**IEEE P802.19**

**Wireless Coexistence**

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| Project | IEEE P802.19 Wireless Coexistence WG | |
| Title | Proposed draft text related to simulation and actual measurement results on coexistence between IEEE 802.11ah and IEEE 802.15.4g | |
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| Abstract | This submission contains a proposed draft text about simulation and actual measurement results on coexistence between IEEE 802.11ah and IEEE 802.15.4g. | |
| Purpose | For developing the TG3a draft. | |
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## Discussion

New PHY and bandwidth combinations for IEEE 802.15.4g and IEEE 802.11ah have been added based on regulation update and IEEE 802.15.4g standard update. Therefore, the combination of IEEE 802.11ah (OFDM-PHY, 1 and 4 MHz) and IEEE 802.15.4g (FSK-PHY and OFDM-PHY, 400 KHz) were newly evaluated using the agreed parameter sets discussed in TG3a. From the view　point of IEEE 802.19.3a recommended practice, new simulation results is recommended to be involved on the amendment.

## Proposed draft text

***TG3a editor: Please add sentences on Section 7.8 and subclause 7.8.1 and 7.8.2 with modifications highlighted red as follows:***

**7.8 Coexistence performance of IEEE Std 802.11ah and IEEE Std 802.15.4g**

Extensive simulations on IEEE Std 802.11ah and IEEE Std 802.15.4g coexistence have been conducted. The coexistence performance results have been presented in Guo, et al. [B11], Guo, et al. [B18], Guo, et al. [B19], Guo, et al. [B19], Guo, et al. [B11], Guo, et al. [B12], ~~and~~ Nagai, et al. [B34], Sumi, et al. [BXXa] [BXXb] [BXXc] [BXXd]. The simulation parameters are set based on [B32] and [BXXe]. In addition to IEEE 802.11ah (OFDM-PHY, 1 MHz bandwidth) and IEEE 802.15.4g (FSK-PHY, 400 KHz bandwidth), IEEE 802.11ah (OFDM-PHY, 4 MHz) and IEEE 802.15.4g (OFDM-PHY, 400 KHz bandwidth) has been evaluated. The PHY data rate for IEEE Std 802.11ah is 300 kb/s and the PHY data rate for IEEE Std 802.15.4g is 100 kb/s. In the simulation the network traffic scenarios, where further coexistence enhancement is needed, are simulated. For the networks with 50 nodes and 100 nodes, two offered network load scenarios are simulated, these are 20 kb/s and 40 kb/s. The offered network load is uniformly distributed among network nodes. For an IEEE 802.11ah node, the duty cycle is 0.13% and 0.26%. For an IEEE 802.15.4g node, the duty cycle is 0.4% and 0.8%. These duty cycles are lower than the constraint specified by any regulation. Using these scenarios, interesting findings have been discovered.

**7.8.1 Data packet delivery rate**

Guo, et al. [B11] presents data packet delivery rate of an IEEE 802.11ah network (OFDM-PHY, 1 MHz bandwidth) and an IEEE 802.15.4g network (FSK-PHY, 400 KHz bandwidth) for a set of simulations, in which data packet delivery rate is measured as the ratio of the number of packets successfully delivered to the total number of packets transmitted. In the simulations, the network size for both the IEEE 802.11ah network and the IEEE 802.15.4g network is either 50 nodes or 100 nodes and the offered network load for the IEEE 802.11ah network and the IEEE 802.15.4g network is 20 kb/s or 40 kb/s.

Sumi, et al. [BXXa][BXXb][BXXc][BXXd] present data packet delivery rate of the combination of an IEEE 802.11ah network (OFDM-PHY, 1 and 4 MHz bandwidth) and an IEEE 802.15.4g network (FSK-PHY and OFDM-PHY, 400 KHz bandwidth) for sets of simulation, in which data packet delivery rate is measured as the ratio of the number of packets successfully delivered to the total number of packets transmitted. The simulation parameters are set based on [B32] and [BXXe].

Combination of PHY and bandwidth for each standard as follow:

* TG3 Case: IEEE 802.11ah (OFDM-PHY, 1MHz bandwidth), IEEE 802.15.4g (FSK-PHY, 400 KHz bandwidth)
* Case 1: IEEE 802.11ah (OFDM-PHY, 1MHz bandwidth), IEEE 802.15.4g (OFDM-PHY, 400 KHz bandwidth)
* Case 2: IEEE 802.11ah (OFDM-PHY, 4MHz bandwidth), IEEE 802.15.4g (FSK-PHY, 400 KHz bandwidth)
* Case 3: IEEE 802.11ah (OFDM-PHY, 4MHz bandwidth), IEEE 802.15.4g (OFDM-PHY, 400 KHz bandwidth)

Data packet delivery rate results reveal the following observations:

1. For all scenarios, the IEEE 802.11ah network delivers near 100% of the data packets, which indicates that network traffic and network size have less impact on IEEE 802.11ah packet delivery rate.
2. IEEE 802.11ah network traffic has impact on IEEE 802.15.4g packet delivery rate. IEEE 802.15.4g network packet delivery rate decreases as IEEE 802.11ah network traffic increases.
3. IEEE 802.15.4g network traffic has more effect on its data packet delivery rate. IEEE 802.15.4g network packet delivery rate decreases significantly as its network traffic doubles.
4. The network size has little effect on IEEE 802.15.4g network packet delivery rate.

Similar trend is also observed on actual measurements presented on [BXXf].

**7.8.2 Data packet latency**

Guo, et al. [B11] also presents the corresponding data packet latency of an IEEE 802.11ah network (OFDM-PHY, 1 MHz bandwidth) and an IEEE 802.15.4g network (FSK-PHY, 400 KHz bandwidth), in which data packet latency is measured as the time difference from the time a packet transmission process starts to the time the packet receipt is successfully confirmed. In other words, the data packet latency is given by: Backoff time + Data TX time + ACK waiting time + ACK RX time.

Sumi, et al. [BXXa][BXXb][BXXc][BXXd] presents the corresponding data packet latency of the combination of an IEEE802.11ah　network (OFDM-PHY, 1 and 4 MHz bandwidth) and an IEEE 802.15.4g network (FSK-PHY and OFDM-PHY, 400 kHz bandwidth) for sets of simulation, in which data packet latency is measured as the time difference from the time a packet transmission process starts to the time the packet receipt is successfully confirmed. The simulation parameters are set based on [B32] and [BXXe].

Combination of PHY and bandwidth for each standard as follow:

* TG3 Case: IEEE 802.11ah (OFDM-PHY, 1MHz bandwidth), IEEE 802.15.4g (FSK-PHY, 400 KHz bandwidth)
* Case 1: IEEE 802.11ah (OFDM-PHY, 1MHz bandwidth), IEEE 802.15.4g (OFDM-PHY, 400 KHz bandwidth)
* Case 2: IEEE 802.11ah (OFDM-PHY, 4MHz bandwidth), IEEE 802.15.4g (FSK-PHY, 400 KHz bandwidth)
* Case 3: IEEE 802.11ah (OFDM-PHY, 4MHz bandwidth), IEEE 802.15.4g (OFDM-PHY, 400 KHz bandwidth)

Data packet latency results reveal the following observations:

1. For all scenarios, the IEEE 802.15.4g network achieves similar packet latency, which indicates that the IEEE 802.15.4g data packet is either delivered with the bounded delay or dropped and therefore, network traffic and network size have little impact on IEEE 802.15.4g packet latency.
2. IEEE 802.11ah network traffic has impact on its packet latency. IEEE 802.11ah data packet latency increases as its network traffic increases.
3. IEEE 802.15.4g network traffic has more impact on IEEE 802.11ah data packet latency. Doubling the IEEE 802.15.4g network traffic has a greater impact on IEEE 802.11ah packet latency than doubling the IEEE 802.11ah network traffic.
4. Network size has a major influence on IEEE 802.11ah packet latency. IEEE 802.11ah packet latency increases significantly as the number of nodes doubles, which indicates that an IEEE 802.11ah packet can be infinitely delayed.

Similar trend is also observed on actual measurements presented on [BXXf].

***TG3a editor: Please add the following references into Bibliography:***

**Bibliography**

[BXXa] T. Sumi, et al., IEEE 802.11ah and IEEE 802.15.4g SUN OFDM PHY Coexistence Simulation, doc.: IEEE 802.19-24/0032r0.

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[BXXd] T. Sumi, et al., Summary of Coexistence Simulation Evaluation for IEEE 802.11ah and IEEE 802.15.4g, doc.: IEEE 802.19-25/0033r0.

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[BXXf] K. Yano, et al., Coexistence experiment between IEEE 802.15.4 SUN and IEEE 802.11 S1G systems, and possible recommended practice, doc.: IEEE 802.19-25/00044r0.