industry as a point to multipoint Field Area Network technology with broadband capacity. The activities have been covered in depth in previous issues. The Working Group entered hibernation following the March 2018 meeting, since no new projects had been proposed. The WG will remain in hibernation until a need for a revision or amendment brings it out of hibernation, or its standards are withdrawn (typically after 10 years without a revision), at which time it is disbanded.

IEEE 802.19 Coexistence Working Group

The IEEE 802.19 working group has initiated a new activity around coexistence of standards operating below 1 GHz. Specifically, IEEE 802.15.4 with the SUN PHY (often referred to as 802.15.4g for the amendment that introduced it), and the 802.11 Sub 1 GHz (S1G) PHY introduced by 802.11ah. The group plans to develop a

[17] https://en.wikipedia.org/wiki/EtherType
[18] https://en.wikipedia.org/wiki/Generic_Substation_Events
[19] https://mentor.ieee.org/802.15/dcn/17/15-17-0113-08-0012-802-15-12-conceptual-overview.pptx
[20] https://mentor.ieee.org/802.15/dcn/16/15-16-0656-12-0012-802-15-12-uli-mandatory-elements-operation.docx

recommended practice for Sub-1GHz Coexistence, and passed a motion to form a Study Group to develop a PAR and CSD.

The 802.19 working group is also addressing a coexistence issue related to the expanded spectrum plan for 802.11ax. The 802.11ax PAR was amended in 2017 to include operation up to 7.125 GHz. Users of the Ultrawideband PHY of 802.15.4 have identified a coexistence problem if 802.11ax operates in the 6 GHz band. A submission from a manufacturer of UWB devices[21] outlines the issue. The 802.11 working group updated the 802.11ax Coexistence Assurance document, as required for the PAR change[22], but the changes did not satisfactorily address the concerns of the 802.15.4 UWB users. The approval of the CA document failed in 802.19, and comments were submitted back to 802.11. This is an ongoing issue that may not be resolvable to the satisfaction of all parties. The FCC has not ruled on how the 6 GHz band would be used, whether licensed, unlicensed, or shared. This is important because the 6 GHz band has been (and continues to be) widely used by utilities for point-to-point microwave links supporting critical operations. The Utilities Technology Council and the Edison Electric Institute have filed comments opposing the use of this spectrum for commercial wireless services.[23]

IEEE 802.21 MIHS Working Group

The IEEE 802.21 working group develops standards for "Media Independent Handover Services". The last amendment to 802.21 (Multicast Group Management, 802.21d) was completed in 2015. It was discussed in prior issues [**16**]. The future of the group was looking uncertain, but in July 2018, a new area of activity emerged. The "Interest Group for Network Enablers for seamless HMD based VR Content Service" started meeting, and is seeking to develop a standard to define new network services to reduce network latency when serving video to virtual reality HMD's. The goal is to minimize "VR sickness" by limiting "motion to photon" delays in VR systems to less than 20 mS[24].

IEEE 802.24 Technical Advisory Group

The 802.24 Technical Advisory Group (TAG) provides coordination across multiple Working Groups that are developing standards related to vertical applications of 802 standards, such the Smart Grid. A TAG is a peer to a Working Group in terms of the 802 organization, but a TAG does not develop standards. The other TAG operating in IEEE 802 is 802.18, which deals with Radio Regulatory issues. The 802.24 web page provides current information, meeting plans, and agendas. EPRI is chairing the 802.24 TAG.

The 802.24 TAG has two Task Groups. The Smart Grid is in the 802.24.1 task group, and the 802.24.2 task group is addressing the Internet of Things (IoT). The 802.24.2 task group is establishing liaisons with IoT-related industry groups such as Industrial Internet Consortium (IIC) and others. 802.24 has established a liaison relationship with the IEEE P2413 IoT Architecture task group, and receives regular updates.

The Smart Grid TG completed development on a white paper to compare and contrast the two 802 standards with smart grid applications in sub 1 GHz spectrum (and in particular, the two standards for the 915 MHz ISM band: IEEE 802.15.4g and 802.11ah). It is available as an 802.24 document, and will be published by IEEE. The TG completed the update of the wireless standards matrix developed by NIST / SGIP PAP02. The final matrix from 802.24 is in document 802.24-17-0004r6. It has been provided to SGIP/SEPA, where the Wireless Characteristics Matrix Task Force is collecting updates for the non-IEEE 802 standards that are referenced.

The 802.24 Smart Grid TG continues development of a White Paper describing IEEE 802 Time Sensitive Network (TSN) in the context of utility applications. This paper is being developed jointly with the 802.1 TSN

[21] https://mentor.ieee.org/802.19/dcn/18/19-18-0040-00-0000-802-11ax-and-uwb-coexistence.pptx
[22] https://mentor.ieee.org/802.11/dcn/16/11-16-1348-03-00ax-coexistence-assurance.docx
[23] https://utc.org/wp-content/uploads/2018/02/Comments-of-UTC-and-EEI-oppose-expanded-use-of-the-6-GHz-bands-for-unlicensed-and-licensed-broadband-2OCT2017.pdf
[24] https://mentor.ieee.org/802.21/dcn/18/21-18-0039-02-0000-new-diagram-for-network-enablers-for-seamless-hmd-based-vr-content-service.pptx

Task Group. The draft after the July 2018 meeting is available as 802.24-17-0006r14. The 802.24 TAG is also collaborating with the IEEE PES S6 Task Force on their report titled "Standards for integrating Home Automation IoT to Power Utilities Communication Systems," and submitted comments and proposed text on their draft. A liaison is being established with the IEC SEG8 (Standards Evaluation Group), a broad-scope group addressing "Communication Technologies and Architectures of Electrotechnical Systems."

IEEE 802.1 and 802.3 Working Groups

The 802.1 working group is charted to "develop standards and recommended practices in the following areas: 802 LAN/MAN architecture, internetworking among 802 LANs, MANs and other wide area networks, 802 Security, 802 overall network management, and protocol layers above the MAC & LLC layers"[25]. It is a cross cutting group that affects all the family of IEEE 802 standards.

The 802.3 working group is responsible for the development of Ethernet. Due to the long historical relationship, 802.1 and 802.3 are closely coupled, and the working groups meet at the same location for interim meetings (typically separate from the wireless working groups). Due to these logistics, I am unable to participate closely with these working groups, but I will briefly highlight developments that have potential relevance to the utility industry.

802.1

For historical reasons, 802.1 standards use a different nomenclature compared to other IEEE 802 standards. The convention of the rest of IEEE 802 is to add a new decimal number for a standalone standard document developed by a working group (as opposed to an amendment to an existing document.) For example, 802.15.4 was the 4th complete standard initiated by the 802.15 working group. The 802.1 working group uses capital letters to designate individual standards. Perhaps the most well-known 802.1 standard is 802.1X for port-based network access control. Like the rest of 802, 802.1 uses lower case letter for amendments. For example, the latest amendment project for the 802.1X standard is 802.1Xck. The standard designators and the amendment designators are one or two-letter fields, following the pattern a..z, aa..az, ba..bz, etc.

802.1 Security Task Group

- 802.1X Port Based Network Access Control (widely used in other IEEE 802 standards)
- 802.1AE MAC Security connectionless user data confidentiality, data integrity, and data origin authenticity
- 802.1AR Secure Device Identity globally unique manufacturer-provided Initial Device Identifier (IDevID)

802.1 Time Sensitive Networking Task Group developing multiple standards defining deterministic services through IEEE 802 networks, i.e., guaranteed packet transport with bounded latency, low packet delay variation, and low packet loss. IEEE Std 802.1CM-2018 (Time-Sensitive Networking for Fronthaul) was published in June 2018. The revision IEEE P802.1AS-Rev (Timing and Synchronization for Time-Sensitive Applications) is starting sponsor ballot following the July 2018 meeting.

802.1 OmniRAN Task Group Integration of multiple IEEE 802 technologies into a unified and managed Access Network. OmniRAN is developing IEEE 802.1CF titled "Network Reference Model and Functional Description of IEEE 802 Access Networks." The task group is initiating sponsor ballot on P802.1CF, Draft 2.2, following the July 2018 meeting.

802.3

The primary focus of the 802.3 working group is developing Ethernet, which has historically centered around continually increasing the data rates. On that front, The working group is currently developing rates up to 200

[25] https://1.ieee802.org/

Gb/s, and looking at 400 Gb/s for the next generation. These are primarily targeting data center applications. Below are a few 802.3 projects that may be more relevant to utility telecom and IT/OT converged networks:

IEEE 802.3 Beyond 10 km Optical PHYs Study Group Ethernet over fiber

IEEE P802.3cg 10 Mb/s Single Twisted Pair Ethernet Task Force Enabling Ethernet to run over a single pair, trading rate for lower cost, size, and weight. Potential applications are in plants and industrial settings connecting or retrofitting new sensors onto existing wiring.

IEEE P802.3bu 1-Pair Power over Data Lines (PoDL) Task Force single-pair Power over Ethernet to complement the single pair Ethernet above.

The IEEE P802.3cb (2.5 Gb/s and 5 Gb/s Operation over Backplane) and IEEE P802.3bt (DTE Power via MDI over 4-Pair) amendments were sent to RevCom for final approval after the July 2018 meeting.

New 802.3 projects (PAR approvals) include IEEE P802.3cn (50 Gb/s, 100 Gb/s, 200 Gb/s, and 400 Gb/s Operation over Single-Mode Fiber and DWDM systems), and IEEE P802.3cq Maintenance #13: Power over Ethernet over 2 pairs).

Industry Groups and Other Standards

Wi-SUN Alliance

The Wi-SUN Alliance is developing test and certification programs for the connectivity and interoperability of devices built to the 802.15.4g standard[26]. The Wi-SUN Field Area Network (FAN) Technical Profile Specification (TPS) was approved as version 1.0 in May 2016. Further refinements and corrections identified during Interoperability Test events have been incorporated into incremental updates. As of March 2018, the latest version is TPS 1.22.

Wi-SUN specifies the communications stack up to Layer 4 (transport). It defines the application and parameterization of RPL (IPv6 Routing Protocol for Low-Power and Lossy Networks - RFC 6550 and family). The Wi-SUN FAN specification also defines frequency hopping interoperability profiles. This specification builds on the Physical Layer Conformance and Interoperability Test specifications for Wireless Smart Utility Network devices. In parallel with the FAN Technical Profile Specification (TPS) document, the Wi-SUN Alliance FAN working group is continuing development of the FAN Conformance Test Specification (currently at version 34 as of March 2018) that will define the certification process.

EPRI is developing an open-source reference implementation of the Wi-SUN FAN. EPRI continues to participate in Wi-SUN Interop events as they are scheduled, and plans to certify the open source implementation to the FAN profile when certification becomes available. EPRI is working with Wi-SUN Alliance Testing and Certification Working Group to make the EPRI platform one of the “Test Bed Units” that are the references for the certification process. Regular interop events have been taking place throughout 2018 to prepare for the launch of FAN certification in the near future.

The next generation of the Wi-SUN FAN Profile Specification will provide support for the OFDM PHY, which is defined in the IEEE 802.15.4g standard, but not currently used in the Wi-SUN FAN 1.0 specification. Extensions to the SUN PHY (OFDM and FSK modes) are being defined in the 802.15.4x to provide higher throughput and longer range, which enables a variety of new and more demanding applications. EPRI’s open

[26] Technically, 802.15.4g no longer exists, since it was incorporated into the base standard IEEE 802.15.4-2015. The Smart Utility Network (SUN) PHYs defined by 802.15.4g are described in clauses 20-22 of 802.15.4-2015.

source reference implementation will support the OFDM PHY. Development of a FAN 2.0 profile specification in the Wi-SUN Alliance will begin when FAN 1.0 certification starts.

Wi-Fi Alliance

EPRI became a member of the Wi-Fi Alliance® in June 2017. The primary activity is developing the standardized functionality needed to support the Persistent Wi-Fi Demonstration (see below). While the Wi-Fi Alliance is well known for certifying interoperability for devices implementing IEEE 802.11, the Alliance also creates specifications complementary to those developed in IEEE.

Wi-Fi Agile Multiband certification began in December 2017. Historically, Wi-Fi devices made independent decisions on which access point and frequency band to connect to, based on limited information available to that device at its location. Wi-Fi Agile Multiband allows the network infrastructure to "steer" devices to the optimum access point, channel, and frequency, based on network RF measurements, loading, and interference at both ends of the link. Wi-Fi Optimized Connectivity builds on Wi-Fi Agile Multiband, providing further improvements in network performance. It utilizes features defined in the 802.11ai Fast Initial Link Setup and 802.11k Radio Resource Management amendments. It provides additional information to devices prior to connection, which improves network discovery, reduces connection time through pre-authentication, and reduces network management overhead.

In January 2018, the Alliance first announced upcoming New Wi-Fi® security features, known as "Wi-Fi CERTIFIED WPA3™." Two of the features will deliver robust protections even when users choose passwords that fall short of typical complexity recommendations, and will simplify the process of configuring security for devices that have limited or no display interface. Another feature will strengthen user privacy in open networks through individualized data encryption. Finally, a 192-bit security suite, aligned with the Commercial National Security Algorithm (CNSA) Suite from the Committee on National Security Systems, will further protect Wi-Fi networks with higher security requirements such as government, defense, and industrial." WPA3 certification was announced on June 25, 2018.

The Alliance also introduced Wi-Fi CERTIFIED Easy Connect™, to simplify the secure connection of IoT-type devices with limited user interface. The Alliance also introduced Wi-Fi EasyMesh to enable interoperable multi-AP deployments in the home and small business.

EPRI Telecom Research

EPRI Project Set 161G

Project Set 161G launched in 2018, carrying on the set of key topics from the Telecom Initiative

- Operating and migrating to packet-based networks for SCADA and protection
- Leveraging licensed, unlicensed, and shared spectrum for private networks
- Public network operation and network sharing
- The strategic deployment of fiber
- Standards and best practices for network management and reliability metrics
- Software Defined Networking for operational networks
- Telecom network planning, visualization, and co-simulation

Project Set 161G will meet at the PDU Advisory meeting in Atlanta, September 17-19, 2018. A Telecom-focused project set meeting will be held in Madison, WI, November 28-29, hosted by Alliant Energy.

The 2019 161G portfolio overview has been posted.

EPRI Persistent Wi-Fi Demonstration Project

Utilities are challenged to effectively manage consumer loads found in a variety of devices such as thermostats, water heaters, charging stations, and other residential and commercial appliances. New utility programs for energy efficiency and demand response using connected devices can have issues with persistence of the connection that can reduce program effectiveness over time. The project will define and demonstrate a Wi-Fi based communications platform that can facilitate secure integration of customer systems with grid operations (both distribution and system operator). This project will demonstrate the use of Wi-Fi to address these problems, and provide the foundation for standard, secure, and durable commercially-ready platforms for integration of customer technologies. This project is in the formation phase and has not yet launched. For further information see Project Summary 3002011409.

For further information on these projects, please contact Tim Godfrey.

Previous Issues

[1] Issue 1: Smart Grid Communications Intelligencer: Fall 2011
[2] Issue 2: Smart Grid Communications Intelligencer: Winter 2011/2012
[3] Issue 3: Smart Grid Communications Intelligencer: Spring 2012
[4] Issue 4: Smart Grid Communications Intelligencer: Fall 2012
[5] Issue 5: Smart Grid Communications Intelligencer: Winter 2012/2013
[6] Issue 6: Smart Grid Communications Intelligencer: Spring 2013
[7] Issue 7: Smart Grid Communications Intelligencer: Fall 2013
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