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Abstract	Continue the LE Ad-Hoc work
Purpose	
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Interference scenarios in 2.4GHz ISM and 5.8GHz UNII bands – not co-located BS/SS

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1. Introduction

The scope of this work is to define the scenarios in which interference between cells can cause disruption in service. The target bands are 2.4GHz, ISM rules and 5.8GHz, according to UNII rules. Will be taken into account un-coordinated deployment cases, to address access providers and private ad-hoc networks. The system parameters defined in the LE Ad-Hoc output document (IEEE 802.16-04_07) were used and also reproduced below.

2. System parameters

The following parameters are proposed, resulting as an average of product characteristics in 5.8GHz:

BST:

Tx power:
2.4GHz: 25dBm
5.8GHz: Ptb = 20dBm;
Antenna gain: omni: AGo = 10dBi; directional: AGba = 17dBi;
Connector loss: CL =1dB;

SS:

Tx power: Pts = 20dBm;
Antenna gain: omni: AGso = 10dBi; directional: AGsa = 17dBi;
Connector loss: 1dB.

Antenna isolation for co-located outdoor antennae:
AI = -75dB for directional – to- directional, 1m between sectors
AI = 30dB for omni-to-directional or omni-to-omni.

Signal BW for evaluation: 10MHz.
Note: for simplification, it is proposed to omit 20MHz here

Fade Margin: 10dB
The Receive Sensitivity Level (RSL), Adjacent Channel Interference (ACI) resistance, Signal-to-Noise Ratio - SNR, at minimum rate, as defined in 802.16REVd/D3 (see Annex 1), are summarized below:

Table 1 – RSL, ACI, SNR

	RSL (dBm) / Modulation	ACI (dB) / Modulation	SNR (dB) / Modulation	Blocking Rx level (dBm)
SCa	-83.2 / QPSK	-9 / QPSK	9.8 / QPSK	-40 (BS) and –20 (SS)
OFDM	-82.6 / QPSK 1/2	-11 / 16QAM 3/4	9.4 / QPSK 1/2	-30
OFDMA	-82.6 / QPSK 1/2	-11 / 16QAM 3/4	9.4 / QPSK 1/2	-30

It is proposed to use the following values:

RSL: -83dBm
SNR: 9dB
Blocking Level: BL= -40dBm
ACI: -12dB.

3. Interference cases

3.1. Subscriber Station to Base Station

3.1.1. Interference level calculation

The assumed scenario is that a foreign SS, belonging to another system, will transmit during the time when the victim BS is in receive state. This situation is relevant also for synchronized MAC Frames or even for FDD deployment, in Licensed bands, no guard interval.
Will be calculated the minimum distance for 1dB threshold degradation, between a Base Station and a Subscriber station, belonging to another system. The figure 4 represents the considered scenario.

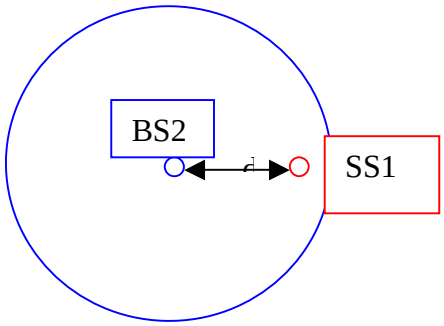

Figure 1 Foreign Subscriber to Base Station Interference

The interfering signal at BS2 is:

$$P_I = Pts1+AG\_s1-CL1+ AG\_b2-CLs2 – Path\_loss\_i = 20+AG\_s1 + AG\_b2-1-1-Path\_loss\_I$$

$$P_I= AG\_s1 + AG\_b2 + 18 – Path\_loss\_i$$

When the foreign SS creates at BS1 location levels higher than RSL+ACI, the degraded RSL (D_RSL) is:

$$D\_RSL = N +I + S/(N+I)$$

where N and I are power levels in watts.

As we look for high interference levels, causing service interruption, is possible to assume that for I >> N,

$$D\_RSL = I + S/I$$

The relative RSL degradation is:

$$Delta = D\_RSL – RSL = I + S/I – (N + S/N) = I - N$$

We can have 3 cases, depending the antenna type. We assume the worst case, LOS propagation and same line antenna mounting, looking one to the other.

In the next two tables, are presented the interference levels, adjacent channel and translated from adjacent channel to co-channel, for ACI=-12dB and N+NF+impl_loss= -93dB. Different SS-BS distances were taken into account.

3.1.2. Service disruption due to interference

There are 2 possibilities of service disruption:

- Radio front end saturated (interference level higher than –40dBm –(SCa definition);
- Interference levels higher than allowed.

The minimum adjacent channel signal that will cause 1dB RSL degradation is:

Degradation_level = RSL-ACI = -83+12 = -71dBm

Any signal higher that this will decrease the cell size. The relation between interference level and the decreased cell size is shown in the following tables.

The color code is:

- radio blocking – violet
- too high interference level – red
- yellow – marginal situation.

Table 2 Interference levels created by one foreign SS, at Base Station location, 2.4GHz

	BS and SS - omni			BS and SS - directional			BS directional, SS omni		
Interference levels at BS, SS at x meters	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.
50	-36.0			-22.0			-29.0		
100	-42.0			-28.0			-35.0		
250	-50.0	-62.0	30.0	-36.0			-43.0	-55.0	37.0
500	-56.0	-68.0	24.0	-42.0	-54.0	38.0	-49.0	-61.0	31.0
1000	-62.0	-74.0	18.0	-48.0	-60.0	32.0	-55.0	-67.0	25.0
2000	-68.0	-80.0	12.0	-54.0	-66.0	26.0	-61.0	-73.0	19.0
4000	-74.0	-86.0		-60.0	-72.0	20.0	-67.0	-79.0	13.0
7500	-79.5	-91.5		-65.5	-77.5	14.5	-72.5	-84.5	
10000	-82.0	-94.0		-68.0	-80.0	12.0	-75.0	-87.0	

Table 3 Interference levels created by one foreign SS at Base Station location, 5.8GHz

	BS and SS - omni			BS and SS - directional			BS directional, SS omni		
Interference levels at BS, SS at x meters	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.
50	-43.6	-55.6	36.4	-29.6			-36.6		
100	-49.7	-61.7	30.3	-35.7			-42.7	-54.7	37.3
250	-57.6	-69.6	22.4	-43.6	-55.6	36.4	-50.6	-62.6	29.4
500	-63.6	-75.6	16.4	-49.6	-61.6	30.4	-56.6	-68.6	23.4
1000	-69.7	-81.7	10.3	-55.7	-67.7	24.3	-62.7	-74.7	17.3
2000	-75.7	-87.7		-61.7	-73.7	18.3	-68.7	-80.7	11.3
4000	-81.7	-93.7		-67.7	-79.7	12.3	-74.7	-86.7	
7500	-87.2	-99.2		-73.2	-85.2		-80.2	-92.2	
10000	-89.7	-101.7		-75.7	-87.7		-82.7	-94.7	

The tables before show very high interference level, such that out-door operation is impossible without sharing in time the frequency resource. Supplementary, the cell size will be reduced.

If the foreign SS will operate 2 channels aside, the radio blocking still remains. The translated interference level will be better by 20dB, relative to the first channel, but still the cell size, QoS and capacity are affected.

Two spare channels will give a satisfactory response to this problem. Unfortunately, this possibility is not applicable in License Exempt bands.

3.2. Base Station to Subscriber Station

3.2.1. Interference level calculation

Same scenario (Figure 2) as before applies. As the SS and BS transmit powers were assumed equal, in 5.8GHz, the results in Table 4 are relevant also for this case. In 2.4GHz the Base Station will transmit at 5dB higher levels, due to regulatory allowance.The interference levels are presented in next table.

Table 5 Interference levels created by one foreign BS, at Subscriber Station location, 2.4GHz

	BS and SS - omni			BS and SS - directional			BS directional, SS omni		
Interference levels at BS, SS at x meters	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.	Level	ACI correction	RSL Degr.
50	-31.0			-17.0			-17.0		
100	-37.0			-23.0			-23.0		
250	-45.0	-57.0	35.0	-31.0			-31.0		
500	-51.0	-63.0	29.0	-37.0			-37.0		
1000	-57.0	-69.0	23.0	-43.0	-55.0	37.0	-43.0	-55.0	37.0
2000	-63.0	-75.0	17.0	-49.0	-61.0	31.0	-49.0	-61.0	31.0
4000	-69.0	-81.0	11.0	-55.0	-67.0	25.0	-55.0	-67.0	25.0
7500	-74.5	-86.5		-60.5	-72.5	19.5	-60.5	-72.5	19.5
10000	-77.0	-89.0		-63.0	-75.0	17.0	-63.0	-75.0	17.0

The situation is worse, as compared with the previous scenarios, due to the higher transmitted power.

3.3. Subscriber Station to Subscriber Station

The same principles, as before, apply for interference calculation. The results are as shown in Table 2, for 2.4GHz and Table 3, for 5.8GHz.

4. Conclusion

The Base Station to Subscriber Station and Subscriber Station to Base Stations are very strong degradation factors.
A solution for spectrum sharing shall address as well these interference scenarios.