IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	**WNAN 5C**	
Date Submitted	[TBD]	
Source	[Phil Beecher]	E-mail: [pbeecher@ieee.org]
Re:	5 Criteria accompanying the WNAN PAR document	
Abstract	[During the July 2008 IEEE 802 Plenary the IEEE P802.15 Working Group adopted the recommendation of the Neighborhood Area Networking Interest Group (IG-NAN), and formed the Wireless Neighborhood Area Network Study Group (SG-NAN), with the goal to create a Project Authorization Request for a WNAN standard effort. This document contains the 5 criteria to accompany the PAR document developed by the Study Group.]	
Purpose	[This document is supporting the submission of the PAR to the P802.15 Working Group]	
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IEEE P802.15 Low Rate Wireless Personal Area Networks Study Group Functional Requirements Standards Development Criteria

The Study Group for Wireless Neighborhood Area Networks (WNAN) reviewed and completed the required IEEE Project 802 Functional Requirements, Standards Development Criteria (a.k.a. the Five Criteria). The IEEE 802.15 WPAN Five Criteria response is in Italics below.

1. BROAD MARKET POTENTIAL

a) Broad sets of applicability

There is a large and rapidly growing demand for wireless utility network applications, with potential to grow to billions of networked devices in the near future. The utility industries are currently adopting solutions based on proprietary wireless technology. The industry has recognized the need for standards-based solutions to ensure an orderly, rapid and cost effective deployment of utility wireless networks. The need for standardization has been recognized in the recently passed energy legislation by the U.S. congress (EISA 2007; Energy Independence & Security Act of 2007), which calls on National Institute of Standards and Technology (NIST) to work with the U.S. standards bodies to develop protocols and standards for the smart-grid network. In the European community, the need is no less urgent and similar standardization mandates are in process worldwide.

Further, there is application synergy with industrial and home automation (Home Area Networks) applications built on 802.15.4, and very large industrial applications that will benefit from the characteristics of the proposed PHY and MAC specifications, broadening the appeal of 802.15.4 based solutions.

Examples of applicable industries include utility (power, water, gas) industry and other large scale distributed process control applications.

With an effective wireless standard, geared to this class of applications, the market potential is huge, with billions of devices. As described in presentations made at the IG-NAN meetings, one US utility alone is planning to spend several billions of dollars in the next three years to deploy smart-grid networks (reference: 15-08-0455-00-0000, Chris Knudsen, July NAN Tutorial). Similarly, large markets are identified in Asia (reference: 15-08-0506-01-0nan, Hoyong Kang et. al.) and elsewhere. Additionally, synergies with home area networking and the industrial markets will open new market opportunities for technologies built on 802.15.4.

Wireless capability is essential to achieving the full market potential; standardization will reduce costs and improve functionality to the industry and the consumers they serve, and contribute significantly to creating better energy solutions world-wide.

b) Multiple vendors and numerous users

The number of participants and breadth of participation of the NAN Study Group demonstrates significant interest in this class of networks. Members in the Interest Group and Study Group include industry leaders, government researchers, academic researchers, semiconductor manufacturers, system integrators, technology providers and end users.

There are at least 10 semiconductor manufacturers providing semiconductor solutions for 802.15.4, several of whom are participating in the NAN Interest Group and Study Group and already provide non-standard silicon solutions for the NAN application spaces. The NAN Interest Group tutorial held in Denver in July 2008 was attended by well over 100 participants. More than 40 participants responded to the call for interest in participating in the NAN standardization activity.

The target user base will be large as indicated by the growing demand for wireless connectivity in almost all devices. Technology adoption is being driven by private industry, consumer demand, government mandates and the current global energy environment.

Importance of the need for a standard for smart-grid networks is recognized in the recently enacted Federal Energy Legislation by the U.S. Congress (Energy Independence and Security Act of 2007), wherein the National Institute of Standards and Technology (NIST) has been charged with the responsibility to work with industry standards bodies such as IEEE to develop inter-operable smart-grid network standards. In the European community, the need is no less urgent and similar standardization mandates are in process worldwide.

c) Balanced costs (LAN versus attached stations)

The proposed amendment can be implemented with connectivity costs which are a reasonably small fraction of the cost of the target devices.

2. COMPATIBILITY

IEEE 802 defines a family of standards. **All standards shall be in conformance with IEEE 802.1 Architecture, Management and Interworking. All LLC and MAC standards shall be compatible with ISO 10039, MAC Service Definition, at the LLC/MAC boundary. Within the LLC Working Group there shall be one LLC standard, including one or more LLC protocols with a common LLC/MAC interface. Within a MAC Working Group there shall be one MAC standard and one or more Physical Layer standards with a common MAC/Physical layer interface. Each standard in the IEEE 802 family of standards shall include a definition of managed objects, which are compatible with OSI systems management standards.**

Note: This requirement is subject to final resolution of corrections and revision to current ISO 10039, currently inconsistent with ISO 8802 series standards.

The MAC (Medium Access Control) Layer of the Wireless Personal Area Network (WPAN) Standard will be compatible with the IEEE 802 requirements for architecture, management, and inter-networking.

3. DISTINCT IDENTITY

a) Substantially different from other IEEE 802 standards.

The proposed amendment to 802.15.4 uniquely supports the WNAN requirements, which require different trade-offs and optimizations than the WLAN, WWAN and other WPAN standards.

The need for a standard to promote orderly and quick evolution of smart-grid networks has been recognized in the recently passed energy legislation by the U.S. Congress (EISA 2007; Energy Independence & Security Act of 2007), which calls on National Institute of Standards and Technology (NIST) to work with standards bodies (such as IEEE) to develop protocols and standards for the smart-grid network. In the European community, the need is no less urgent and similar standardization mandates are in process worldwide.

The responses received by and presented to the NAN Interest Group indicate an already large and rapidly growing market for WNAN applications that fit the objectives of 802.15, but are not satisfied by existing IEEE 802 standards.

Utility networking and very large scale industrial applications have requirements to keep infrastructure to a minimum, scale to millions of nodes across diverse geographical environments, and do so with carrier grade reliability. To reach every node in the network WNAN needs the capability to vary radio range from a few meters to 5 km LOS while providing for high spectral reuse.

Document numbers for IEEE posted Utility presentations regarding their WNAN experiences are:
a. 15-08-0245-00-wng0-utilities-view-of-smart-grid-network-needs.ppt – George Cosio/Phil Slack - FPL
b. 15-08-0297-00-0000-pg-e-smart-grid-discussion.ppt – Chris Knudsen – PG&E
These presentations document the experiences within each of the presenting utilities in their several pilots and trial installations. Discussed are a variety of technologies, wireless and wired, proprietary and standards-based. The requirements presented in the applications above are generally applicable and are not limited to the utilities that gave the presentations.

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Utility networking and very large scale industrial applications have requirements to keep infrastructure to a minimum, scale to millions of nodes across diverse geographical environments, and do so with carrier grade reliability.

The 802.11 standards have been optimized for high data rates along with support for star network topologies with centralized control.

Achieving maximum data rate in a given spectrum - as 802.11 does - is achieved at the expense of simultaneously achieving maximum range. WNAN requirements for complete ubiquity – communicating with all devices within a geographic territory – explicitly requires maximum range within existing local regulations.

Applications for WNAN further intensify the need for maximum range as many devices are located sub-optimally. An example is WNAN devices located in rural areas as at the end of electricity 'feeders' – where doubling range reduces cost by a factor of four as the area covered increases by the same factor.

802.16 standards are optimized for high data rate, point-to-point and point-to-multipoint network topologies.

Achieving maximum data rate in a given spectrum - as 802.16 does - is achieved at the expense of simultaneously achieving maximum range. WNAN requirements for complete ubiquity – communicating with all devices within a geographic territory – explicitly requires maximum range within existing local regulations. While some flexibility exists for trading data rate for range, ranges that could be accomplished with a PHY optimized for the WNAN requirement (e.g., 40 kbps), with its corresponding on-air bandwidth, are not supported.

As mentioned before, the requirements of the WNAN further intensify the need for maximum range as many devices are located sub-optimally. An example is electricity meters located in highly obstructed, high multipath locations with inflexible antenna orientation. This makes it cost prohibitive to meet the WNAN requirement of 100% coverage with 802.16.

The cost of licensed spectrum is another factor affecting WNAN system costs. Existing WNAN installations occupy unlicensed spectrum. 802.16 standards support unlicensed operation in the microwave ISM spectrum at 5 – 6 GHz. Unlicensed use of this spectrum imposes regulatory transmitter power limits while physics imposes propagation limitations – both reducing range and thus reliability in the WNAN application.

An essential requirement of WNAN is the ability to support bursty, asynchronous upstream traffic. An example of this is the need for highly responsive outage detection. Typically, when an electric meter loses mains power, a 'last gasp' is emitted. This 'last gasp' is stored in a capacitor that can hold for 300ms. The connection-oriented, TDM-based 802.16 standard is not optimized for massively bursty, low duty cycle applications (i.e., does not maintain connections to idle nodes).

An important requirement of WNAN is the ability to support peer-to-peer distribution automation applications such as groups of switch reclosers or feedback loops for volt/VAr management. Star topologies are sub-optimal in supporting distributed peer-to-peer applications.

The 802.15.4 standard is being used in utility networks today along with multiple proprietary solutions . It meets many but does not meet all the WNAN requirements. It currently does not support frame sizes of 1500 bytes in length. Error detection in 802.15.4 is currently limited to a two byte CRC which is statistically likely to pass undetected errors given the large number of packets processed daily through the WNAN network.

WNAN device densities are variable and can be quite high; urban meter densities range upward of 5000 devices per square kilometer. Much WNAN traffic is event driven (e.g., a power outage report) and thus occurs simultaneously and at high priority. The WNAN requirement is thus for the largest number of orthogonal traffic carrying channels allowed per local regulations consistent with the simultaneous requirement to provide at least 40kbps.

In order to facilitate an orderly and effective evolution of standards-based WNAN networks, this amendment to the 802.15.4 is urgently required.

b) One unique solution per problem (not two solutions to a problem).

The proposed amendment to 802.15.4 will provide a unique solution for the WNAN. This is the first standardization effort targeting the application areas identified for Neighborhood Area Networks.

c) Easy for the document reader to select the relevant specification.

The proposed amendment to 802.15.4 will be a clearly distinguishable PHY specification.

4. TECHNICAL FEASIBILITY

a) Demonstrated system feasibility

There are many existing non-standard solutions already in the market with similar PHY characteristics and MAC functionality, supported by multiple system vendors and semiconductor manufacturers. These devices and networking technologies meet the threshold requirements of the service providers and consumers. Since the demand is growing rapidly, existence of non-standard solutions is no longer desirable for an orderly and rapid evolution of this fast-growing market.

b) Proven technology, reasonable testing

There are examples of technology that exist today, which will allow design and fabrication of these radio systems. Hundreds of market trials have been conducted. Many utilities have started large-scale deployments, as was discussed by them in their presentations to the NAN Interest Group.

c) Confidence in reliability

The proposed functionality will be designed to meet relevant reliability standards. Existing products provide confidence in the reliability, robustness, and scalability of the proposed project.

A coexistence assurance document will be submitted to the 802.19 TAG.

5. ECONOMIC FEASIBILITY

a) Known cost factors, reliable data

High volume utility network applications will drive volume production and provide a low cost source of components. Existing products indicate cost targets are easily met.

b) Reasonable cost for performance

Based on test results, prototype, and production solutions, the estimates meet expected size, cost, and power requirements. The system and devices are expected to work 24/7 in rugged outdoor conditions with the highest availability.

c) Consideration of installation costs

One of this proposed amendment's objectives includes low cost installation with minimal to no operator intervention.