**IEEE P802.19**

**Wireless Coexistence**

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| Project | IEEE P802.19 Wireless Coexistence WG |
| Title | Recommended Practice for Local and Metropolitan Area Networks - Part 19: Coexistence Methods for 802.11 and 802.15.4 based systems operating in the Sub-1 GHz Frequency Bands  |
| Date Submitted | July 31, 2019 |
| Source | Jianlin Guo (MERL)Yukimasa Nagai (MERL)Philip Orlik (MERL)Benjamin A. Rolfe (MERL/BCA)Joerg Robert (FAU Erlangen)Takenori Sumi (Mitsubishi Electric) | E-mail: guo@merl.com nagai@merl.com porlik@merl.com ben@blindcreek.com joerg.robert@fau.de Sumi.Takenori@dc.MitsubishiElectric.co.jp  |
| Abstract | This document is the draft of P802.19.3 table of content |
| Purpose | To provide as a guideline for the call for technical proposals |
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1. **Overview**
	1. Scope

This recommended practice provides guidance on the implementation, configuration and commissioning of systems sharing spectrum between IEEE Std 802.11ah-2016 and IEEE Std 802.15.4 Smart Utility Networking (SUN) Frequency Shift Keying (FSK) Physical Layer (PHY) operating in Sub-1 GHz frequency bands.

* 1. Need for the Project

Many millions of devices based on IEEE Std 802.15.4 are currently operating in Sub-1 GHz frequency bands, and the field is expanding rapidly. Critical applications, such as grid modernization (smart grid) and internet of things (IoT) are using the low to moderate data rate capabilities of IEEE Std 802.15.4. IEEE Std 802.11ah-2016 may operate in the same Sub-1 GHz frequency bands and provides higher data rate capabilities than IEEE Std 802.15.4. In consideration of the current usage, as well as anticipation of yet unforeseen usage models enabled by the standards within the scope of this recommended practice, and to fully realize the opportunity for successful deployment of products sharing the spectrum, strategies and tactics to achieve good coexistence performance are critical. This recommended practice enables IEEE Std 802.15.4 and IEEE Std 802.11ah-2016 to most effectively operate in license exempt Sub-1 GHz frequency bands, by providing best practices and coexistence methods. This recommended practice uses existing features of the referenced standards and provides guidance to implementers and users of IEEE 802(R) wireless standards.

1. **Normative reference**
2. **Definitions, acronyms and abbreviations**
	1. Definitions
	2. Acronyms and abbreviations
3. **Overview of Sub-1 GHz band systems considered**

4.1 IEEE 802.11ah

4.2 IEEE 802.15.4g

4.3 IEEE 802.15.4w

4.4 LoRa

4.5 SigFox

Provide basic information for the above systems such as frequency band (country dependent), channel width, transmission power, PHY modulation, communication range, deployment scenarios (outdoor/indoor), and possibility of coexistence with others.

**Have draft by Jianlin Guo, Phil Orlik, Yuki Nagai, Ben Rolfe, Take Sumi, Jorg Robert, ?**

1. **Use cases of the IEEE 802 Sub-1 GHz technologies**

5.1 Smart utility

5.2 Smart city

5.3 Field monitoring

5.4 Building automation

For 802.11ah, expect to receive inputs from Wi-Fi alliance and Japan 802.11ah promotion council. Smart utility and smart city are expected to main candidates.

For 802.15.4g, main use scenario is smart utility. Field monitoring and building automation are also candidates. Wi-SUN alliance may provide helpful information.

For all LPWAN systems (i.e. 802.15.4w, LoRa and SigFox) the main use-cases are focusing on monitoring applications. Hence, highly asymmetrical traffic can be expected with typical focus on the uplink.

**Have presentations by Yasuhiko Inoue, Phil Beecher, Phil Orlik, Ben Rolfe, ?**

1. **Sub-1 GHz spectrum allocation (informative, could be annex)**

6.1 Japan

6.2 US

6.3 Europe

The spectrum allocation for Europe is given in ETSI EN 300 220-2 Annex B and Annex C. Table 1 lists the most relevant operational bands according to Annex B that EU wide harmonized. Operational bands that are listed in Annex C ant are not EU wide harmonized mainly define additional frequencies between 870 MHz and 920 MHz.

Table 1: Within the scope of this document most relevant EU wide harmonized operating bands according to
ETSI EN 300 220 -2 V3.2.1 (June 2018) Annex B

|  |  |  |  |
| --- | --- | --- | --- |
| **Name: Frequency range** | **Max. Tx power (e.r.p.)** | **Max. bandwidth** | **Usage restrictions** |
| D: 169,4000 MHz to 169,4875 MHz | 500 mW | 50 kHz | ≤ 1% duty cycle, ≤ 10% duty cycle for metering devices |
| H: 433,050 MHz to434,790 MHz | 10 mW | Whole band | ≤ 10 duty cycle |
| J: 433,050 MHz to434,790 MHz | 10 mW | 25 kHz |  |
| K: 863 MHz to 865 MHz | 25 mW | Whole band | < 0.1% duty cycle or polite spectrum access |
| L: 865 MHz to 868 MHz | 25 mW | Whole band | < 1% duty cycle or polite spectrum access |
| M: 868,000 MHz to868,600 MHz | 25 mW | Whole band | < 1% duty cycle or polite spectrum access |
| N: 868,700 MHz to869,200 MHz | 25 mW | Whole band | < 0.1% duty cycle or polite spectrum access |
| O / P\*): 869,400 MHz to 869,650 MHz | 500 mW | Whole band | < 10% duty cycle or polite spectrum access |
| P: 869,700 MHz to870,000 MHz | 5 mW | Whole band |  |
| Q: 869,700 MHz to870,000 MHz | 25 mW | Whole band | < 1% duty cycle or polite spectrum access |

\*) Band P is most likely a typo in ETSI EN 300 220-2 V3.2.1 and should be named band O.

The latest version of ETSI EN 300 220-2 allows the use of polite spectrum access instead of a classical duty cycle. The definition of polite spectrum access is given in the latest revision of ETSI EN 300 220-1. It is a precise definition of CCA and timing parameters, e.g. a maximum transmit duration of 1s for a single transmission. The maximum duty cycle is given by 2.7% per 200 kHz portion of spectrum usage. Hence it can be sig that can be significantly increased if a narrow-band system uses frequency hopping. A system with a bandwidth of less than 200 kHz hopping in the 600 kHz wide band M could therefore reach a duty cycle of 8.1%. This means a significant extension compared to the classical 1% duty cycle.

Table 2 shows the theoretical applicability of the different EU wide harmonized band for the different systems. Caused by its high bandwidth 802.11ah is restricted to the operational bands K and L only. Furthermore, the minimum bandwidth of 125 kHz does not allow the use of LoRa on bands D and J.

Table 2: Theoretical applicability of the different system on the EU wide harmonized available operational bands, green: can be used, yellow: can be used but potential issues (see text below), red: cannot be used

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Band** | **802.11ah** | **802.15.4g** | **802.15.4w** | **LoRa** | **SigFox** |
| **D** |  |  |  |  |  |
| **H** |  |  |  |  |  |
| **J** |  |  |  |  |  |
| **K** |  |  |  |  |  |
| **L** |  |  |  |  |  |
| **M** |  |  |  |  |  |
| **N** |  |  |  |  |  |
| **O / P\*)** |  |  |  | Preferred Downlink | Preferred Downlink |
| **P** |  |  |  |  |  |
| **Q** |  |  |  |  |  |

**Potential issues with operational bands K and L:**

The operational bands K and L from 863 MHz to 868 MHz are also used by Radio Frequency Identification (RFID) systems. The maximum allowed transmit power is 2 W e.r.p., which is significantly higher than the 25 mW that allowed for communication systems. The RFID signal itself can be described as almost continuous signals with low signal bandwidth. Hence, in dense RFID application scenarios with many RFID interrogators (e.g. airports) significant interference in bands K and L can be expected, which may negatively impact communication performance. The exact performance degradation is subject to future work. However, it can be expected that broadband systems will be more affected than narrow-band systems. Only the impact on 802.15.4w will be very low, as the system is designed to cope with such types of interferers.

**Potential issues with operational band O**:

The so-called high power band O allows a transmit power of up to 500 mW e.r.p. in the 868 MHz band with a duty cycle of up to 10%. Consequently, the band is used as downlink frequency for typical LoRa or SigFox networks. Additionally, additional long-range systems also utilize this band. Consequently, it is highly crowed and significant levels of interference can be expected.

6.4 others?

How much spectrum is allocated for 802.11ah and 802.15.4g based applications?

Are the non-overlapping frequency bands allocated for 802.11ah and 802.15.4g? If yes, there is no coexistence issue. If no, there is possibility that 802.11ah and 802.15.4g need to coexist.

Following sections are for the countries where 802.11ah and 802.15.4g may be forced to share spectrum.

**Have presentation by Yuki Nagai (Japan), Take Sumi for Japan, ? for Japan, Phil Orlik, Ben Rolfe, Jianlin Guo for US? Someone for Europe? (Jorg Robert for link)**

1. **802.11ah and 802.15.4g coexistence mechanisms and issues (informative)**

7.1 802.11ah coexistence mechanisms (from standard)

7.2 802.15.4g coexistence mechanisms (from standard)

7.3 Coexistence performance of 802.11ah and 802.15.4g (via simulation results)

7.4 Factors that cause coexistence issues (CCA, CSMA, slot duration, etc.)

7.5 Can coexistence performance be improved? (Possible technologies and their performance, e.g., simulation results)

**Jianlin Guo, Phil Orlik, Yuki Nagai, Ben Rolfe, Take Sumi, Shoichi Kitazawa, ?**

**Presentations:**

**alpha-fairness based coexistence control by Mitsubish Electric**

**Q-Learning based coexistence control by Mitsubish Elrctric**

**Prediction based self-transmission control by Mitsubishi**

**Centralized coexistence control by Shoichi Kitazawa**

**Measurement of Radio Noise and Interference over 920 MHz band
in Japan by Kazuto Yano, Satoru Shimizy, Susumu Ano, Yoshinori Suzuki**

**Jorg Robert for 802.15.4w**

1. **Recommendation scenarios**
	1. CSMA/CA recommendations (e.g., 802.11ah uses RAW to give opportunity for 802.15.4g transmission when 802.15.4g is detected)
	2. CCA recommendations (e.g., 802.11ah lows its ED threshold when 802.15.4g is detected)
	3. Transmission duration recommendation (e.g., frame size and TXOP constraints)
	4. Duty cycle recommendation (e.g., Japan allows 10% duty cycle)
	5. PHY parameter recommendation (e.g., ED threshold, CCA time)
	6. MAC parameter recommendation (e.g., number of backoffs, slot duration)
	7. Network topology recommendation (e.g., location of nodes, number of hops)
	8. Application based recommendation (e.g., data priority, packet delivery rate requirement, latency requirement)

The recommendations can be made to three phases:

 Device manufacturing stage

 Device deployment stage

 Device in use stage

**Jianlin Guo, Phil Orlik, Yuki Nagai, Ben Rolfe, Take Sumi, Shoichi Kitazawa, Jorg Robert, ?**

1. **Coexistence architectures**

9.1 Distributed coexistence control (nodes do not receive any information about other network, nodes perform coexistence functions based on their own judgment)

 Presented methods above, channel hopping if possible, ?

9.2 Centralized coexistence control (assume there is some coordination device such as gateway or hybrid device, nodes perform coexistence by considering information received from coordinator and their own information)

 Inter-system coordination, intra-system coordination, ?

**Jianlin Guo, Phil Orlik, Yuki Nagai, Ben Rolfe, Take Sumi, Shoichi Kitazawa, ?**

1. **Conclusion**

**Jianlin Guo, Phil Orlik, Yuki Nagai, Ben Rolfe, Take Sumi, Shoichi Kitazawa, ?**

1. **References**

**Annex A**

**Evaluation and simulation practice**

Simulation profiles

Evaluation metrics (e.g., packet delivery ratio and latency) and thresholds (application dependent)

Propagation models

 Model for stations below roof height (stations have similar height)

 Model for stations above or below roof height (stations have different height, e.g., for smart utility, data collectors are mounted on the electric pole, which is much higher than smart meters mounted on the house)