Criteria for Standards Development - P802.22, Revision to IEEE Std. 802.22-2011

1. IEEE 802 criteria for standards development (CSD)

The CSD documents an agreement between the WG and the Sponsor that provides a description of the project and the Sponsor's requirements more detailed than required in the PAR. The CSD consists of the project process requirements, 1.1, and the 5C requirements, 1.2.

1.1 Project process requirements

1.1.1 Managed objects

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

a) The definitions will be part of this project.
b) The definitions will be part of a different project and provide the plan for that project or anticipated future project.
c) The definitions will not be developed and explain why such definitions are not needed.

Ans: a) The definitions will be part of this project.

1.1.2 Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

a) Will the WG create a CA document as part of the WG balloting process as described in Clause 13? (yes/no)
b) If not, explain why the CA document is not applicable.

No, the CA document will not be provided. It is not applicable in this case. SOS devices do not transmit.

1.2 - 5C Requirements

1.2.1. Broad Market Potential

a) Broad sets of applicability

Recenty, 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, 11] - 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.

This emphasis on greater spectrum efficiencies, spectrum sharing and spectrum utilization requires not only database driven configuration of the radios, but systems that can provide spectrum occupancy at a particular location and at a particular time. Regualtors all over the world have realized the importance of better spectrum utilization.

Since 2005, the 802.22 Working Group has been developing cognitive radio technologies which include spectrum sensing, cognitive radio messaging and control as well as spectrum management [8-11]. The Spectrum Occupancy Sensing (SOS) Project plans to extract and re-structure these functions, in order to create a stand-alone system.

SOS has many applications which include:

1. On-demand spectrum survey and report
2. Collaborative spectrum measurement and calibration
3. Labeling of systems using the spectrum
4. Spectrum planning
5. Spectrum mapping
6. Coverage analysis for wireless deployment
7. Terrain and topology - shadowing and fading analysis
8. Quantification of the available spectrum through spectrum observatories [2, 13],
9. Complement the database access for spectrum sharing by adding in-situ awareness and faster decision making.
10. Space-Time-Frequency spectrum hole identification and prediction where non-time-sensitive tasks can be performed at certain times and at certain locations, when the spectrum use is sparse or non-existent
11. Identification and geolocation of interference sources.

The SOS systems may be deployed to characterize many bands such as VHF/ UHF, L, S, C and X bands.

b) Multiple vendors and numerous users

The applications listed in Setion a) are useful for a diverse community of users which include but not limited to spectrum access database providers, new equipment vendors, manufacturers and users of semiconductor, enterprise networking devices, consumer electronic devices, mobile devices, wireless internet service providers etc.

1.2.2. Compatibility

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

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

1.2.3. Distinct Identity

a) Substantially different from other IEEE 802 standards

The proposed SOS effort will produce a new IEEE Std. 802.22.3. This effort will benefit many other projects within the 802 community which are engaged in creating standards for spectrum sharing. It will also complement IETF standards such as IETF Protocol to Access White Spaces (PAWS) based systems to obtain additional information about the spectrum usage.

Since 2005, the 802.22 Working Group has been developing cognitive radio technologies which include spectrum sensing, cognitive radio messaging and control as well as spectrum management.

The Spectrum Occupancy Sensing (SOS) Project plans to bring out these functions, in order to create a stand-alone system.

There are no completed or on-going activities that are similar to the proposed SOS project within the IEEE 802 community. However, there are a few other similar standards in this space which are listed below.

a. IEEE Std. 1900.6-2011: IEEE Standard for Spectrum Sensing, Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communications Systems
b. IEEE P1900.6a: IEEE Draft Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communication Systems Amendment: Procedures, Protocols and Data Archive Enhanced Interfaces

It is to be noted that although these P1900 standards describe communication protocols, they do not specify the operating characteristics for the sensor.

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

1. The Spectrum Occupancy Sensing (SOS) Project plans to bring out functions and messaging already contained in the IEEE Std. 802.22-2011 and create a stand-alone system. In that sense, this effort is unique.
2. The aim is to use messaging structures, interfaces and primitives that are derived from IEEE Std. 802.22-2011, and to use any existing transport mechanism to achieve the control and management of the SOS system.
3. This standard will consider work done in other standards such as IEEE Std. 1900.6-2011 as well as emerging P1900.6a Standard.
4. This standard may specify interfaces and primitives to provide value added sensing information to various spectrum sharing database services.
5. This standard may specify the attributes of the Spectrum Occupancy Sensing (SOS) entity and provide informative annex on sensing, fusion, interpolation, extrapolation etc. algorithms to enable coalescing of the sensing information from a wide variety of sensors with varying degrees of capabilities.

6. This standard may also provide an informative annex that specifies the quality and the density of the sensors that may be required to produce accurate results using the SOS system.

1.2.4. Technical Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

a) Demonstrated system feasibility

Spectrum sensing, has been a focus of research and investigation since many years. Over the last few years more than 25 thousand research papers have been written on spectrum sensing. Companies such as NICT, ETRI, BAE Systems, Shared Spectrum Company, Microsoft [3-7] etc. have built spectrum sensing hardware implementations, prototypes as well as products.

The IEEE 802.22 Working Group devoted significant time and effort in formulating spectrum sensing techniques. More than ten companies contributed to this effort. Based on extensive real time waveform samples of signals, various spectrum sensing algorithms were formulated and tested through extensive modelling and simulations.

Systems simiar to the proposed SOS has been implemented by many companies and universities. These include Microsoft Spectrum Observatory [2], Illinois Institute of Technology Spectrum Observatory[13], Shared Spectrum etc.

b) Proven similar technology via testing, modeling, simulation

The IEEE 802.22 Working Group devoted significant time and effort in formulating spectrum sensing techniques. More than ten companies contributed to this effort. Based on real time waveform samples of signals, various spectrum sensing algorithms were formulated and tested through extensive modelling and simulations.

Companies such as Microsoft, have established spectrum observatories that are continuously monitoring the spectrum at certain locations and reporting the findings onto their website [2]. Such spectrum observatories have also been established in Universities such as Illinois Institute of Technology (IIT) [13] where the effort has been funded by Government institutions like the National Science Foundation (NSF) in the United States. Some other companies such as Shared Spectrum have demonstrated their spectrum sensing systems and deployed it for applications that require spectrum management.

Hence SOS is clearly feasible technically.

1.2.5. Economic Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

a) Balanced Costs

This standard aims at creating economies of scale through uniform and consistent operation of low cost spectrum sensors. This system consists of Receive only spectrum sensing devices. It is expected that any individual spectrum sensing device is not likely to be a major contributor to the cost of the entire spectrum sensing network.

b) Known cost factors

The spectrum sensing techniques and implementations have evolved substantially in the last few years. Hence the proposed SOS system is likely to have known cost factors.

c) Consideration of installation costs

Installation costs for the SOS system are likely to be similar to, or even smaller than the installation costs of the radios. This is because this is a service of Receive only sensors.

d) Consideration of Operational Costs

Once the spectrum sensors are deployed, the operational cost to service them and maintain them should be miniscule.

e) Other areas, as appropriate.

None

References

[1] President' s Council of Advisors on Science and Technology Report – Realizing Full Potential of the Government Held Spectrum to Spur Economic Growth. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf

[2] Microsoft Spectrum Observatory - http://observatory.microsoftspectrum.com/

[3] C. M. Spooner, A. N. Mody, J. Chuang, M. P. Anthony, "Tunnelized Cyclostationary Processing: A Novel Approach to Low Energy Spectrum Sensing," IEEE MILCOM 2013.

[4] Chunyi Song, Matsumura Takeshi and Hiroshi Harada, "A Prototype of TV White Space Spectrum Sensing and Power Measurement," *IEICE Trans. on Communications*, VOL.E97-B, NO.2, pp 314-325, Feb. 2014.

[5] Chunyi Song and Hiroshi Harada, "Proposal and Hardware Implementation of a Partial Channel Bandwidth Based Feature Detection Method for Sensing under Adjacent Channel Interference," *IEEE Trans. on Wireless Communications*, Vol.12, Issue 11, pp.5444-5453, Nov. 2013.

[6] Chunyi Song and Hiroshi Harada, "Proposal and Hardware Performance of an Enhanced Feature Detection Method for OFDM Signals of Digital TV Standards," *IEICE Trans. On Communications*, VOL.E96-B, NO.3, pp.875-884, March 2013.

[7] Chunyi Song, M. Azizur Rahman and Hiroshi Harada, "Proposal and Implementation of a Robust Sensing Method for DVB-T Signal," *IEICE Trans. on Communications*, VOL.E95-B, NO.4, pp.1276-1285, April 2012.

[8] World's First TV White Space Prototype Based on IEEE 802.22 for Wireless Regional Area Network: http://www.prnewswire.com/news-releases/worlds-first-tv-white-space-prototype-based-on-ieee-80222-for-wireless-regional-area-network-188002621.html

[9] World's First Breakthrough Achieved for Long-Range Broadband Communications in TV White Space http://www.hitachi-kokusai.co.jp/global/news/news140123.html

[10] IEEE Std. 802.22-2011 – Part 22: Cognitive Wireless RAN, Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operating in the TV Bands.

[11] Singapore TV White Space Trials: https://mentor.ieee.org/802.22/dcn/11/22-11-0138-00-rasg-singapore-tvws-trial-publication.pdf

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

[13] T. Taher, R. Bacchus, K. Zdunek, D. Roberson, "Long Term Spectrum Occupancy Finidings in Chicago," IEEE DySPAN 2011