

Wireless Personal Area Networks: An Overview of the IEEE P802.15 Working Group

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Wireless personal area networks will proliferate early in the millennium and the IEEE P802.15 Working Group for Wireless Personal Area Networks (WPAN's) will provide the leadership in the IEEE 802 Standards Committees to establish open standards for these WPAN's. The IEEE P802.15 Working Group for WPANs will develop Wireless Personal Area Network standards for short-range wireless networks. The Working Group is cognizant of emerging industry specifications, viz., Bluetooth™, HomeRF™, etc. and realizes that it is important to build on the work of these groups as they enjoy significant market interest and industry participation. One of the primary motivations for this Working Group is to ensure the best use of a shared medium. The Authors believe that the IEEE 802 Committee provides the best forum for the development of consensus open standards and that this process will provide for rock-solid, market-accepted WPAN technologies.

Introduction

In March 1999 the IEEE 802 Local and Metropolitan Area Network Standards Committee formed a new Working Group to develop communications standards for Wireless Personal Area Networks for portable and mobile computing devices. Portable and mobile computing devices are defined as unobtrusive computing devices, networking devices, software and peripherals which are worn or carried by individuals to enhance their ability to perform productive work as well as provide entertainment.

The new group is designated Project 802.15 Working Group for Wireless Personal Area Networks (WPANs). The Standards created by P802.15 will address the requirements for wireless personal area networking of a new class of computing devices. This class, collectively referred to as pervasive computing devices includes, PCs, PDAs, peripherals, cell phones, pagers and consumer electronic devices to communicate and interoperate with one another.

During the first nine months of its existence, the P802.15 Working Group established close working relationships with Special Interest Groups such as Bluetooth™ and Industry Consortia namely HomeRF™. The Working Group is also soliciting industry input, in general, on market requirements and technical solutions for WPANs with 0 to 10 meter range. A variety of data rates from substantially less than 1Mbit/s to in excess of 20 Mbits/s are being con-

sidered. Maintaining low power consumption, small size (less than 0.5 cubic inches) and low cost relative to target device are primary considerations. The goal is to create a standard or series of standards that have broad market applicability and deal with the issues of coexistence and interoperability.

The group currently has four activities underway. The first under Task Group 1 is drafting a standard based on Bluetooth™ Specification Version 1.0. Task Group 2 will develop a Recommended Practice for Coexistence. The third activity is a new Study Group chartered with determining the market need and developing a Project Authorization Request (PAR) for a High Rate WPAN standard in excess of 20 Mbits/s intended for Digital Imaging and Multimedia applications. The fourth activity is a marketing effort aimed at promoting understanding of the issues and activities of P802.15

IEEE P802.15 Working Group Sponsor

The IEEE P802.15 WPAN Working Group is sponsored by the IEEE 802 Local and Metropolitan Area Network Standards Committee (LMSC). The LMSC has the basic charter to create, maintain, and encourage the use of IEEE/ANSI and equivalent ISO/IEC Joint Technical Committee for Information Technology (ISO/IEC JTC 1) standards primarily within layers 1 and 2 of the OSI (Open System Interconnect) Reference Model. The LMSC has met at least three

times per year as a Plenary body since it was formed in February 1980¹. An explicit objective since inception has been the goal of establishing international standards in JTC 1. The IEEE series of standards are known as IEEE 802.xxx and the JTC 1 series of equivalent standards are known as ISO/IEC 8802-nnn. In the IEEE 802 context "local" means campus and "metropolitan" means intra-city.

The IEEE 802 LMSC is sponsored by the IEEE Computer Society and submits standards through the IEEE Standards Association. The IEEE Computer Society is the oldest and largest association of computer professionals in the world. It offers its 100,000 members comprehensive program of publications, meetings, and technical and educational activities, encouraging an active exchange of information, ideas, and innovation. The society is the world's leading publisher of technical material in the computing field. Headquartered in Washington, DC, the society serves its members from offices in Los Alamitos, California, USA; Tokyo, Japan; and Brussels, Belgium.

The Need for Standards

In the last few years, the communications industry has witnessed explosive growth in mobile computing and related communications areas. The fact that the Bluetooth™ SIG has over one thousand four hundred (1,400) Adopter companies further amplifies the directions that will be taken by the users and manufacturers of mobile technologies over the next few years. As the community of users of mobile computing devices for business continues to grow and the variety of such devices proliferates, the need for standards becomes obvious. This community is and will be driven by the need for mobile communications in service industries, maintenance and training organizations and a very mobile work force, as well as a whole host of other applications. The user community will be demanding standards-based technologies because they will likely result in:

- Multiple suppliers of the technologies and services to enhance competition
- Cost-effective devices, services and implementation

¹IEEE 802 celebrates its 20th anniversary this year. The IEEE 802 Local and Metropolitan Area Network Standards Committee has the basic charter to create, maintain, and encourage the use of IEEE/ANSI and equivalent IEC/ISO JTC 1 standards primarily within layers 1 and 2 of the OSI (Open System Interconnection) Reference Model. The committee has met at least three times per year as a Plenary body ever since it was formed in February 1980.

Bluetooth Special Interest Group

The Bluetooth technology is a specification for small form factor, low-cost, wireless communication and networking between PCs, mobile phones and other portable devices. The Bluetooth Special Interest Group (SIG) is driven by the common goal of revolutionizing connectivity for both personal and business mobile devices. Formed in May of 1998, and having grown faster than any other wireless specification to over 1,400 members, the Bluetooth SIG is led by a nine-company Promoter group including 3Com Corporation, Ericsson, IBM Corporation, Intel Corporation, Lucent Technologies, Microsoft Corporation, Motorola Inc., Nokia, and Toshiba Corporation. By working together, the Promoter group companies will combine their respective skills to help drive the program forward as Bluetooth enabled products come to market. For more information and specifications, please visit <http://www.bluetooth.com/> or see "Bluetooth: Vision, Goals, and Architecture," Mobile Computing and Communications Review, Vol. 2, No. 4, October 1998.

- Open systems for interoperability, and ease of use
- Standard interfaces
- World-wide regulatory acceptance of standards-based technology

These benefits clearly demonstrate the need for standards in an environment that faces growth patterns that may even exceed that of the cellular phone market.

Personal use of mobile computing technologies will also likely witness explosive growth. Interoperability between mobile computing devices in a nomadic society will be critical. Laptops, cell phones, palmtops, and similar "wearable" technologies enhance productivity and will provide seamless communications for the public. These factors support the need for standards for the WPAN that will provide the basis for the network connectivity required to enable highly mobile services. In fact, these thoughts provided the impetus to initiate the activity to develop IEEE standards for the WPAN.

History of the Evolution of IEEE P802.15

The chain of events leading to the formation of IEEE P802.15 began in June 1997 when the IEEE Ad Hoc "Wearables" Standards Committee was initiated by one of the Authors [RCB] during an IEEE Standards

Activities Board (SAB) meeting. According to Braley, the purpose of the Committee was to “encourage development of standards for wearable computing and solicit IEEE support to develop standards.” The consensus recommendation to Braley from the SAB meeting was that he should take his request to encourage such standards development to the IEEE Portable Applications Standards Committee (PASC).

During the PASC Plenary Meeting in July 1997, an IEEE Ad Hoc Committee was assembled (17 attendees) to discuss “Wearables” Standards. The Committee identified several areas that could be considered for standardization, including short range wireless networks or Personal Area Networks (PANs), peripherals, nomadicity, wearable computers, and power management. Of these, the committee determined that the best area of focus was the Wireless PAN because of its broad range of application. The IEEE Ad Hoc “Wearables” Standards Committee met twice more - once in December 1997 and again in January 1998. During the January 1998 meeting it was agreed that the 802 LAN/MAN Standards Committee (LMSC) was probably a more suitable home for the groups activities, especially with a PAN focus. Two delegates were sent to the IEEE P802.11 Interim Meeting, that was taking place that same month, to get reactions and to gain support for the proposal. At that meeting it was agreed to propose the formation of a Study Group under P802.11 at the March Plenary of 802. A WPAN Tutorial was organized to socialize the idea within 802. The result was that in March 1998, the “Wearables” Standards Ad Hoc Committee under PASC became the IEEE P802.11 Wireless Personal Area Network (WPAN) Study Group within LMSC with the goal of developing a Project Authorization Request (PAR) for the development of a WPAN standard.

At the time the Study Group was formed, there had been no other publicized initiatives in the WPAN space other than the Infrared Data Association’s IrDA specification. IrDA’s line-of-sight restrictions do not allow it to adequately address the problem. By the time the work of the Study Group concluded, a year later, both the Bluetooth™ Special Interest Group and HomeRF™ were active in developing WPAN specifications. By March 1999, when the Study Group and P802.11 submitted the PAR to the 802 Executive Committee for approval, Bluetooth™ had over 600 adopter companies and HomeRF™ had over 60. Because of the significance of these groups in the WPAN market space, it was felt that the standards development process would be better served if a new Working

Group were formed to address the problem rather than pursue it as a Task Group under P802.11. The PAR was approved and the new group was designated as IEEE P802.15 Working Group for Wireless Personal Area Networks.

Current Status

During the July 1999 Plenary of the IEEE 802 the P802.15 Working Group had its first session. There were sixty-three (63) attendees over the weeklong meeting and thirty-nine (39) Working Group attendees achieved Voting Member status. There are currently forty-three (43) active voting members. The Working Group meets every two months. All meetings are held in conjunction with P802.11 to facilitate communication between the two groups writing standards in the Industrial Scientific and Medical (ISM) radio frequency bands (see below).

The Draft Operating Rules of IEEE P802.15 Working Group were reviewed and approved during the July meeting. The provisional officers were elected for the balance of the term and approved by the 802 Executive Committee. A Study Group was formed to make a recommendation on how to best deal with coexistence and draft a PAR, if appropriate. A Marketing Committee was formed to advise on how to best position activities and to provide insight on what the market really wants. Finally, a Task Group was formed to begin the work of rapidly developing the first draft standard. The Task Group, designated Task Group 1 (TG1), was formed as a direct result of a Bluetooth™ Special Interest Group submission.

At the November IEEE 802 LMSC 1999 Plenary, the Working Group voted to submit the Bluetooth™-based draft standard from TG1 to Working Group Letter Ballot. The Coexistence Study Group PAR was approved by the 802 Executive Committee and has been forwarded to the IEEE New Standards Committee for final approval. The new Task Group will develop a Recommended Practice for Coexistence of applications using the ISM bands. Also at this meeting, a new Study Group was formed to look at High Rate WPANs. The new group will quantify the market requirements and, if warranted, draft a PAR to begin development of a draft standard to address the unique requirements of WPANs for digital imaging and multimedia applications.

At the January 2000 IEEE P802.15 Interim Meeting the results from the first Working Group Electronic Letter Ballot were discussed and the resultant Draft Comment Resolution was begun in earnest.

This TG1 Letter Ballot 1 was for our first Standard; P802-15 Draft 0.6. The motion to submit to IEEE Sponsor Ballot failed with a tally of 18/15/2/7 (Yea/Nea/Abstain/Fail) or 54.5% approved and 75% was needed to pass. LB1 yielded 1013 comments to be resolved against Draft 0.6 of which 193 were Technical Comments and 818 were Editorial Comments. The latest information is available at: <http://grouper.ieee.org/groups/802/15/pub/LB1/LB1.html>.

At the March 2000 IEEE 802 LMSC Plenary, it is expected that the Working Group will seek approval for the formation of a High Rate Task Group, continue work on the Bluetooth™ based draft standard, and conduct a Call for Interest for a low rate, ultra low cost WPAN.

Base WPAN Requirements

The P802.15 Task Group 1 (TG1) Functional Requirements have converged to coincide with the Bluetooth™ Specification. An overview of these requirements is provided below.

With the exception of speed and primary usage model, many of these requirements are shared with the proposed High Rate activity.

Personal Area Networks

A Personal Area Network (PAN) is distinguished from other types of data networks in both size and scope. Communications in PANs are normally confined to a person or object that typically extends up to 10 meters in all directions and envelops two or more objects or persons whether stationary or in motion. The term Personal Operating Space (POS) is also used interchangeably with PAN.

This is in contrast to Local Area Network (LAN), Metropolitan Area Network (MAN), and Wide Area Network (WAN) which are moderately sized geographic area, such as a single building, campus, city, or that may interconnect facilities in different parts of a country or of the world.

Wireless Personal Area Network

A Wireless Personal Area Network (WPAN) is a wireless ad hoc data communications system that allows a number of independent data devices to communicate. The worldwide 2.4 GHz ISM band is the frequency of interest for WPANs because of its general availability worldwide and its suitability to low cost radio solutions. It is noted that there are efforts at harmonizing

the spectrum allocation such that there is a minimum of 83.5 MHz bandwidth worldwide.

An ad hoc (a.k.a Piconet) network is a network composed solely of stations within mutual communication range of each other via the wireless medium. A Pico network is typically created in a spontaneous and unobtrusive manner. The principal characteristic of a Piconet network is its limited temporal and spatial extent.

These limitations allow the act of creating and dissolving the Piconet network to be straightforward and convenient. This allows it to be achievable by non-technical users of the network facilities. These users typically have no specialized 'technical skills'. It is required that the be able to function with little and/or no investment of time or additional resources required beyond the stations which are to participate in the WPAN network.

Distance

WPANs are capable of operating over an area up to 10 meters in diameter. To support other uses, for example the home environment, the PAN can extend the range (up to 100m). This is accomplished primarily by choosing 0dBm or +20dBm Modules.

Why Not P802.11?

In June, 1997, the IEEE Standards Board approved the IEEE P802.11 Standards for Wireless Local Area Networks (WLAN's). As indicated earlier in this article, the IEEE P802.11 WPAN Study Group was sponsored by P802.11 because it seemed to be the most natural fit at the time, based on the knowledge base of the members. However, as a result of the Ad Hoc Committee activities and the ensuing activities of the WPAN Study Group, it became apparent that a new Working Group would be required. In the paragraphs to follow, the rationale for not selecting the IEEE P802.11 Standard for WPAN's will be presented.

As noted in the previous section, the WPAN requirements that resulted from numerous SG meetings and Calls for Applications clearly are intended for shorter range, lower data rates, and are more severely impacted by power consumption. After numerous efforts to develop an acceptable technical approach for the WPAN Standard, the Protocol Implementation Conformance Statement (PICS) was reviewed with the intent of making acceptable modifications to satisfy the WPAN requirements and still remain within the P802.11 Working Group. Even with the reduction of MAC sublayer protocol capabilities and PHY

layer capabilities, it was concluded that the P802.11 WLAN Standards would not be acceptable for WPAN standards. There continues to be on-going discussions regarding an P802.11 Lite version that may be acceptable for WPAN's. If such a standard is forthcoming, and is determined to be acceptable to P802.15, then it could be introduced via PAR and considered for standardization.

The Authors note that in the WPAN Study Group investigation of the P802.11 MAC sublayer, as it applies to WPAN applications, the Authors were advised that a number of changes to the P802.11 MAC sublayer needed to be made. Specifically:

- Providing stations with the ability to rotate the Access Point responsibility, including a mechanism that will recognize when an Access Point is lost
- Adding power management modes to the Access Point
- Removing the Request To Send/Clear To Send handshake
- Significantly slimming the Management Information Base, and
- Eliminating support for Independent Basic Service Set

These changes would extend the current capabilities of P802.11 and simplify the implementation of P802.11 stations. However, the Authors are not aware of any submissions to the P802.15 Working Group from P802.11 Working Group.

In conclusion, it is essential that mobile computing devices be as power efficient as possible. This is consistent with the short range requirement for WPAN and many other characteristics. The evaluation of the WPAN Study Group clearly implied to the Study Group leadership that IEEE P802.11 was not the correct solution for WPAN, and as a result the request was made to move along a different path that resulted in the formation of the IEEE P802.15 Working Group.

Coexistence and Interoperability Issues

The issue of coexistence is one of the more vexing problems that must be addressed when dealing with a shared medium such as an ISM band. In a wired environment or in a licensed Radio Frequency band, there is only a single use. The issue is one of interoperability which will be discussed in more detail later.

In ISM bands both Primary and Secondary uses are allowed. Secondary uses are unlicensed, but must follow certain rules e.g., FCC 47 C.F.R. Part 15, etc. relating to total radiated power and the use of spread spectrum modulation schemes. Interference among the various uses is not addressed as long as the rules are followed. The attractiveness of operation in an ISM band is the fact that no license is required. The downside is the fact that the bands must be shared and potential interference tolerated.

Under normal circumstances, interference is not a major problem. The spread spectrum and power rules are fairly effective in dealing with multiple users in these bands provided the radios are physically separated. Multiple uses, including self-interference of multiple users of the same application, have the effect of raising the noise floor in the band resulting only in some degradation of performance. When the radios of different applications are operating in the same band and are in close proximity, the picture is somewhat different. Transmitters close to other receivers can easily saturate the receiver front ends effectively shutting down operations.

Because of its almost global availability, a popular band for WPANs is the 2.4 GHz ISM band. Microwave ovens are a primary user of the band at 2.45 GHz. In addition, P802.11 has standards for WLANs operating in this band, and HomeRF™, Bluetooth™ and several cordless phone manufacturers are planning to operate there as well. With modest physical separation of the radios, initial studies indicate that all these applications can coexist with some degradation in performance. However, a major problem arises because P802.11 devices, HomeRF™ devices and WPAN devices will likely all come together in a Laptop and may come very close together at a desktop. Without some careful planning things will not work forcing the marketplace to weed out solutions that have not adequately addressed the problem. Within 802, addressing coexistence between P802.15 WPANs and P802.11 WLANs has been mandated by the Executive Committee of the LMSC.

At a different level is the issue of interoperability. There are two classes of interoperability. The first is 'intra-standard' interoperability. It is important that two devices that conform to the P802.15 standard interoperate with one another at the Physical Layer. The second is 'inter-application' interoperability. It may also be desirable to have WPAN and WLAN or other devices interoperate at some higher layer. The issues of coexistence and interoperability are related as shown in Figure 1.

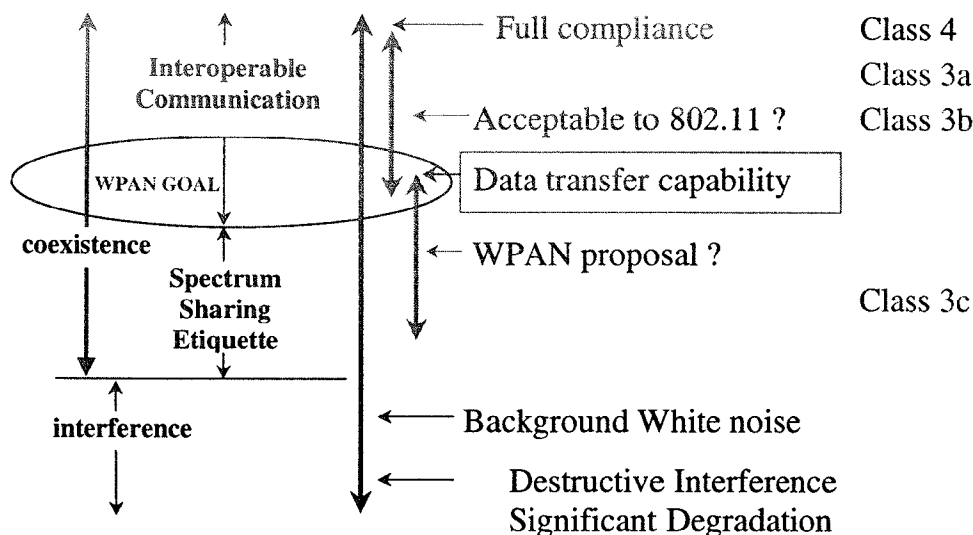


Figure 1: Coexistence/Interoperability Continuum

The various classes of interoperability are defined in the bulleted list below.

- Class 4 - Full Compliance to the P802.11 MAC & PHY PICS
- Class 3 - Partial Interoperability: there is a way on the medium to exchange data without an intermediate device
 - Class 3a Transmit and Receive
 - Class 3b Receive Only
 - Class 3c Detect Energy
- Class 2 - Bridge-like (1 MAC/2 PHYs)
- Class 1 - Gateway-like (> 1 MAC)
- Class 0 - Non Interoperable

Devices that interoperate can coexist since they are able to exchange information and are aware of the others operation. The degree of coexistence is dependent on the degree of interoperability. Fully interoperable implies the highest degree of coexistence. At a basic level, energy detect, or listen-before-talk is more etiquette oriented and permits close proximity coexistence at reduced performance levels. In the absence of more effective schemes, the default would be to let an application deal with the problem at higher layers, but this is sure to be performance inefficient.

Bottom line, coexistence is an issue that must be dealt with especially when the Authors consider the number of embedded platforms like cell phones, laptops, PDAs, and pagers that will contain a successful

WPAN standard and the likely proximity of these devices to WLANs and home networks.

In an effort to deal more effectively with the problem, P802.15 has completed work on a coexistence Project Authorization Request and is in the final stages of approval to form a Task Group on Coexistence within P802.15. The goal is to create a series of reports describing the impact of a WPAN on a WLAN in the same vicinity, and visa versa and to develop a Recommended Practice for both the WPAN and WLAN to maximize coexistence.

When the Coexistence Study Group was formed in P802.15 during the July 1999 Plenary, the Study Group motion read: "To approve the formation of a Study Group within P802.15 to determine the need and if warranted, develop a PAR on coexistence for submission to the SEC by the November 1999 Plenary." This has been done. The Authors believe that the resulting Task Group could be the vessel to recommend a set of recommended practices for reducing the probability of interference in the 2.4 GHz general unlicensed band.

Here are the various types of Standards Documents:

- Standard – mandatory (shall)
- Recommended Practice – suggested procedures (should)
- Guide – guidelines (may)

The Task Group recommendation should be considered as a submission to the leading world Regulators e. g., FCC, CEPT, MPT, etc. and/ or an IEEE Recommended Practice.

Existing Options for Standardization

The IEEE P802.15 has been reviewing Industry as well as Standards based solutions to try and not reinvent any wheels. To that end, the Authors have conducted numerous calls to actively solicit proposals as well as applications to help us identify candidate radio transmission technologies.

During the First Call For Proposals, May 1998 to March 1999, the IEEE received five (5) submissions - May 1998: GTE Technology Organization, Intermec Technologies Corporation, M/A-COM, Inc. Proposals. July 1998: Motorola, Inc. Proposal. January 1999: Eastman Kodak Company Proposal. During the Second Call For Proposals, June 1999 to July 1999, the IEEE received one (1) submission - Bluetooth™ Special Interest Group. [Authors note: AmeriSys, Inc. provided an "application" proposal however the frequency of interest was 13.56 MHz and did not meet the WPAN Requirements. A WPAN-LR (Low Rate) Study Group is likely to evolve from this and other low rate applications.]

Additionally, the Authors are aware of WPAN interests in the IEEE P802.11 as well as external to IEEE e.g., AmeriSys, Inc. HomeRF™ WG, Personal Electronic Devices Inc. and XETRON Corporation.

The IEEE P802.15 also conducted a Call For Applications, July 1998 to November 1998, which provided eight (8) submissions - September 1998: Federal Express Corporation, The Boeing Company, Personal Electronic Devices Inc., Symbol Technologies Inc., Texas Instruments Inc. Applications. October 1998: Eastman Kodak Company Application. November 1998: AmeriSys, Inc. Application.

To deal with the introduction of additional WPAN draft standard submissions to the Working Group such as a "low rate" or "high rate" WPAN standards, the WG anticipates using the following nomenclature: (1) "WPAN" (Task Group 1 a Bluetooth™ derivation), (2) WPAN-Low Rate or "WPAN-LR", and WPAN-High Rate or "WPAN-HR". These terms will help differentiate the multiplicity of standards that the Working Group will entertain.

Selection of Bluetooth™ as The First P802.15 Standard

As noted in the previous section, and at the end of the Second Call For Proposals, the P802.15 Working Group received only one response - Bluetooth™ Special Interest Group.

One of the major goals for the IEEE P802.15 as well as for Bluetooth™ is global usage. While

the WLAN technologies are specifically designed for devices in and around the office or home, a WPAN/Bluetooth™ device will travel from country to country, be used in cars, airplanes, boats and is truly designed for international use.

Because of this, much of the Bluetooth™ technology is focused on a single standard that meets the world-wide regulatory requirements that fall into two categories: spectrum/power and security. As the radio link will contain private business and personal data/voice, security is a requirement for this. As security is heavily regulated world-wide, the technology has to conform or work with the various world wide agents to insure it meets these requirements.

In regards to spectrum and power, the technology needs to travel with the user. Unlike a typical WLAN, that is setup in one area and never moved, mobile devices travel with the users. As such the technology needs to be designed such that a single technology meets the spectrum power requirements of the world (don't want to break the law when crossing a border).

These areas are key attributes of Bluetooth™ (which was designed for this personal area networking) which the Authors don't believe are addressed in the variety of WLAN devices.

Specifically, the Bluetooth™ Special Interest Group intends to submit their Specification for use by the IEEE P802.15 Working Group to develop the P802.15 technology. It is the desire of the Bluetooth™ SIG that the IEEE P802.15 standard maintain compatibility with Bluetooth™ specification in order to:

1. Prevent consumer and user confusion that could result from non-interoperable specifications, and
2. Provide a mechanism to test interoperability between Bluetooth™ and P802.15 solutions by maintaining appropriate testing interfaces.

The Bluetooth™ v1.0 Foundation specification was made publicly available on July 26, 1999. The v1.0 specification includes an official "Bluetooth™ Specification v1.0 Foundation Core" and "Bluetooth™ Specification v1.0 Foundation Profiles." The Bluetooth™ Specification v1.0 Foundation Core provides the details for creating products using the Bluetooth™ radio architecture. Where as, the Bluetooth™ Specification v1.0 Foundation Profiles provides the guidelines for ensuring interoperability between devices enabled with the Bluetooth™ technology.

The IEEE has signed a limited, non-exclusive, non-transferable license from the Bluetooth™ SIG to adopt

or adapt and copy a portion of the Bluetooth™ Specification to be used as base material in the IEEE Standards Project P802.15, on the condition that the IEEE P802.15 standard is:

- 100% compatible with the Bluetooth™ v1.0 Foundation Specification (as measured by a certified Bluetooth™ test house)
- Maintains and requires inclusion of Bluetooth™ testing interfaces as described in the current Bluetooth™ specification (to allow interoperability testing between Bluetooth™ and P802.15 compliant solutions)
- Any P802.15 extensions (beyond Bluetooth™ v1.0 specification) must not break interoperability with existing Bluetooth™ v1.0 certified radios and be approved by the Bluetooth™ SIG Promoters.

Therefore, the selection process was the Second Call For Proposals and the act of submitting a draft standard to the IEEE P802.15 was the first step in the IEEE standardization process.

Conclusions and Future Directions

Wireless personal area networks will proliferate early in the next millennium and the IEEE P802.15 Working Group for Wireless Personal Area Networks (WPAN's) is providing the leadership in the IEEE 802 Standards Committees to establish open standards for these WPAN's.

The first Standard derived by P802.15 from the Bluetooth™ v1.0 Foundation Specification is addressing the requirements for Wireless Personal Area Networking (WPAN) for a new class of computing devices. This class, collectively referred to as pervasive computing devices includes, PCs, PDAs, peripherals, cell phones, pagers and consumer electronic devices to communicate and interoperate with one another. The Authors anticipate that this standard will be approved by the IEEE Standards Board on or before December 2000. Just in time for the first year of the real new millennium i.e., 2001-2100. The P802.15 Working Group is paving the way for Personal Area Network Standards that will be - **Networking the World™**.

For additional or more current information on the IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) please point your Internet browser at: <http://grouper.ieee.org/groups/802/15/index.html>

Acknowledgments

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Biographies

Dick Braley was born in Birmingham, Alabama, USA. He received his Bachelors and Masters Degrees in physics from Case Institute of Technology in Cleveland, Ohio. He is the ex-Chair of the IEEE P802.11 Wireless Personal Area Network (WPAN) Study Group, and Manager of Systems Design and Development in the Courier Technology Department at FedEx in Memphis, Tennessee, U.S.A. He initiated the WPAN standards development activity within the IEEE in 1997 and has played a key role in championing the WPAN efforts within the P802.11 Working Group.

Ian Gifford was born in Framingham, Massachusetts, USA. He received a Bachelors in Economics from Boston University, Boston Massachusetts, USA, in 1981. He is Vice Chair of the IEEE P802.15 Working Group for WPAN and Director of Standards at M/A-COM, Inc., a Tyco Electronics Company, in Lowell, Massachusetts, USA. For the past 15 years he has worked on wireless solutions for wide area, local area and personal area networks.

Bob Heile was born in Chicago, Illinois. He received his PhD in Physics from The Johns Hopkins University, Baltimore, Maryland in 1973. He is Chair of the IEEE P802.15 Working Group for WPANs and Director of Wireless Opportunity Development with GTE's Technology Organization, in Waltham, Massachusetts. He was Vice Chair of the P802.11 WPAN Study Group leading to the formation of P802.15. For the past 15 years he has worked on wireless solutions for wide area, local area and personal area networks.