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IEEE 802.16S OVERVIEW

The electric utility and critical infrastructure industries prefer licensed spectrum to deploy highly reliable wireless field area networks. Utilities lack access to suitable spectrum to meet their increasing communications needs; in addition, the licensed spectrum that utilities own is largely allocated in narrowband channels, which do not provide sufficient data capacity to support many of the applications associated with the smart grid. To compensate, utilities are using unlicensed spectrum, but it is subject to interference and congestion, which reduce reliability, and to power restrictions, which limit coverage. Utilities need licensed spectrum that will provide the capacity and coverage to support highly reliable wireless field area networks.

APPLICABLE SPECTRUM

The 700 MHz Upper A block (757–758 MHz/787–788 MHz) is one example of suitable spectrum. It represents a desirable opportunity because the spectrum is available over much of the nation and provides suitable coverage and capacity to support utility communications needs. Several large utilities, including FirstEnergy, Great River Energy, Northwestern Energy, Portland General Electric, and Salt River Project, have acquired licenses to use the spectrum, and several more are evaluating the spectrum for potential acquisition. The 700 MHz Upper A block is allocated in a 1×1 MHz paired block of spectrum. The challenge with this spectrum (and those in other bands with similar channel sizes) is the lack of standards-based equipment that can operate in a channel bandwidth of 1 MHz. Broadband wireless standards are specified for larger channels.

THE NEED FOR AN AMENDED STANDARD

The IEEE 802.16s standard development process addresses an industry need for a standard for wireless networks operating in spectrum with channel widths below 1.25 MHz. The current IEEE 802.16 standard operates in channel bandwidths down to 1.25 MHz. The 3GPP LTE standard specifies option in channels as narrow as 1.4 MHz. An amendment to 802.16 was pursued by the utilities because the WiMAX system is focused on vertical markets such as utilities, critical infrastructure, and aviation, whereas the 3GPP standards are oriented primarily toward the commercial cellular system. The 802.16s amendment is intended to support those utilities that have acquired 700 MHz Upper A block spectrum and may attract additional utilities interested in acquiring this (or similar-sized) spectrum.

PERFORMANCE CHARACTERISTICS OF IEEE 802.16S

The IEEE 802.16s amendment is not final, but the current draft version (Draft 2, known as P802.16s/D2) appears to be rather stable. The draft was developed with input from the WiMAX Forum, the Electric Power Research Institute (EPRI), Utilities Technology Council (UTC), and several utilities with specific use cases in mind. The amendment builds on the WiMAX implementation of the 802.16 standard, which has been widely deployed by utilities in other bands. It provides sufficient flexibility to allow optimizations for different applications and reduces overhead to allow more efficient operation in narrower channels. The objective is to meet performance and reliability requirements for critical grid applications, optimizing the use of licensed spectrum allocations between 100 KHz and 1.25 MHz in width. 802.16s aims to provide a performance level that cannot be achieved by technologies focused on "IoT" applications with lower data rates and duty cycles.

The draft amendment implements changes in two areas. First, the OFDMA physical layer has modifications to the subcarriers allocation and preambles to support the narrower channels. Second, some MAC layer messages and formats are streamlined to reduce overhead and improve efficiency.

Defining the performance of an IEEE 802.16 system is complex because there are many interacting parameters that can be varied. The operating frequency is defined by the user, but it is not specified in the standard.

Table 1 – Key parameters set by the user

Parameter	Range or Values	Reference in IEEE 802.16s D2
Channel bandwidth	100 KHz to 1.2 MHz in 50 KHz steps	Table 8-104a, Tables 12-41a, b, c, d
Frame duration	5, 10, 12.5, 20, 25, 40, 50 mS	Table 8-113, Table 11-62, Tables 12-44a, b, c, d
Modulation	QPSK, 16 QAM, and 64 QAM UL and DL	8.1.4.4.7, 8.1.5.3.7

Some parameters are modified for narrow-channel operation under 802.16s/D2, but they are not user options:

- FFT size is 128 for all channel bandwidths below 1.25 MHz.
- Band AMC permutation is used for all channel bandwidths below 125 MHz.
  - Band AMC 1×3, 1×6, and 2×3 are defined per bandwidth groups, as specified in the system profiles in 802.16s/D2, Clause 12.9.

IEEE 802.16 defines a cellular architecture network with multiple base stations. This type of network provides full coverage without having to engineer each device's link individually. Handover is supported and can improve reliability if devices can reach more than one base station. IEEE 802.16s inherits mechanisms for frequency reuse. The frequency reuse plan is important to maximize system throughput and minimize interference among base stations. Frequency reuse options include dividing the spectrum into discrete channels, using Band AMC to define sub-channels within a larger operating channel, or combining the two.

OPTIMIZATIONS FOR SPECIFIC USE CASES

These three examples show the performance results from optimizing parameters for specific objectives with frequency reuse 3 and SISO. Throughput values are at the MAC layer and do not incorporate any compression.

Case 1: Maximum throughput. Choose 1 MHz channel, 25 ms frame, 1:1 UL/DL ratio, CP=1/16, AMC 2x3

- 50 ms roundtrip (ping) latency
- 737 Kbps UL or DL throughput with 64 QAM
- 1.47 bps/Hz average cell spectral efficiency

Case 2: Low latency. Choose 1 MHz channel, 5 ms frame, 1:1 UL/DL ratio, CP=1/16, AMC 2x3

- 10 ms roundtrip (ping) latency
- 461 Kbps UL or DL throughput with 64 QAM
- 0.9 bps/Hz average cell spectral efficiency

Case 3: Narrowest channel. Choose 100 KHz channel, 50 ms frame, 1:1 UL/DL ratio, CP=1/16, AMC 1x3

- 100 ms roundtrip (ping) latency
- 63.4 Kbps UL or DL throughput with 64 QAM
- 1.3 bps/Hz average cell spectral efficiency

STANDARDIZATION SCHEDULE FOR IEEE 802.16S

The IEEE 802.16s/D2 draft amendment entered the first IEEE sponsor ballot, conducted with a group of 63 voters, as of mid-April 2017. Comments on the sponsor ballot will be addressed by the 802.16 Working Group at Session 109 in late May. A recirculation ballot will be conducted to allow voters to review the changes made during the comment resolution process. One or more recirculation ballots may be conducted (if needed) before the IEEE 802 Plenary session in July. If the ballot is approved with a sufficient percentage of affirmative votes, and comments have been resolved properly, the amendment will be forwarded to the IEEE-SA Standards Board, via the specified process, for final approval potentially in September 2017.

In parallel with the IEEE 802.16s amendment project, the IEEE 802.16 Working Group is developing a revision to incorporate all outstanding amendments (including 802.16s) into the base standard.

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