Class Notes

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IEEE 802 Standards

The IEEE 802 standards are a set of networking standards developed by the Institute of Electrical and Electronics Engineers (IEEE) for local area networks (LANs) and metropolitan area networks (MANs). These standards define the protocols and specifications for the implementation of networking technologies, ensuring interoperability and compatibility among different network devices and systems. The 802 standards cover a wide range of aspects related to network architecture, protocols, and technologies.
Here are some key aspects of IEEE 802 standards and why they are essential:

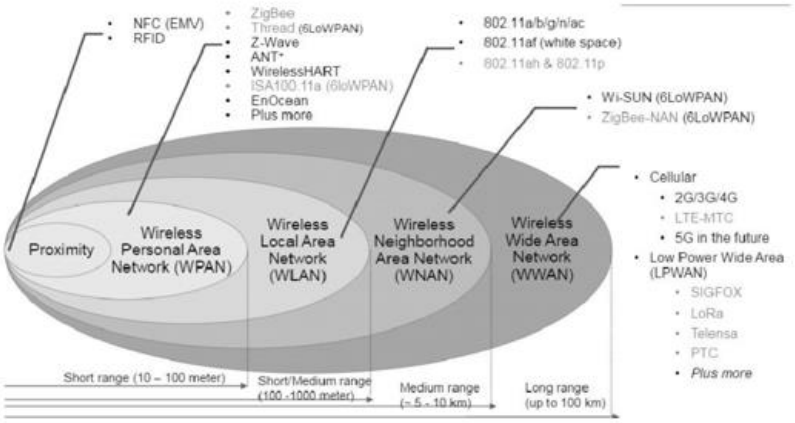
- **Interoperability:** IEEE 802 standards provide a common framework for the design and implementation of network protocols. This ensures that devices from different manufacturers can work together seamlessly within a network. Interoperability is crucial for the success and widespread adoption of networking technologies.
- **Compatibility:** By adhering to IEEE 802 standards, network equipment and devices can communicate effectively with each other. This compatibility simplifies the deployment and management of networks by allowing users to choose hardware and software components from different vendors without worrying about compatibility issues.
- **Scalability:** The standards address the scalability of networks, allowing them to grow and accommodate increasing numbers of devices and users. This is essential for adapting to the evolving needs of organizations and ensuring that networks can handle expanding workloads.
- **Reliability:** IEEE 802 standards contribute to the reliability of networks by defining robust protocols and specifications. Reliable networking is crucial for businesses and critical applications that depend on constant and uninterrupted connectivity.
- **Security:** Some IEEE 802 standards include provisions for network security. For example, IEEE 802.1X provides a framework for port-based network access control, enhancing the security of LANs by authenticating and authorizing devices before granting them access to the network.
- **Innovation:** The standards evolve over time to incorporate advancements in networking technologies. This allows the industry to innovate and adopt new technologies while maintaining a common framework for compatibility and interoperability.

Below you can observe the different IEEE 802 standards and their status of use:

Name	Description	Status
IEEE 802.1	Higher Layer LAN Protocols Working Group	Active
IEEE 802.2	LLC	Disbanded
IEEE 802.3	Ethernet	Active[3]
IEEE 802.4	Token bus	Disbanded
IEEE 802.5	Token Ring MAC layer	Disbanded
IEEE 802.6	MANs (DQDB)	Disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable	Disbanded
IEEE 802.8	Fiber Optic TAG	Disbanded
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet)	Disbanded
IEEE 802.10	Interoperable LAN Security	Disbanded
IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	Active
IEEE 802.12	100BaseVG	Disbanded
IEEE 802.13	Unused[4]	Reserved for Fast Ethernet development[5]
IEEE 802.14	Cable modems	Disbanded
IEEE 802.15	Wireless PAN	Active
IEEE 802.15.1	Bluetooth certification	Disbanded
IEEE 802.15.2	IEEE 802.15 and IEEE 802.11 coexistence	Hibernating[6]
IEEE 802.15.3	High-Rate wireless PAN (e.g., UWB, etc.)	?
IEEE 802.15.4	Low-Rate wireless PAN (e.g., Zigbee, WirelessHART, MiWi, etc.)	Active
IEEE 802.15.5	Mesh networking for WPAN	?
IEEE 802.15.6	Body area network	Active
IEEE 802.15.7	Visible light communications	?

IEEE 802.15	Broadband Wireless Access (WiMAX certification)	Hibernating
IEEE 802.15.1	Local Multipoint Distribution Service	Hibernating
IEEE 802.15.2	Coexistence wireless access	Hibernating
IEEE 802.17	Resilient packet ring	Disbanded
IEEE 802.18	Radio Regulatory TAG	Active
IEEE 802.19	Wireless Coexistence Working Group	?
IEEE 802.20	Mobile Broadband Wireless Access	Disbanded
IEEE 802.21	Media Independent Handoff	Hibernating
IEEE 802.22	Wireless Regional Area Network	Hibernating
IEEE 802.23	Emergency Services Working Group	Disbanded
IEEE 802.24	Vertical Applications TAG	?

Wifi standards based on their range

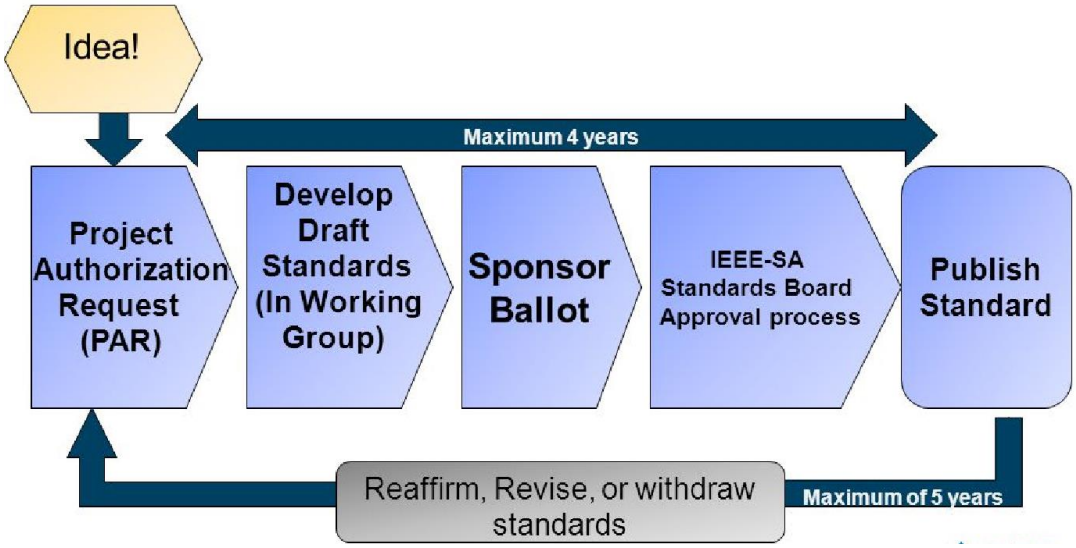


Types of 802.11 Standards Activities

Activity	Tag	Description
IEEE 802.11 Working Group	WG	The Working Group is comprised of all of the Standing Committees, Task Groups, Study Groups, and Ad-Hoc Groups. Membership is at the WG level. All WG members may participate in any of these sub-groups.
Task Group	TG	The committee(s) that are tasked by the WG as the author(s) of the Standard or subsequent Amendments via an approved PAR
Study Group	SG	A committee responsible for researching a possible future amendment. The output of the SG is usually a project authorization request (PAR). Study groups are authorized by the IEEE 802 executive committee (EC) and are expected to have a relatively short lifetime (~6 months). The SG terminates when it has submitted a PAR, or failed to gain approval for a PAR, or when the IEEE 802 EC declines to approve an SG extension.
Topic Interest Group	TIG	A committee that gathers together interested members to work together on a specific topic. Typically this might be used before a study group to determine technical feasibility and initial requirements before deciding to request a study group. The TIG is formed by WG motion and dissolved by the WG chair. It typically lasts 6 months.
Standing Committee	SC	A committee with a determined role/task, that does not modify the IEEE 802.11 standard. These committees are created by the 802.11 chair and are relatively long-lived.
Ad-hoc Committee	AHC	A committee with a determined role/task, that does not modify the IEEE 802.11 standard. These committees are created by the 802.11 chair and are relatively short-lived.

IEEE Standards Process

The IEEE standard development process involves several stages, from the initial idea for a standard to its eventual publication. Below is an overview of the key steps in this process:



Idea:

- Origination of the Idea: The process typically begins with an idea or a recognized need for a new standard in the field of interest. This idea can come from individuals, industry groups, or other stakeholders in the community.

Project Authorization Request (PAR):

- Submission of PAR: Once the idea is formulated, it needs to be documented in a Project Authorization Request (PAR). The PAR is a formal document that outlines the scope, purpose, and need for the standard.
- Approval by IEEE-SA Standards Board: The PAR is submitted to the IEEE-SA (Standards Association) Standards Board for review and approval. The Standards Board assesses whether the proposed project aligns with the goals and procedures of the IEEE-SA.

Develop Draft Standards (In Working Group):

- Formation of Working Group (WG): If the PAR is approved, a working group is formed to develop the draft standard. The working group consists of volunteers and experts in the relevant field.
- Draft Development: The working group collaborates to develop the technical content of the standard. This involves defining specifications, protocols, and other relevant details. The draft is refined through multiple iterations and discussions within the working group.

Sponsor Ballot:

- Sponsor Approval: Once the working group has completed the draft standard, it is submitted to the IEEE-SA for approval to go to the Sponsor Ballot. The Sponsor is typically a specific IEEE society or committee related to the subject matter of the standard.

- Sponsor Ballot: The draft standard is then subjected to a Sponsor Ballot, where members of the Sponsor organization review and vote on the proposed standard. A successful Sponsor Ballot indicates support for the standard within the relevant community.

IEEE-SA Standards Board Approval Process:

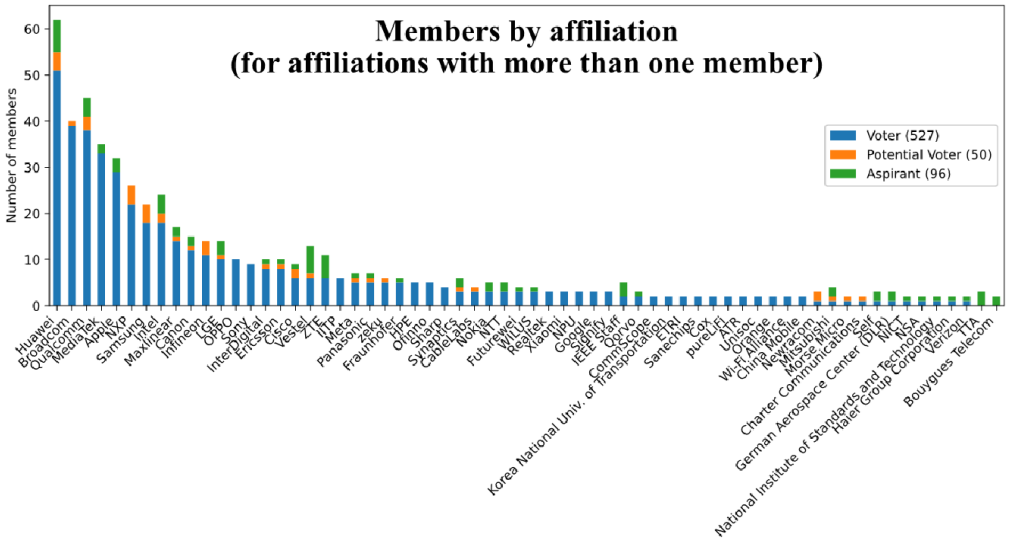
- Standards Board Review: After a successful Sponsor Ballot, the standard is submitted to the IEEE-SA Standards Board for review and approval. The Standards Board assesses whether the standard development process followed IEEE policies and procedures.
- Approval or Disapproval: Based on the review, the Standards Board may approve the standard or request revisions. If approved, the standard proceeds to the final stage.

Publish Standard:

- Publication: Once the standard receives IEEE-SA Standards Board approval, it is published. IEEE publishes standards through its IEEE Xplore Digital Library, making them publicly accessible.

Member Companies

In the IEEE 802 standards development process, member companies play a significant role in contributing to the creation and evolution of standards. The IEEE 802 standards cover a wide range of technologies related to local and metropolitan area networks, including Ethernet and wireless networking.



The role of the member companies can be understood as below:

Participation in Working Groups:

- Member companies often nominate technical experts to participate in IEEE 802 Working Groups. Working Groups are responsible for developing and revising specific standards within the IEEE 802 family.

- These experts, who are often engineers and professionals with expertise in the relevant technology, collaborate with representatives from other companies and individuals to contribute to the development of technical specifications.

Contribution of Technical Expertise:

- Member companies contribute their technical expertise to the development of standards. This includes proposing technologies, protocols, and specifications that address the needs and requirements of the industry.

Review and Comment:

- During the development process, member companies have the opportunity to review draft standards and provide comments. This iterative review process ensures that the standards are technically sound, reflect industry needs, and are implementable.

Sponsorship and Support:

- Member companies often sponsor specific standards or working groups within the IEEE 802 framework. Sponsorship may involve financial support, resource allocation, and other forms of assistance to facilitate the development and maintenance of standards.

Participation in Sponsor Ballot:

- Member companies, through their representatives, participate in the Sponsor Ballot process. This is a crucial step where the draft standard is reviewed and voted upon by members of the relevant IEEE society or committee (the "Sponsor").
- The success of the Sponsor Ballot is indicative of industry support and consensus for the proposed standard.

Standards Adoption and Implementation:

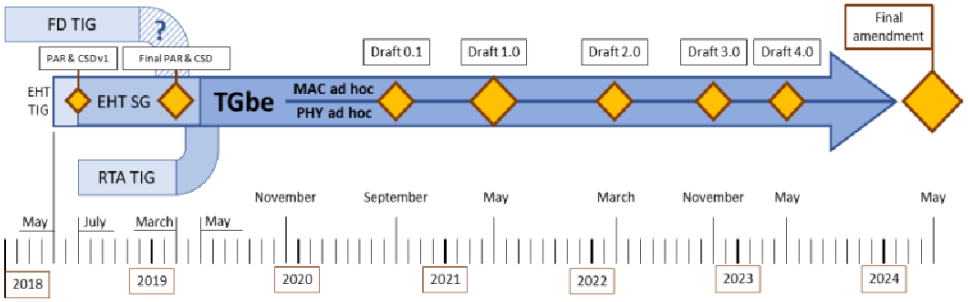
- Once a standard is published and approved, member companies may adopt and implement these standards in their products and solutions. Adherence to common standards facilitates interoperability and compatibility among devices from different manufacturers.

Feedback and Continuous Improvement:

- Member companies provide feedback based on their real-world implementation experiences. This feedback can be used for the continuous improvement of existing standards and for informing the development of new standards to address emerging needs.

Proposed Timeline for 802.11b standard

As an example, below is the proposed timeline for the new IEEE standard, 802.11be



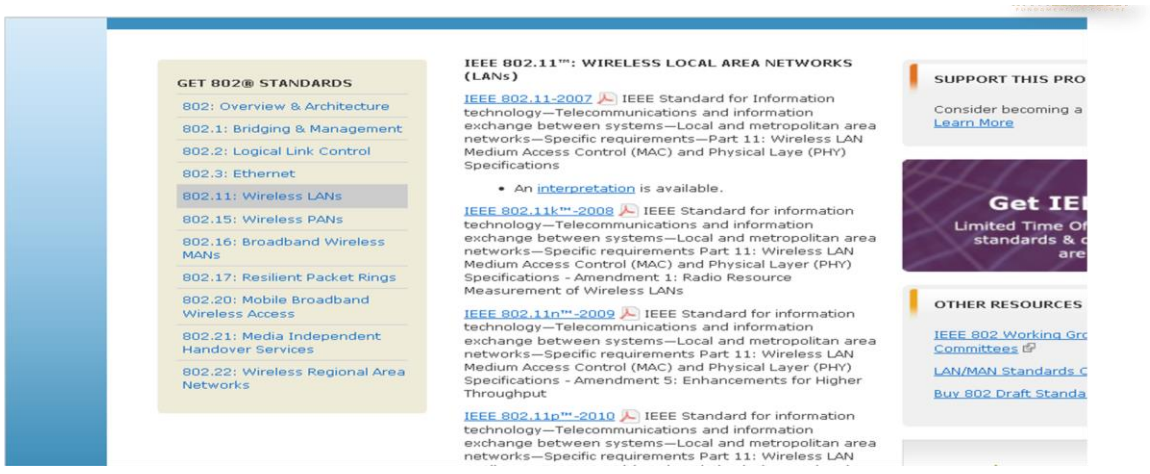
Here you can observe the different stages of 802.11be or popularly known as wifi 7 standard development process

• PAR approved	Mar 2019
• First TG meeting	May 2019
• D0.1	Sept 2020
• D1.0 Letter Ballot	May 2021
• D2.0 LB	Mar 2022
• D3.0 LB	Nov 2022
• Initial Sponsor Ballot (D4.0)	May 2023
• Final 802.11 WG approval	Mar 2024
• 802 EC approval	Mar 2024
• RevCom and SASB approval	May 2024

NOTE:

- Implementation and product release can occur before the final standardization.
- Products are often released during the draft stage.
- Residential access points and Wi-Fi routers implement and release products during this phase.

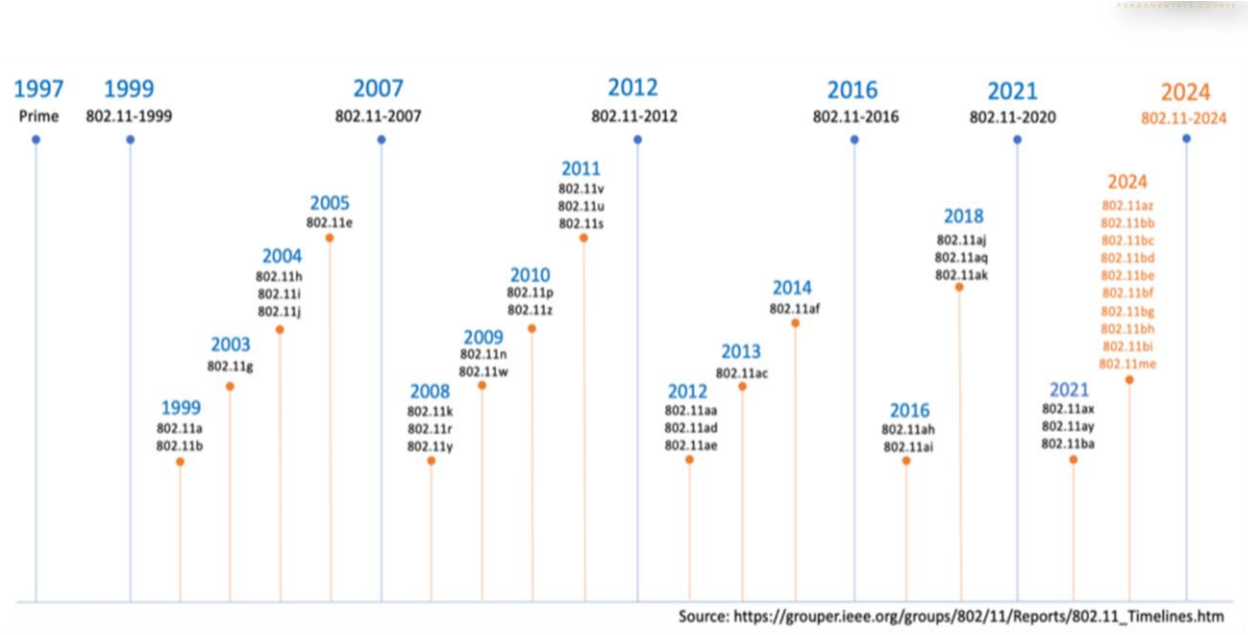
Standard Document



Standards documents, particularly in the context of Wi-Fi technology, are both intriguing and challenging for newcomers to the field. These documents delve deep into the intricate details of Wi-Fi technology, making them somewhat daunting for those just starting their careers. However, for those with IEEE membership, accessing these documents is made possible through internet downloads, although they can be incredibly extensive, often spanning thousands of pages. Despite their complexity, standards documents serve as an indispensable resource, containing a comprehensive repository of knowledge about Wi-Fi technology. In fact, virtually everything one needs to learn about Wi-Fi technology, including course content and foundational

knowledge, can be found within these documents. Therefore, while they may appear formidable at first, delving into standards documents is key to gaining a profound understanding of Wi-Fi technology, making IEEE membership a valuable pathway to accessing these vital resources.

802.11 Standards Timeline



- **Base Standard and Amendments:** The Wi-Fi standardization process involves the development of a base standard, initially established in 1997. This base standard is created based on the use cases and technology available at that time, supporting specific features, such as 11 Mbps data rates and 2.4 GHz spectrum technology.
- **Evolution and Expanding Use Cases:** Over time, new technologies, applications, and use cases emerge. For example, the introduction of the 5 GHz band for Wi-Fi and various business and technology developments led to the need for amendments or extensions to the existing standard. Amendments are created to address specific new use cases or technologies.
- **Amendment Process:** Each amendment, like 802.11a, 802.11b, and 802.11g, goes through a standardized process, including the formation of a study group, task group, and standardization procedures. This ensures that new technologies and use cases are properly standardized before being incorporated into the main standard.
- **Integration into Main Standard:** Once the amendments are developed and standardized, they are eventually integrated into the main standard. For example, the 2007 version of 802.11 incorporated various extensions and amendments, resulting in an updated and comprehensive standard.
- **Continual Evolution:** The Wi-Fi standardization process is an ongoing, evolving process. Over the years, multiple amendments and extensions have been added to address real-world use cases and technological advancements. This process continues, with new extensions and updates added as needed.
- **Future Base Standards:** The process repeats over time, with new base standards periodically introduced. For instance, a new base standard is expected in 2024, which will encompass technologies and developments spanning over two decades, making it a substantial document.

This process highlights how Wi-Fi standards evolve to accommodate changing technology landscapes and expanding use cases while ensuring that all updates go through a rigorous standardization process before being included in the main standard.

802.11 Alphabet Soup

The development of Wi-Fi standards has evolved over time, starting with the base standard in 1997 and subsequent extensions and amendments to meet changing technological needs:

- **Base Standard (1997)**: Introduced 1 Mbps and 2 Mbps data rates using 2.4 GHz frequencies.
- **Extension to 5.5 and 11 Mbps (1999):** The base standard was extended to include data rates of 5.5 and 11 Mbps.
- **Introduction of 5 GHz Spectrum (Late 1990s - Early 2000s):** As the 5 GHz spectrum became available for Wi-Fi, the 802.11 standard was introduced, supporting up to 54 Mbps using OFDM technology.
- **Quality of Service (QoS) Requirement (Early 2000s):** With the increasing use of voice over Wi-Fi and the need for prioritizing traffic, the 802.11e amendment was introduced to implement QoS in Wi-Fi networks.
- **Enhanced Security (Early 2000s):** To improve security in Wi-Fi networks used in enterprises and offices, the 802.11i amendment, also known as enhanced security, was introduced.
- **Radio Resource Management (Early 2000s):**The need for efficient channel usage in environments with multiple access points led to the development of the 802.11k standard for Radio Resource Management.
- **High Throughput Wi-Fi (2000s)**: To meet demands for higher speeds, 802.11n introduced features such as MIMO, wider channels, and higher throughput.
- **Vehicular Wi-Fi (802.11p):** Addressed the implementation of Wi-Fi technology in vehicles for transportation applications.
- **Seamless Roaming (802.11r):** Introduced fast roaming capabilities to maintain connectivity while moving between access points.
- **Mesh Networks (802.11s):** Developed for mesh network implementations.
- **Wireless Network Management (802.11u):** Focused on improving network management capabilities.
- **Protected Management Frames (802.11w):** Enhanced security for management frames in Wi-Fi.
- **Introduction of Two-Letter Standards:** Beyond single-letter standards, two-letter standards like 802.11ac (Wi-Fi 5),802.11ad (WiGig, operating in the 60 GHz spectrum), 802.11ax (Wi-Fi 6, introducing OFDMA technology), and 802.11be (in progress, aiming for extremely high throughput) have been developed to address specific use cases and technological advancements.

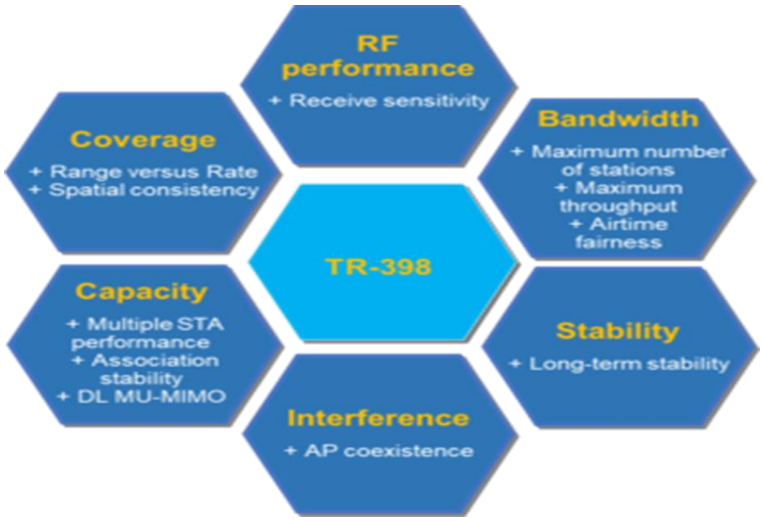
These extensions and amendments have contributed to the continuous evolution of Wi-Fi technology, addressing various use cases, speeds, security, and efficiency requirements. The standardization process involves rigorous procedures and collaboration among multiple companies, ensuring that new technologies are properly integrated into the Wi-Fi ecosystem.

Wi-Fi Alliance's Role and Functions:

The Wi-Fi Alliance serves as a pivotal organization in the realm of wireless technology. Its primary functions include:

- **Simplifying Complex Standards:** The Wi-Fi Alliance simplifies intricate technical standards, making them more accessible to the general public.
- **Certifications:** They facilitate certifications for various Wi-Fi standards and technologies. Manufacturers can have their devices tested and certified for compatibility and interoperability.
- **Standardization and Interoperability Testing:** Wi-Fi Alliance assists in standardizing essential features from the vast array proposed in the original specifications. They conduct interoperability tests (Plug Fests) during the implementation stages, ensuring devices from different manufacturers can communicate seamlessly.
- **Term Coining:** Wi-Fi Alliance introduced user-friendly terms like "Wi-Fi 7" to replace complex nomenclature (e.g., 802.11be). This simplifies communication about Wi-Fi technologies.
- **Security Standards:** They certify security protocols like WPA3, ensuring devices adhere to the latest security standards, protecting users from potential cyber threats.
- **Various Certifications:** Wi-Fi Alliance provides certifications for specific technologies, such as Wi-Fi 6, Wi-Fi 7, WPA3, WMM (Wi-Fi Multimedia), and more.

Broadband Forum and Residential Access Points:



- **Changing Requirements:** Residential Access Points have evolved. They are no longer simple devices but sophisticated systems capable of supporting multiple devices, streaming, IoT, and more.
- **Broadband Forum:** This organization introduced the TR-398 certification, focusing on rigorous testing criteria. It assesses performance metrics like coverage, bandwidth, stability, and capacity, ensuring modern residential access points meet high standards.

Wireless Broadband Alliance (WBA) and Collaboration:

- **WBA's Collaborative Efforts:** The Wireless Broadband Alliance (WBA), alongside similar organizations, contributes to the collaborative effort within the Wi-Fi ecosystem. Workgroups and projects address specific challenges and promote standardization.

Standardization Process:

The IEEE (Institute of Electrical and Electronics Engineers) develops the technical standards, but Wi-Fi Alliance helps standardize and simplify features. Not all features proposed in the original IEEE specs make it into the final product. Wi-Fi Alliance identifies and standardizes the most essential ones. They facilitate interoperability testing through plug fests, allowing different manufacturers to test early implementations of the standard to ensure devices can communicate and pass traffic.

Wi-Fi Alliance offers various certification programs, including Wi-Fi 6, Wi-Fi 7, WPA3 (for security), and others. These certifications validate that devices meet specific standards and can work together seamlessly. For example, a manufacturer can get their access point certified for WPA3, demonstrating compliance with the latest security standards.

In summary, the Wi-Fi Alliance, along with other organizations like Broadband Forum and Wireless Broadband Alliance, simplifies complex standards, conducts certifications, fosters collaboration, and educates professionals, ensuring the seamless integration of Wi-Fi technologies into our everyday lives. These efforts collectively enhance user experiences and drive the evolution of wireless communication.

The Various Resources Available for Wi-Fi Enthusiasts and Professionals:

1. Ensuring Wi-Fi Product Quality:

Alongside the standards-setting entities, there are certification bodies responsible for ensuring the quality and compliance of Wi-Fi products and technologies. These certification organizations evaluate and test Wi-Fi devices to confirm that they meet the established standards. Certification is essential to ensure that Wi-Fi products from different manufacturers can work together seamlessly and provide reliable performance.

2. Educational Organizations:

Various organizations aim to educate individuals about Wi-Fi technology. These organizations provide resources and information for learning about Wi-Fi. They focus on educating people about real-world Wi-Fi implementations and problem-solving.

3. WLAN Pros:

WLAN Pros is mentioned as one of the outlets for Wi-Fi enthusiasts. It hosts events multiple times a year where experts gather to discuss Wi-Fi technology. These events feature presentations on technology, troubleshooting, and real-world Wi-Fi issues. Videos of these talks are available on WLAN Pros' website. Videos, including short 10 to 20-minute talks, cover various Wi-Fi-related topics. These resources are valuable for staying up-to-date on Wi-Fi technology.

Mobility Field Day

1. Mobility Field Day:

Mobility Field Day is a platform where multiple companies showcase their latest Wi-Fi products and technologies. For example, Juniper presents its new AI technology and product innovations at such events. Videos of these presentations are typically available online, providing insights into the latest features and implementations by companies.

2. Learning from Mobility Field Day Videos:

Mobility Field Day videos offer valuable knowledge about what features companies are implementing based on Wi-Fi standards. Companies may choose to implement specific features out of the numerous available in the standards. These videos can help you understand industry trends and the practical application of Wi-Fi standards.

OpenWiFi Technology:

Open Wi-Fi technology is a project involving collaboration among several companies. The goal of this project is to make Wi-Fi technology open source. Traditionally, Wi-Fi technology development was proprietary and closed. Companies like Cisco or Aruba took 10-20 years to develop closed, proprietary Wi-Fi router technology. Proprietary firmware and software are used in access points, making them closed and inaccessible to others. Closed technology provides an advantage to the companies that own it, leading to specialization and higher costs for Wi-Fi routers. The challenge is to make Wi-Fi technology more widely adopted.

Advantages of Open-Source Wi-Fi:

Open sourcing Wi-Fi technology involves making all software and firmware open and accessible. The community collaboratively develops and shares the software on the internet. New companies interested in Wi-Fi access points can use certified hardware and open Wi-Fi software. They can customize the software, add their branding, and quickly establish their Wi-Fi company. This approach encourages more players to enter the market, leading to market commoditization and wider adoption. The main idea is to promote widespread adoption by open-sourcing Wi-Fi technology.

PM-WANI (Prime Minister Wireless Access Network Infrastructure):

PM-WANI is a government initiative in India aimed at improving internet access, especially in less-developed regions of the country. The goal is to address the digital divide and provide internet access to the majority of the population. While major cities like Bangalore and Hyderabad have robust internet connectivity, rural areas lack adequate infrastructure. The government recognizes that the internet is crucial for modern businesses and economic growth.

1. Improving Economic Growth through Internet Connectivity:
In the modern world, many aspects of business and daily life depend on internet connectivity. Expanding internet access across the country can lead to faster, more efficient business operations. This, in turn, can contribute to the overall GDP of the country. The government believes that a well-connected network is essential for economic development.

2. Standardization of Infrastructure:
The government has standardized the infrastructure for PM-WANI. Organizations like CDOT are involved in the standardization process. This standardized infrastructure forms the backbone of the initiative.

3. Public Data Office (PDO):
Similar to public telephone booths from the past, the PM-WANI initiative introduces the concept of Public Data Offices (PDOs). PDOs are small locations like village panchayats or shops where people can access Wi-Fi. These PDOs are connected to an aggregator and managed through a central registry. PDOs have the flexibility to charge for Wi-Fi access if they choose to do so. The goal is to democratize technology and make internet access more accessible in various locations, including rural areas.

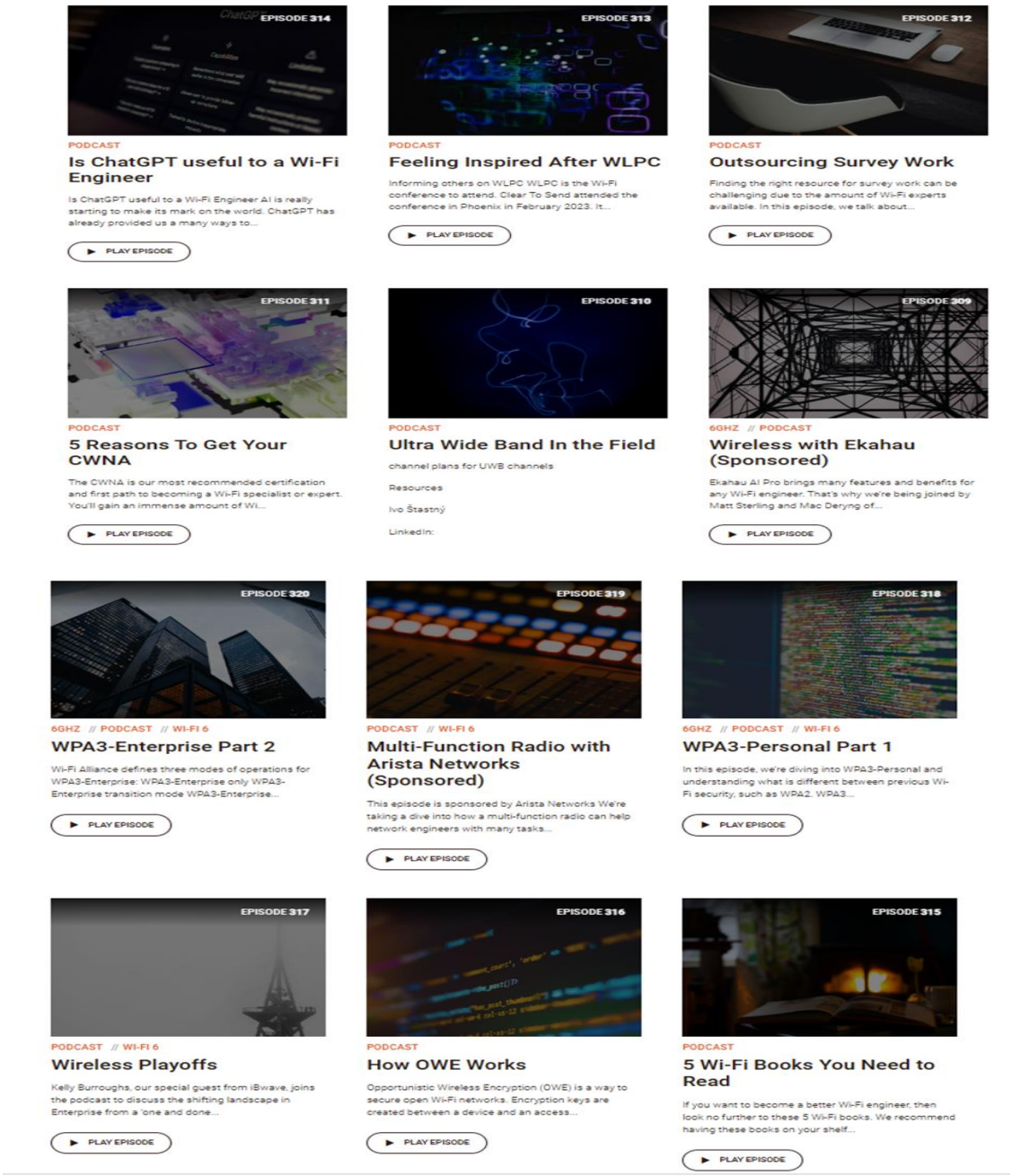
4. Business Benefits of PM-WANI:
Expanding Wi-Fi access can benefit local businesses, such as roadside tea shops or coffee shops. Offering internet access attracts more customers and enhances the business. Ultimately, better network connectivity can lead to improved economic activity in various locations.

5. Status of PM-WANI:
PM-WANI is in a mid-level implementation stage. Some networks have been installed, but the initiative still has a long way to go in achieving widespread coverage and impact.

Wi-Fi NOW

Organizations like Wi-Fi Now help Wi-Fi technology grow. They organize big meetings where companies can show their Wi-Fi products and ideas. These events are like big shows where companies have booths to display their technology. The goal is to make more people know about Wi-Fi and bring everyone in the Wi-Fi world together. It helps companies work together and learn from each other. This way, Wi-Fi gets better and more people use it all over the world.

Clear to Send Podcasts:

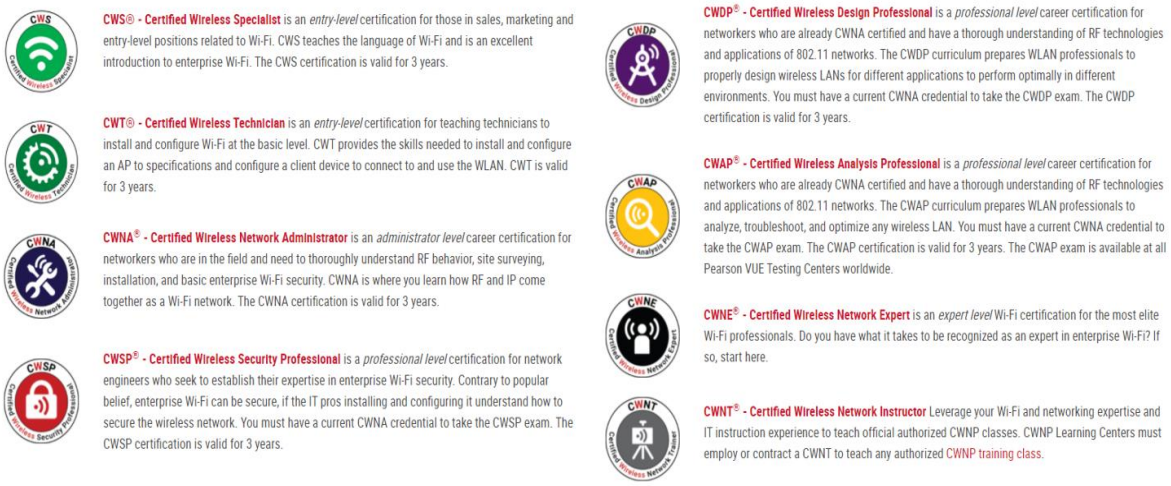


Podcasts:

- Companies participate in trade shows to showcase products, present technology, and raise awareness about Wi-Fi.
- Organizations like Wi-Fi Now host events and podcasts like "Clear to Send" focus on Wi-Fi technical challenges and solutions.

- Certifications are valuable in the trillion-dollar Wi-Fi market, and organizations like CWNP offer certifications in various areas.

CWNP Certifications:

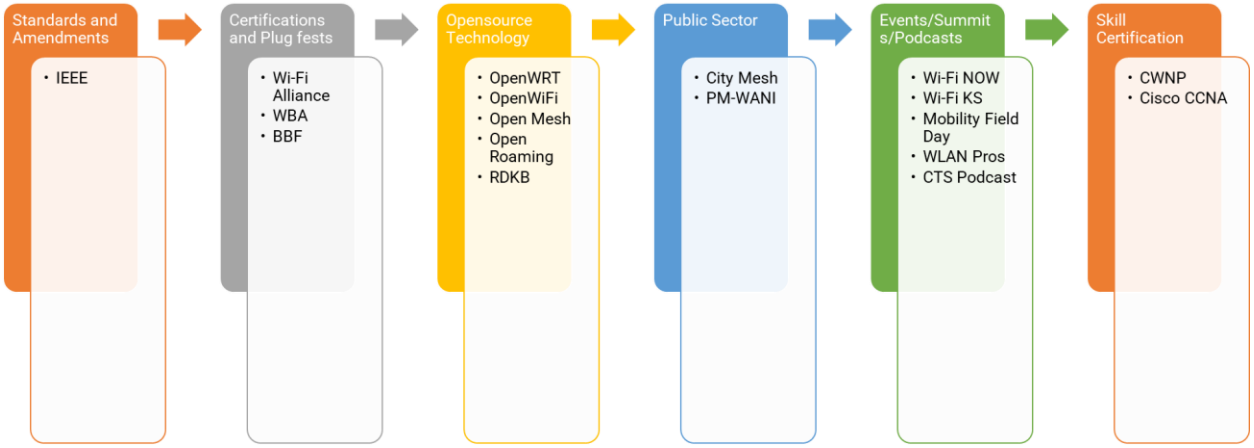


These certifications cover various aspects of Wi-Fi, from basic terminology to advanced security and network design, and they are valuable in the Wi-Fi job market. Each certification has its focus area and prerequisites.

- **CWS (Certified Wireless Specialist):** Entry-level certification for sales, marketing, and entry-level Wi-Fi positions. Teaches Wi-Fi terminology and serves as an introduction to enterprise Wi-Fi. Valid for 3 years.
- **CWTO (Certified Wireless Technician):** Entry-level certification for teaching technicians to install and configure basic Wi-Fi. Covers AP installation, configuration, and client device connectivity. Valid for 3 years.
- **CWNA (Certified Wireless Network Administrator):** Administrator-level career certification for network professionals in the field. Covers RF behavior, site surveying, installation, and basic enterprise Wi-Fi security. Valid for 3 years.
- **CWSP (Certified Wireless Security Professional):** Professional-level certification for network engineers focusing on enterprise Wi-Fi security. Requires a current CWNA credential. Valid for 3 years.
- **CWDP (Certified Wireless Design Professional):** Professional-level career certification for CWNA-certified individuals with expertise in RF technologies and 802.11 network applications. Prepares professionals to design wireless LANs for different applications and environments. Requires a current CWNA credential. Valid for 3 years.
- **CWAP (Certified Wireless Analysis Professional):** Professional-level career certification for CWNA-certified individuals with expertise in RF technologies and 802.11 network applications. Prepares professionals to analyze, troubleshoot, and optimize wireless LANs. Requires a current CWNA credential. Valid for 3 years.
- **CWNE® (Certified Wireless Network Expert):** Expert-level Wi-Fi certification for elite Wi-Fi professionals.

CWNT (Certified Wireless Network Instructor): Certification for experienced Wi-Fi and networking professionals to teach authorized CWNP classes.

In Summary:



Standards and Amendments:

- IEEE 802.11 standards, including 802.11n, 802.11ac, etc., are fundamental in Wi-Fi technology.

Certifications and Plug Fests:

- Various certifications are available, such as CWMP (industry-neutral) and those offered by major companies like Cisco (CCNA, CCIE), Aruba, Juniper, etc.
- Plug fests are events where devices are tested for interoperability.

Open-Source Technology:

- Open-source technologies like OpenWRT, OpenMesh, Open Roaming, and RDKB are significant in Wi-Fi development.

Public Sector:

- Public sector initiatives include the deployment of city mesh networks, supported by governments and programs like PM-WANI.

Events/Summit/Podcasts:

- Events and summits like Wi-Fi Now, Wi-Fi Knowledge Summit, Mobility Field Day, and WLAN Pros Conference offer opportunities for industry experts to meet and share knowledge.
- Podcasts are valuable resources for staying updated on Wi-Fi developments.

Skill Certification:

- Skill certifications are offered by organizations and companies to validate expertise in Wi-Fi technologies, such as CCNA and CCIE wireless from Cisco, certifications from Aruba, Juniper, and others.

IEEE 802 Standards Process

(Information provided by Dr. Tom Alexander, senior members in standards bodies):

IEEE Standards meetings are grouped into Plenary and Interim meetings. There are always 3 Plenary sessions and 3 Interim sessions per year. The principal difference is related to voting rights and "official" passage of standards drafts. A member must attend a certain number of plenary meetings, along with a certain number of meetings of any kind, in order to retain voting rights. Also, standard ballots to decide passage of standards are normally held during plenaries. That being said, much of the actual work of drafting the standard occurs during interim meetings (as well as plenaries), because these meetings are more informal and lead to more people attending. Plenaries are very large and have the entire 802 Committee. Interims are much smaller and normally only have the Working Group, though I've been to Interims where there were multiple WGs.

Some groups (e.g., the electrical power people) move so slowly that they do not have Interim meetings. Groups like 802 have a lot of work, so they require both kinds. There are occasionally informal meetings in between Plenaries and Interims where some sub-group (usually the TG or SG, see below) will meet to do more work, but the decisions taken during these meetings are non-binding. Only votes taken during Plenary or Interim meetings are binding, and Plenary votes are required to forward standards to the IEEE Standards Committee.

The IEEE 802 standards process is as follows:

- A group of members makes a presentation to the Working Group on the need for a new standard. This is typically a Call for Interest, and occurs during the late hours of plenaries or even interims
- If a majority of the Working Group (a subgroup of the main body of the 802 committee, such as "802.11") agrees, then the members are authorized to form a Study Group
- The purpose of the Study Group is to gather technical and market data supporting the standard, and also (unofficially) to drum up support within the WG
- After some maximum time period (usually 2-3 Plenaries), the SG is expected to come back to the WG with a request to actually begin work on the standard. This is the PAR (Project Authorization Request)
- If the WG agrees, then they recommend to 802 that the members should be authorized to form a Task Group (TG)
- A TG has all the usual structure: a TG chair, a TG editor, vice chair, etc. Larger TGs may have multiple officers and multiple editors. For example, the 802.3 10GE TG had 12 editors
- The TG is given some time limit (usually 2 years) to come up with a draft standard, and also to drum up support within the WG for passing the standard
- Once the TG can come up with a draft standard, it will forward it to the WG with a request to start balloting it
- The WG then takes up the draft standard and begins ballot rounds
- After the WG reaches consensus on the standard (all comments have been addressed or disposed of, and the WG votes to proceed), it is forwarded to the entire 802 committee as a whole
- The 802 committee then goes through its own rounds of ballots. This is usually mostly a formality, but sometimes leads to high drama
- Once the 802 committee agrees that this is a valid standard, it is forwarded to the IEEE Standards Committee for ratification. This is almost always a formality. The WG has moved on (or disbanded) after that.

The above is the process in rough. Obviously, something that takes years is a bit more complicated than that! But that is the outline.

There is also the PAR (Project Authorization Request) that is required to be approved at the IEEE SC level, based on the recommendation from the WG. A PAR needs to be approved initially, based on a set of technical and market criteria, and then reapproved every so often (I believe it's 2 years) to ensure that it remains up to date. Mostly all formality. The WGs decide what they are going to work on, and the SC goes along.

Amendments to standards are done exactly the same way as full standards. For example, the 802.11 WG came up with the initial Wi-Fi standard which had only optical signaling and 1 or 2 Mb/s QPSK, I think. But then we had the actual 802.11a, b, g etc. which were amendments to the 802.11 standard. For the very first version of the standard there is no TG, because there is no overarching group to have a task group from. Thus, the entire WG works on the initial standard. However, after the initial standard is approved, then the WG breaks into TGs to work on amendments to the initial.

https://www.ieee802.org/orientation.shtml