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Abstract	This article explains the process of standardization in the IEEE Standards Association.It emphasizes topics relevant to the wireless engineer,particularly the IEEE 802 LAN MAN Standards Committee and its three projects defining a Wireless Internet infrastructure. This article was published as "IEEE Standardization for the Wireless Engineer, Roger B. Marks, *IEEE Microwave Magazine* 2, pp. 16-26, June 2001." <http://ieeexplore.ieee.org/iel5/6668/20011/00924914.pdf>
Purpose	This document may improve the effectiveness of standards developers by aiding their understanding of the IEEE Standards Association.
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IEEE Standardization for the Wireless Engineer

Standards shape communications technology and drive it into the economy. Who creates those standards? In many cases, the answer is people like you.

Many of the key technologies in data communications, particularly in wireless, are developed by the IEEE, and IEEE members have special opportunities to participate in the process, whether or not they attend meetings.

This Speaker's Corner article explains the process of standardization in the IEEE Standards Association. It emphasizes topics relevant to the wireless engineer, particularly the IEEE 802 LAN MAN Standards Committee and its three projects defining a wireless Internet infrastructure.

IEEE has a number of active standards projects of interest to the wireless engineer:

- Many of the world's leading standards, including those defining an infrastructure for the wireless Internet, are produced through IEEE. Do you realize that Ethernet, the ubiquitous local area network (LAN), is IEEE Standard 802.3? In fact, the IEEE 802 LAN MAN Standards Committee now has three important wireless standards projects, including the immensely successful IEEE 802.11 wireless LAN standard, the IEEE 802.15 project standardizing Bluetooth™ and developing other wireless personal area network standards, and the IEEE 802.16 WirelessMAN™ group developing a series of fixed broadband wireless access standards for wireless metropolitan area networks (MAN). While IEEE 802 is sponsored by the IEEE Computer Society, the MTT Society co-sponsors IEEE 802.16.
- The MTT Society has occasionally sponsored standards projects. MTT Technical Committees are a good place to handle the development. For instance, Technical Committee MTT-8 (Filters and Passive Components) is currently developing a standard "Definition of Terms for Microwave Filters."
- IEEE is a leader in the very difficult but vital problem of drafting standards on the biological effects of nonionizing electromagnetic radiation. The work is handled mainly by Standards Coordinating Committees (SCC) that cut across the borders of IEEE Societies. For example, SCC 28 (http://grouper.ieee.org/groups/scc28) studies "Nonionizing Electromagnetic Energy Safety Standards to 300 GHz." SCC 34 ("Product Performance Safety") has active projects in experimental and computational dosimetry for human absorption of electromagnetic energy from wireless handsets. This influential work is critical to wireless and microwave technology.

In addition, IEEE is open to creating new standards projects but needs people like you to take the initiative. This article overviews IEEE Standards from the view of a wireless engineer, with a focus on IEEE 802.

IEEE Standards Association

In addition to its many technical and regional activities, IEEE carries out an active program in standardization through the IEEE Standards Association (IEEE-SA). IEEE-SA efforts are accredited by the American National Standards Institute (ANSI). ANSI oversight ensures that its guiding principles of consensus, due process, and openness are followed. While IEEE-SA is accredited by a U.S. organization, many of its projects are global in scope, and it is increasingly working to internationalize and globalize its procedures.

IEEE-SA standards are openly developed with consensus in mind. Participation in their development, and use of them, is entirely voluntary. However, history has shown that standards developed in an open forum can produce high-quality, broadly accepted results that can focus companies and forge industries.

IEEE-SA oversees the standardization process through the IEEE-SA Standards Board. Project development is delegated to individual standard sponsors, which are generally units of IEEE technical societies. One of the most important of the IEEE-SA sponsor groups is the IEEE 802 LAN MAN Standards Committee.

IEEE 802 LAN MAN Standards Committee

The IEEE 802 LAN MAN Standards Committee (http://ieee802.org), which is sponsored by the IEEE Computer Society, first met in 1980 to develop a local area network (LAN) standard. It develops and maintains standards for physical (PHY) layers and medium access control (MAC) layers, each of which fits under a common logical link control (LLC) layer. Together, these make up the two lowest layers of the OSI seven-layer model for data networks.

IEEE 802 holds week-long plenary meetings three times per year, with attendance on the order of 1,000 people recently. In between these plenaries, most of its active working groups hold interim meetings.

Historically, 802 has been best known for the IEEE 802.3 standard, informally known as Ethernet. The 802 portfolio of active projects in the cabled realm grew in late 2000 with the approval of the 802.17 Working Group on Resilient Packet Rings. While Ethernet has been greatest success of 802, it is now the home of a number of wireless network standardization projects. These projects take advantage of the highly successful system of standards development pioneered by 802.

IEEE 802 addresses a communications industry and, therefore, deals primarily with interoperability standards. These are intended to assure that products produced independently by different manufacturers can reliably communicate with each other. This can be a more subtle problem than simply writing a standard to ensure that two products are similar in some descriptive way.

Standardization Process

The IEEE 802 process is oriented to quick development of standards with broad consensus. The demand for consensus helps to ensure that standards are technically superior and meet market needs.

The development process in IEEE 802 follows the chronological steps outlined below. The process is overseen by the 802 Sponsor Executive Committee (SEC) and defined by a set of rules and procedures.

Study Group

When sufficient interest has been identified in a topic, a study group may be chartered to investigate the problem and consider the scope of and interest in a possible standardization project. Should a study group wish to pursue standardization, it must draft a project authorization request (PAR); this is a form by which all new IEEE-SA projects become authorized. Before the SEC considers approving a PAR for submission to the IEEE-SA Standards Board, it requires a statement addressing "Five Criteria for Standards Development" of 802. This statement must demonstrate that the potential standard has broad market potential, compatibility with other 802 standards, distinct identity within 802, technical feasibility, and economic feasibility.

Working Group
Development of Draft

The SEC assigns each new project to an existing or new working group and

charters that group to develop the standard. Technical decisions are made by the working group by vote of at least 75% of its members. Working group membership belongs to individuals, not to companies or other entities, and it is awarded on the basis of participation at meetings. Nonmembers participate actively as well.

The initial draft development method varies among groups, but the typical process is to delegate a Task Group to the problem and issue a public call for contributions for documented input. Eventually, a basic draft is selected by the members of the working group. This phase is sometimes contentious, as the competing interests of different companies and technology interests are often reflected in meetings. However, it offers a good opportunity for new participants to come to understand the process and become comfortable in discovering commonality among a group with diverse interests. The fact that professional individuals, not companies, are the recognized entities helps to set a tone of collegiality. New participants continuously enter the process. They sometimes appear aggressive at first, only to discover that this approach can be ineffective. The process demands excellent communication and preparation as well as technical skills. Those most effective at furthering their causes are those who clearly state their intent, present well-documented arguments, and look for opportunities to unite with others who have compatible goals. The system is an excellent training ground for bringing out effective communications skills, and many of the most effective participants learn their skills the hard way.

Once a working group has adopted a draft, the process changes subtly but significantly. At this point, the interest of the participants begins to align; all have the common goal of improving the draft. The typical process is driven by distributing the draft and requesting comments in the form of specific requests to make changes. Before the SEC will advance the draft, it must be approved in a working group letter ballot in which the members are asked to approve the document. Any vote against the document must be accompanied by

specific comments on what changes are required in order that the voter will approve it. This process forces constructive change suggestions and helps drive the process to quick improvement after a few cycles. Members voting to approve are also solicited to offer suggestions, as are nonmembers. A approval rate of 75% is required for draft acceptance. However, changes made in response to comments, and negative comments that have not been accepted by the editorial team, must be recirculated for approval by the voters. In effect, the ballot cannot close until those voting negative have had their say and failed to attract other voters to their argument. The approval margin is typically much higher than 75% at closure.

Sponsor Ballot

Once a draft standard is completed by any developing group, IEEE-SA puts the document before a broad group of interested individuals in a "sponsor ballot." For IEEE 802 projects, this is similar to a rerun of the working group letter ballot except that the ballot group is not restricted to members of the working group.

The process works like this:

- The IEEE-SA maintains a Web-based form at http://standards.ieee.org/db/balloting/ballotform.html for use by individuals who wish to register their interest in future sponsor ballots. The form lists particular technical fields and standards development groups, not particular standards. The MTT Society has its own checkbox, as do the 802 working groups.
- When a draft is ready for sponsor ballot, the Sponsor will identify a set of interest areas and invite all those who registered interest in those area to participate in the ballot. A letter or email will be delivered indicating the key facts about the standard.
- Potential balloters will be notified that, by agreeing to participate, they are committed to voting. This commitment is critical, for the ballot is deemed to have failed without a return rate of at least 75%. Voters who vote "abstain" are counted toward the return rate, but a result with over 30% abstentions will also fail. Therefore, balloters should be willing to read the draft and issue a vote. In addition to the vote, of course, critical comments are vital to the success of the process.

Members of the IEEE-SA are eligible to participate in sponsor ballots without a fee. This is one of the best practical reasons for you to join the IEEE-SA. IEEE-SA membership costs only $10 per year on top of your IEEE membership. If you are not an IEEE-SA member, you can join quickly. One distinct benefit is the free draft standard delivered for balloting. Such drafts are copyrighted by IEEE and generally offered for sale.

Issues

A number of key issues are facing the IEEE-SA and its leadership. For instance:

Patents

The IEEE-SA Patent Policy is similar to that of most standards-developing organizations (SDO) in the world. One key statement of the policy is: "IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard." A number of factors make the policy problematic, but many of these problems are shared by other (SDOs).

Consortia

A number of industry consortia have arisen to compete with traditional SDOs, such as the IEEE-SA, by issuing their own specifications. Sometimes, these consortia are driven by a belief that conventional standardization is too slow. In many of these cases, consortia discover some disagreement within their ranks. In this case, they may be forced into the difficult and time-consuming process of rulemaking. Standards groups generally come into existence with an efficient and practical set of rules, so they can often move more quickly than consortia if motivated. The final approval of a draft standard may be slow, but, once the draft is in ballot, companies see it as fairly stable and may begin to develop products around it. In any case, the additional time spent by a draft in ballot allows the work to be refined and the bugs to be cleaned out. Generally, this is time well worth investing.

Another aspect of the ballot process is the IEEE-SA requirement for "balance." This means that no "interest group" (such as, for example, "user" or "producer") can make up more than half of a ballot group. In contrast, a consortium might be dominated by equipment manfacturers who radically misjudge the needs of their users. Good examples of this problem may be found, even among large and apparently indomitable consortia.

In some cases, consortia are organized with the primary goal of performing the hard work required to develop a standard. Such groups may, through common participants, distinctly influence an standardization group, even when that group maintains its official distance. This is generally regarded as positive in the sense that anyone who

can clearly articulate a position is considered an asset in the standardization process. Balloting helps to offset the influence of the consortium. While the IEEE 802 working groups generally keep consortia and companies at arm's length, IEEE 802.15 has developed a close working relationship with the Bluetooth™ Special Interest Group.

In many cases, consortia are driven by patent issues. For instance, consortium members may pool their patent rights or offer each other royalty-free use. How such arrangements relate to conventional SDO patent policies is a complicated legal matter that can be a barrier to successful cooperation between consortia and SDOs.

IEEE-SA is facing one particularly challenging consortium issue within its own ranks. In early 1999, IEEE created an independent corporation called the IEEE Industry Standards and Technology Organization (ISTO). ISTO has a legal status different from IEEE and is a separate corporation, but IEEE, Inc. is the sole member of that corporation. Apparently, ISTO holds the rights to make use of the IEEE's name and logo. In a recent case, ISTO created a program that declared the existence of a standard that overlapped the interest of an existing IEEE 802 project. This specification did not arise from an accredited process and, therefore, lacked the openness, broad review, and other checks and balances that give IEEE standards their wide credibility. IEEE entities have insisted that ISTO cease referring to its specifications as "standards." Some individuals have expressed concern that the casual attachment of the IEEE name and logo to corporate products is akin to a paid endorsement that will diminish the stature of IEEE. This issue, yet unresolved, is a clear indication of the potential conflict between consortia and traditional SDOs.

Development Costs

Developing a standard is expensive. The costs do not flow through the standardization group, which generally collects income only to pay meeting expenses. However, the participants themselves take on large travel expenses, and even these pale by comparison to the labor costs of preparing and documenting proposals, studying documents, and so forth. Individuals and their employers or other sponsors have apparently found this worthwhile, for they continue to invest their time.

Expensive work, such as validation by simulation or measurement, can sometimes be difficult for single individuals or companies to justify. This sort of work can sometimes be effectively carried out in within a consortium.

Publication Costs

Standards can be expensive to purchase. For example, the set of IEEE 802.11 standards in electronic format sells for $346 to IEEE Members. For companies intending to implement the standard, this is not a major expense. However, the cost limits the availability of the documents. Generally, as in IEEE publications, the authors would prefer easy or free distribution, while the publishers need to recoup costs. With IEEE standards, the costs are nontrivial. For instance, the editorial work done by IEEE staff project editors has a major impact on quality control. On the other hand, working groups generally prefer ready availability. For example, standards can form excellent educational materials, but prices are prohibitive for classroom use and, in some cases, even research work. Since IEEE copyrights all draft standards, even these have limited distribution (although they are sometimes offered for sale at fairly low prices, and the sponsor ballot process provides them for free).
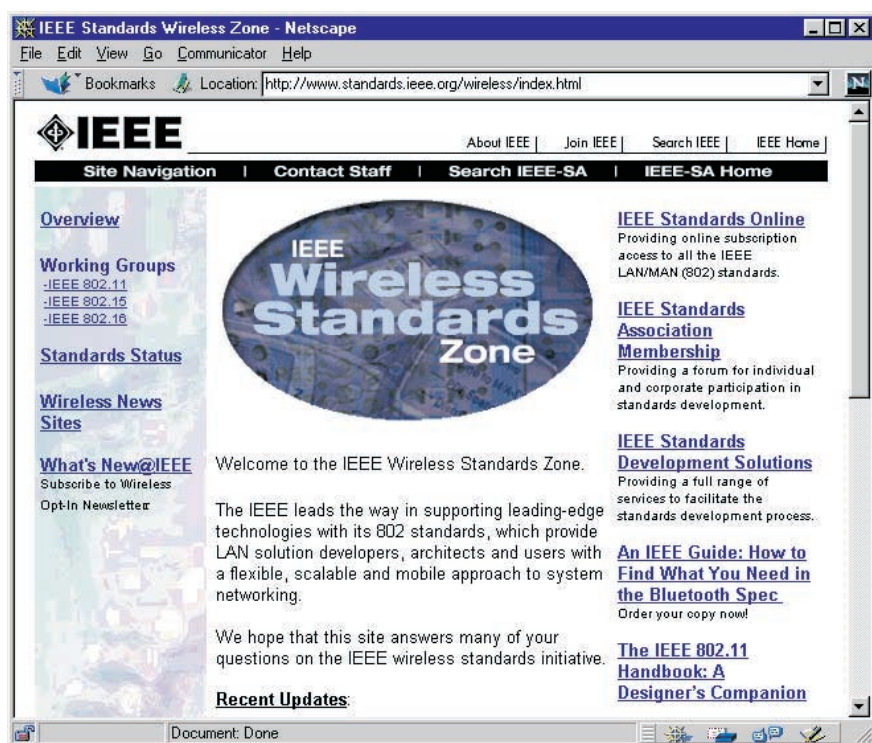
This is a continuing issue that development groups are addressing. For example, IEEE 802 is attempting to arrange a process for limited free distribution of standards in which IEEE costs are subsidized directly by developers of the standards. This is an extra burden on those who already shoulder the significant costs of development, but most of the participants seem willing to make the contribution if it will result in better access to the standards.

Followup

Post-standardization activities can be important to the market success of a standard. For example, compliance testing is required to ensure that products intended to be built to an interoperability standard are actually interoperable. They might not be, for a number of reasons:

- Ambiguity in the standard
- Failure to correctly implement the standard
- Different choices of options.

By building confidence in interoperability, compliance testing aids in

market acceptance. IEEE Standards groups themselves have not been effective at running compliance tests, possibly because of the costs involved. Some groups have considered writing test specifications as part of the standard; in principle, this is a task for which a working group is well suited. Implementation in the case of IEEE Standards is generally left to an outside group. A good example is the Wireless Ethernet Compatibility Alliance (WECA), which sponsors interoperability testing for IEEE 802.11b Wireless LAN parts. WECA specifies a particular set of options within the standard and awards a WECA-controlled logo to compliant devices. The existence of this program seems to have greatly contributed to the success of the 802.11b standard in the market.

Internationalization

Many IEEE standards are intended for international use. In the past, IEEE has encouraged the acceptance of IEEE standards as U.S. National Standards through ANSI. Through ANSI's role in the International Standards Organization (ISO) and sometimes jointly with the International Electrotechnical Commission (IEC), the original IEEE Standards have subsequently become certified as international standards. Because of the open, thorough, and deliberate IEEE process, IEEE standards have been widely accepted in the international arena.

Recently, with the move toward globalization, many IEEE groups have moved to establish direct relationships with international organizations such as ISO, IEC, and the International Telecommunications Union (ITU). This may make for more rapid and efficient internationalization. Indeed, true globalization appears to favor groups such as IEEE that develop consensus standards in an open, global, technical environment and then bring the results to the somewhat more political international bodies for final approval.

How to Participate

There are many ways to participate in making IEEE standards. Take a look at the Web site of the IEEE Standards Association, http://standards.ieee.org. While there, consider joining the IEEE-SA, as

other MTT Society members have done (232 of those memberships were as of February 2001). You'll also see listings of projects with links to further information; for instance, you can find IEEE and its working groups at http://ieee802.org.

The typical working group philosophy on participation is something like this:

- You are welcome to participate. Understand that this will require an effort.
- You are welcome not to participate. You should decide whether your participation is worthwhile to you.
- You are not expected to sacrifice your individual interests for the benefit of the group. The group will seek commonality among individual interests and channel the results for the benefit of the participants and the economic and social fabric.

A recent formal survey of participants of IEEE Standards development activities helps to illustrate the level of interests in different process steps. Here are some sample results, including only the two highest levels of interest:

- How valuable to you is participating in IEEE standards working groups developing standards? Highly valuable: 55%; Valuable: 43%
- How valuable to you is participating in writing specific portions of IEEE Standards? Highly valuable: 31%; Valuable: 52%
- How valuable to you is balloting on IEEE standards projects that impact your company and industry? Highly valuable: 55%; Valuable: 40%.

Here are some specific ways to get involved.

Buy and Read a Standard

Buying and reading a standard is a great way to learn about a technical area. It's a great background for further technical work in a field. As a side benefit, you'll develop a better understanding of what a standard is.

Follow a Working Group Using the Internet

Many of the working groups have an active Web presence. Some contain

hundreds of documents and hundreds of megabytes of data. These can be popular sources of technical information as well as of organizational documents, such as meeting calendars and minutes. For example, the IEEE 802.16 Web site, http://WirelessMAN.org, received over 2.8 million file requests in the year 2000.

Many of the groups maintain active email reflectors (mailing lists) for administrative announcements or technical discussions. Often, these reflectors are open to subscription, and, in some cases, the archives are readily accessible.

Attend a Meeting

Meeting frequency varies widely. Many IEEE 802 working groups hold week-long meetings six times per year; other groups may meet annually or irregularly. Although a travel-free development program would appeal to many people, meetings remain a key element in development and a good forum for making decisions. For a productive first meeting, use your observation skills to pick up the group's process and culture and detect the key technical issues. Also, try to learn some names and faces. You'll find that most groups welcome new participants, and even the established groups often have a high turnover rate. You might gain influence in a group quickly, but you need to be prepared. Read the minutes of previous meetings and study the documents in advance. Unless you offer a fresh viewpoint, you may try the patience of a group if you frequently open up issues on which consensus has already been reached. Also, keep in mind that standardization is about finding commonality. Attract people to your ideas with sound technical arguments. Assertions of authority or pure marketing presentations are readily detected and will be counterproductive to your aims.

Contribute Documents or Comments

Many working groups will issue a call for contributions inviting input to be considered at an upcoming meeting. These groups seek a wide range of viewpoints. If you have an idea and docu-

ment it, it will be considered, even if you are a new participant or from a small company. The IEEE 802 rule that working group membership belongs to individuals, not to companies or institutions, helps to reinforce the notion that people participate as professional experts. Perhaps as a result, the IEEE Standards process, compared to other systems, seems to be driven less by the demands of large corporations.

An excellent way to get quickly involved in a group is to respond to a call for comments, in which a groups invites comments on a draft. Such a "call" could be part of a letter ballot or could be issued before the letter ballot stage. Many new participants have quickly become an integral part of a group by studying a reading, submitting specific change recommendations with sound reasons, and attending the meeting to discuss their suggestions. Attendance is optional if the documentation is clear, but, to convey your points and get to know the interests and concerns of the group members, attendance definitely helps.

The greatest barrier to submitting comments may be the lack of availability of the draft due to its copyrighted status. In some cases, drafts are provided only to members. Generally, though, IEEE allows for drafts to be circulated for standardization activities. If you want to participate but are held back by lack of access to the draft, ask the working group chair for help.

Participate in a Sponsor Ballot

To participate in a sponsor ballot, you first need to join one or more ballot pools using the Web-based form at http://standards.ieee.org/db/balloting/ballotform.html. When relevant drafts are ready, you will be invited to join the ballot group. This is where your IEEE membership comes in handy, since you can easily upgrade to membership in the IEEE-SA and thereby be entitled to participate in ballots without a fee.

Start a New Project

Do you have an idea for a new standards project? It may be easiest to attach it to an existing organization; for example, IEEE 802.16 was begun by individuals who approached 802 with the idea of creating broadband wireless access standards. However, you can also start up something new. For microwave-specific projects, the MTT Standards Coordinating Committee can guide you in developing a project and is authorized to sponsor your PAR. Contact the Standards Coordinating chair for help.

2001 IEEE Conference on Standardization and Innovation in Information Technology

The MTT Society is sponsoring the 2001 IEEE Conference on Standardization and Innovation in Information Technology (SIIT 2001), which will be held in Boulder, Colorado, USA, on 3-5 October 2001. This is a premier world forum for exploring broadly the issue of standardization and how it relates to innovation in the technology, the economy, and society. SIIT 2001 is organized by the International Center for Standards Research at the University of Colorado. See the Web site, http://www.siit2001.org, for details.

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