5 Criteria- P802.22, Revision to IEEE Std. 802.22-2011

1. Broad Market Potential

a) Broad sets of applicability

Since 2005, when the 802.22 PAR was first submitted and approved, FCC, NTIA and other regulators have broadened their horizons for cooperative spectrum sharing approaches in order to optimize spectrum utilization. For example see the PCAST Report [1] - Realizing Full Potential of Government Held Spectrum.

FCC/ NTIA are in the process of opening new spectrum bands which specifically require multi-levels of regulated users to share the spectrum utilizing cognitive radio behavior. For our purposes, we define spectrum sharing as a mechanism which ensures that primary services are protected from interference while allowing other opportunistic devices to share the spectrum.

While these new bands have been specified by the FCC for the United States, they may be different in other countries. The intention of this PAR is to align the current 802.22 technology with emerging regulations so as to provide wide sets of applications of this technology.

Wireless device manufacturers are seeking a common protocol to be used across these shared spectrum bands and for multiple applications. Hence, the aim is to change the spectrum management framework to align 802.22 to be used in these other bands. For example, 802.22 may be used in the proposed Federal radar bands (e. g. 2700 MHz – 3700 MHz) which allow spectrum sharing, since 802.22 already contains the basic cognitive radio capabilities and mechanisms that are needed to enable spectrum sharing. One other potential emerging application for 802.22 based services is cost-effective backhaul applications. Affordable access mechanisms that can provide backhaul using shared spectrum has become extremely important and necessary.

The proposed revision will enable a number of new broadband applications in bands that allow spectrum sharing such as television white spaces (TVWS) as well as newly available Government bands such as radar bands. The revision will enable 802.22 networks to be deployed to provide broadband services and monitoring applications.

b) Multiple vendors and numerous users

It is expected that this revision will be applicable in all markets where the 802.22 technology will be used. The new features of the revision are expected to bring new equipment vendors, manufacturers and users of semiconductor, personal computer, enterprise networking devices, consumer electronic devices, home networking equipment, mobile devices, wireless internet service providers etc.

2. Compatibility

The revision will be compatible with IEEE 802 family of standards, specifically 802 overview and architecture, 802.1 including 802.1AC and 802.1Q.

3. Distinct Identity

a) Substantially different from other IEEE 802 standards

The proposed standard will produce a revision to the IEEE std. 802.22-2011

The fundamental assumption behind the operation of IEEE 802.22 systems is that spectrum is shared with primary users. Hence the shared spectrum may or may not be available at all times and at all the locations. The radio will

have to automatically change its characteristics and behavior to operate in appropriate alternate spectrum as directed by the cognitive sharing mechanism (e. g. database, spectrum access system, sensing or beaconing). Hence 802.22 is highly applicable for use in bands that allow spectrum sharing such as the TV Broadcast bands and radar bands between 2700 MHz to 3700 MHz in the United States.

Some other similar projects are listed below -

a. IEEE P802.11AF: IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications - Amendment: TV White Spaces Operation

b. P802.15.4m: IEEE Standard for Local and Metropolitan Area Networks Part 15.4: Low Rate Wireless Personal Area Networks
(LR-WPANs) Amendment: TV White Space Between 54 MHz and 862 MHz Physical Layer

c. IEEE P1900.7: Radio Interface for White Space Dynamic Spectrum Access Radio Systems Supporting Fixed and Mobile Operation

Below is the summary of how the proposed Revision to the IEEE 802.22 Standard is likely to be substantially different from these on-going or completed projects:

1. No other IEEE standard supports all the three mechanisms of spectrum sharing namely, sensing, database access and beaconing. There is no other Cognitive Radio IEEE 802 standard or project, for combined broadband services and monitoring applications aimed at wireless regional area networks.

2. The IEEE 802.11 AF and IEEE 802.15.4m amendments propose carrier sense multiple access medium access control (MAC) mechanisms, whereas the IEEE 802.22 proposes time division multiple access (TDMA).

3. The IEEE 802.11 AF amendment proposes throughputs (e. g. 24 Mb/s to 384 Mb/s) that are similar to IEEE 802.22 and the P802.22b amendment, but it is generally designed for shorter ranges due to a smaller cyclic prefix, in-home and enterprise applications.

4. IEEE 802.15.4m defines PHY and MAC for low rate communications services (where throughputs range from 50 kb/s to 6.25 Mb/s) such as smart grid and machine to machine applications.

5. P1900.7 activities are still on-going with the intention to reach working group letter ballot by the end of 2014. They have two proposals for PHY, one proposing multi-carrier modulation and the other proposing direct sequence spread spectrum (DSSS). The group is leaning towards the use of carrier sense multiple access (CSMA) MAC.

6. IEEE 802.22 and its amendments propose physical layer (PHY) and medium access control layer (MAC) that is designed for long distance regional area networks with typical ranges of 10 km up to 30 km as a result of a larger orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) FFT size and a larger cyclic prefix (CP). Such a CP can absorb channel delay spreads of as much as 74 us. MAC features use time division multiple access (TDMA) time division duplex (TDD) that allow downlink (DL) and uplink (UL) designs which accomodate distances of up to 100 km. Cognitive radio capabilities such as sensing, beaconing and database access have been added to accommodate for dynamic spectrum sharing. Additional security sublayer has been added to protect cognitive functions. Spectrum management functions have also been added to manage channel allocations dynamically when the channel availability is not guaranteed e. g. in the TV Broadcast VHF and UHF Bands between 54 MHz to 862 MHz.

7. The new revision PAR proposes additional capabilities that will allow 802.22 systems to operate in bands that allow spectrum sharing between primary services and opportunistic communications devices (e. g.

Incumbent Access, Priority Access and General Authorized Access in the 3.55 to 3.65 GHz in the United States). The revision PAR will modify the spectrum management framework to align 802.22 to be used in these other bands that may require slightly different operation – e. g. real time push from the database (spectrum access system).

8. This revision may also introduce new clauses on how 802.22 systems can be used for other applications. For example, backhaul and broadcast services have now been recognized as critical components to serve rural and remote areas in developed and developing countries. These new clauses will describe the requirements, architecture and specifications for the use of 802.22 systems for such uses.

4. Technical Feasibility

a) Demonstrated system feasibility

TVWS regulations are being formulated in various regulatory domains. Overall testing and certification programs for the WhiteSpace Devices are being defined. Experimental licenses for the WhiteSpace devices are being issued and trials, pilots and deployments of the WhiteSpace devices have begun.

Many companies are currently working on their IEEE 802.22 prototypes and products. Such announcements for 802.22 can be found in [2], [3], [4] and [5].

Research and regulatory inquiries are on-going to explore the possibility of using newer bands that could potentially be allowed for spectrum sharing [6]. These other potential bands where spectrum sharing is likely to be allowed, may require slightly different spectrum management framework. The proposed revision project plans to align 802.22 to be used in these other bands and hence corresponding changes are likely to be made accordingly.

b) Proven similar technology via testing, modeling, simulation,

The PHY and MAC technologies used in 802.22, such as OFDMA for PHY and TDMA for MAC, have been thoroughly tested and commercially deployed by other IEEE 802 standards. Cognitive radio technology features to fulfil the requirements to operate in TVWS bands are being tested for compliance with requirements of various regulatory organizations (e.g., Federal Communications Commission (FCC), USA, Infocomm Development Authority (IDA), Singapore, OfCom, UK etc.) [5].

IEEE 802.22 prototypes are being developed and field tested [2] and [3].

The testing programs for WhiteSpace devices and databases have been established by various regulatory domains such as the Federal Communications Commission. Other alliances and industry consortiums such as the WhiteSpace Alliance are working on 802.22 (Wi-FAR™) inter-operability specification, compliance, testing and certification procedures.

5. Economic Feasibility

a) Balanced Costs

The IEEE 802.22 systems are designed for operation in rural areas where the population density is likely to be low. However, an IEEE 802.22 base station (BS) covers a large area typically with 30 km radius implying a reasonable cost per geographical unit of coverage. The CPEs are expected to be inexpensive and hence cost for overall network performance would be reasonable.

Also, since 802.22 systems will operate in bands that allow spectrum sharing, the cost of spectrum is expected to be fairly low, and hence resulting in a reasonable cost for performance.

b) Known cost factors

IEEE 802.22 uses OFDMA for PHY and a TDMA based MAC. The cost factors to implement an OFDMA PHY and TDMA based MAC are well known today. The mandatory cognitive radio features such as access to database can be easily implemented in software. Other cost factors such as geolocation based on global positioning system (GPS) technology are well known.

c) Consideration of installation costs

Installation costs will be those of the updated base standard and are expected to be reasonable.

d) Consideration of Operational Costs

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[6] FCC 3.5 GHz Workshop - http://www.fcc.gov/events/35-ghz-workshop