Title: Interference between systems sharing spectrum in 3.65GHz

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Base Document
Purpose:

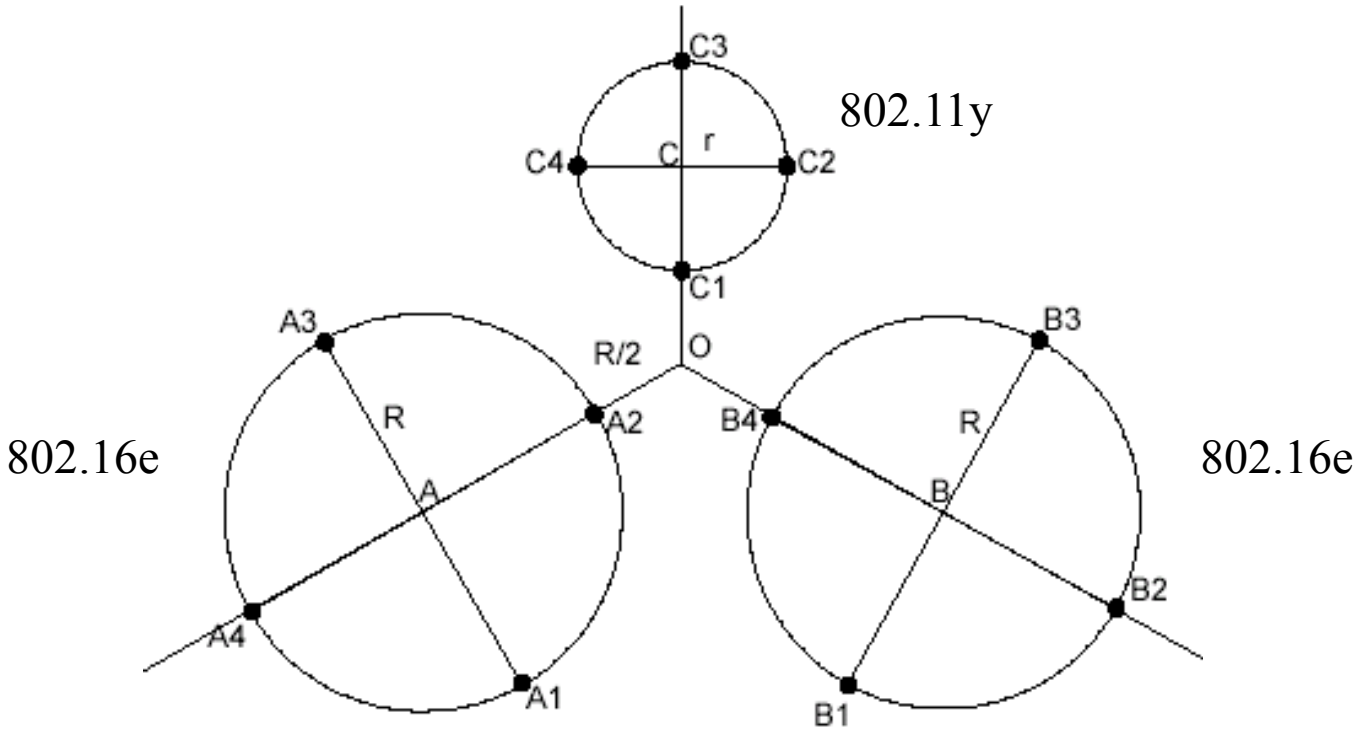
Outline

- Main assumptions
- Co-channel interference
- Interference from systems in adjacent channel
- Conclusions

Main assumptions

- Main system parameters
  - BS: similar parameters for radio and antenna used in 802.11 and 802.16 Base Stations
    - DL: eirp at the regulatory limit; 10dBi BS and 6dBi SS/STA antennae
  - SS (802.16) implement UL-OFDMA on 4 sub-channels
  - STA – 802.11y – parameters according to the standard
  - 20MHz channels
  - Reference points
    - QPSK3/4 for 802.16DL and UL, 802.11 DL
    - STA (802.11y) compensate the link budget with reduced modulation – QPSK1/2
- Propagation model
  - Dual slope (more realistic for large area deployments)
- Fade Margin: 7dB
- Interference accommodation: 1dB
- 802.11y levels for energy detect: -72dBm
- Detailed assumptions: IEEE C802.16h-07/039

Co-channel interference - geometry



R=10km for 802.16e

r = 5.2km for 802.11y

System separation: 8.5km between terminals

Interference into 802.11y system

- One 802.16h system active

Element in system C	I+N (dBm)	SINR	Connectivity
C	-77.398	-8.60	No
C1	-81.676	2.68	No
C2	-87.895	8.89	QPSK1/2
C3	-88.273	9.27	QPSK1/2
C4	-85.508	6.51	BPSK1/2

- Two 802.16h systems active

Element in system C	I+N (dBm)	SINR	Connectivity
C	-74.4356	-11.56	No
C1	-81.6762	2.68	No
C2	-84.799	5.80	BPSK
C3	-87.0456	8.05	QPSK1/2
C4	-84.799	5.80	BPSK

- Results
  - The stations see low levels of interference and may transmit
  - The BS is not able to receive

Interference into 802.16h system - 1

- Only the 802.11y system is active

Element in system A	I+N (dBm)	SINR	Connectivity
A	-81.49	-5.52	No
A1	-93.77	8.76	QPSK3/4
A2	-81.25	-3.76	No
A3	-88.30	3.29	QPSK1/2 rep 2
A4	-95.83	10.82	QPSK3/4

  - Cell size degradation
    - At QPSK ¾: from 10km to 2.5km
      - Cell coverage reduced from 100% to 6.7%
    - At QPSK ½: from 10km to 5km
      - Cell coverage reduced from 100% to 25%
- One 802.11y system and one 802.16h systems are active

Element in system A	I+N (dBm)	SINR	Connectivity
A	-81.0093	-6.00	No
A1	-87.5752	2.56	QPSK1/2 rep 2
A2	-79.8877	-5.12	No
A3	-86.7591	1.75	QPSK1/2 rep 4
A4	-90.8556	5.85	QPSK1/2 rep 2

Interference into 802.16h system - 2

- One 802.16h system is active

Element in system A	I+N (dBm)	SINR	Connectivity
A	-85.90	3.19	QPSK1/2 rep 2
A1	-83.89	3.76	QPSK1/2 rep 2
A2	-80.32	0.77	QPSK1/2 rep 4
A3	-88.83	7.00	QPSK1/2
A4	-89.84	7.51	QPSK1/2

  - Still significant degradation

Master sub-frame concept

- Assumptions
  - Quiet Element in Beacons (see 7.3.2.23 Quiet element in 802.11h**);**
  - Change of the Time Unit from 1024 us to 1000us;
  - Beacon period equal with four MAC periods of 802.16 (typically 20ms)

- Work according to the CX-Frame approach in 802.16h/D2

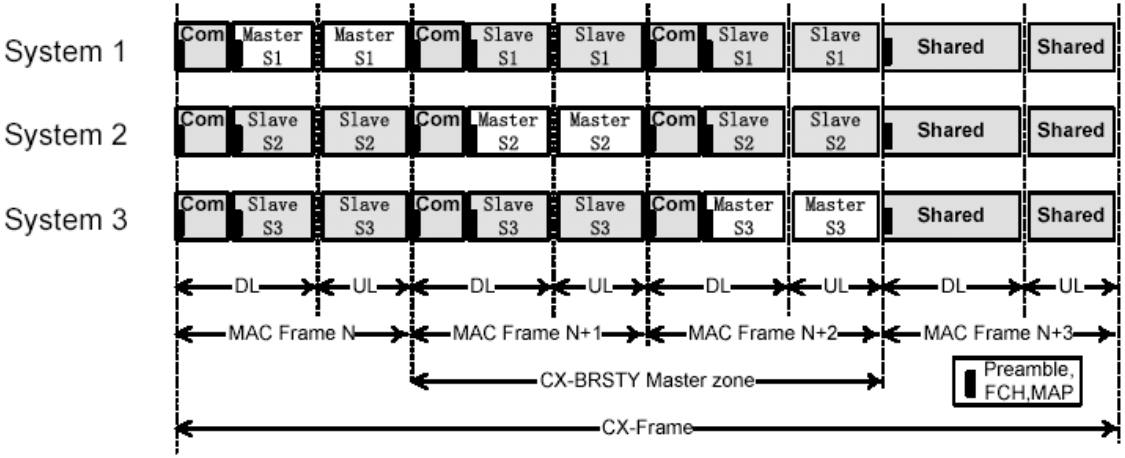


Figure h46—Coexistence Frame Functionality

- Master only

Receiver in system A	SNR (dB)	Connecti vity	Receiver in system B	SNR (dB)	Connecti vity	Receiver in system C	SNR (dB)	Connecti vity
A	9	QPSK3/4	B	9	QPSK3/4	C	5	QPSK1/2
A1	9	QPSK3/4	B1	9	QPSK3/4	C1	9	QPSK3/4
A2	9	QPSK3/4	B2	9	QPSK3/4	C2	9	QPSK3/4
A3	9	QPSK3/4	B3	9	QPSK3/4	C3	9	QPSK3/4
A4	9	QPSK3/4	B4	9	QPSK3/4	C4	9	QPSK3/4

802.16h Slave in parallel with 802.16h DL Master

- Master (System A) performance in case of 9dB power reduction for Slave (system B) Tx, Slave cell size of 3km

Element in system A	I+N (dBm)	SINR	Connectivity
A1	-92.87	7.86	QPSK1/2
A2	-91.67	6.66	QPSK1/2
A3	-93.69	8.68	QPSK3/4
A4	-93.77	8.76	QPSK3/4

Element in system B	I+N (dBm)	SINR	Connectivity
B5	-89.63	7.44	QPSK1/2
B6	-91.17	8.98	QPSK3/4
B7	-90.87	8.68	QPSK3/4
B8	-89.15	6.97	QPSK1/2

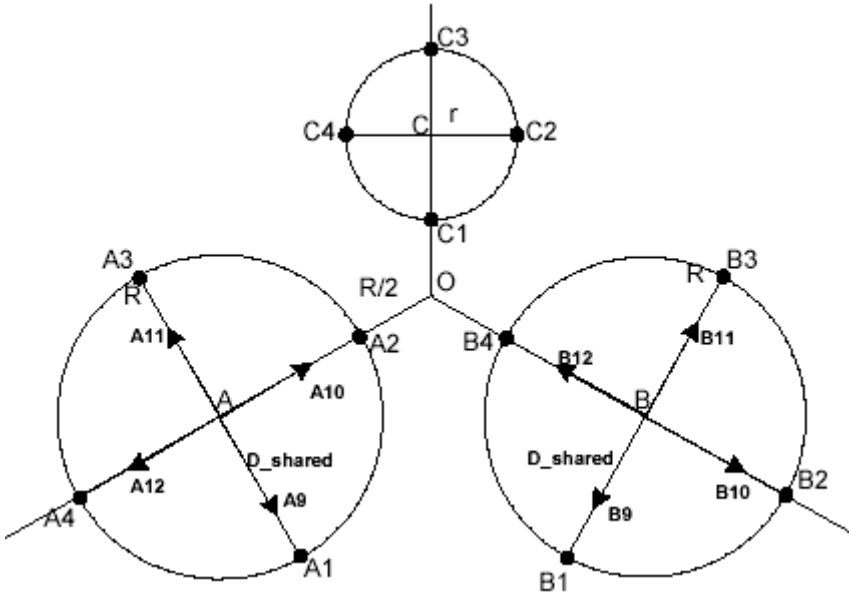
- Master (System A) performance in case of 12dB power reduction for Slave (system B) Tx, Slave cell size of 2km

Element in system A	I+N (dBm)	SINR	Connectivity
A1	-93.39	8.38	QPSK3/4
A2	-92.67	7.66	QPSK1/2
A3	-93.83	8.82	QPSK3/4
A4	-93.88	8.87	QPSK3/4

Element in system B	Signal (dBm)	I+N (dBm)	SINR	Connectivity
B5	-81.67	-89.95	8.28	QPSK3/4
B6	-81.67	-90.87	9.20	QPSK3/4
B7	-81.67	-90.62	8.95	QPSK3/4
B8	-81.67	-89.51	7.85	QPSK1/2

Two 802.16h systems in DL Shared sub-frames

- Power reduction for both BSs: 6dB
- Cell size 6km



Element in system A or B	I+N (dBm)	SINR	Connectivity
A9, B9	-92.19	8.98	QPSK3/4
A12, B10	-93.27	10.06	QPSK3/4
A11, B11	-93.12	9.91	QPSK3/4
A10, B12	-91.42	8.21	QPSK3/4

Adjacent Channel Interference – 802.11BS into 802.16h SS

- SS blocking level: -30dbm

Distance between 802.11 BS and 802.16 SS/MS	Interference in the adjacent channel (dBm)	Interference translated into channel (dBm)	I+N (dBm)	RSL degradation (dB)	New cell size at QPSK3/4 (km)	New cell size at QPSK1/2 (km)
10	-14.65	-37.65	-37.6458	56.34	0.02	0.03
20	-20.67	-43.67	-43.6664	50.32	0.04	0.05
50	-28.63	-51.63	-51.625	42.36	0.09	0.13
100	-34.65	-57.65	-57.6448	36.34	0.18	0.25
185	-39.99	-62.99	-62.9858	31.00	0.33	0.47
500	-48.63	-71.63	-71.6001	22.39	0.89	1.26
1000	-54.65	-77.65	-77.5462	16.44	1.76	2.49
2000	-60.67	-83.67	-83.2809	10.71	3.41	4.82
5000	-68.63	-91.63	-89.6382	4.35	7.09	9.24
10000	-76.04	-99.04	-92.8085	1.18	9.33	11.08

- The SS will not be able to receive for distances lower than few km from a BS transmitter in the adjacent channel!
- Again the cell size may be strongly deteriorated

Adjacent Channel Interference: 802.11y BS into 802.16h BS

- BS Blocking level: -45dBm

Distance between 802.11 BS and 802.16 BS	Interference in the adjacent channel (dBm)	Interference translated into channel (dBm)	I+N (dBm)	RSL degradation (dB)	New cell size at QPSK3/4 (km)	New cell size at QPSK1/2 (km)
10	-14.65	-37.65	-37.6459	58.34	0.01	0.02
20	-20.67	-43.67	-43.6664	52.32	0.03	0.04
50	-28.63	-51.63	-51.6251	44.36	0.07	0.10
100	-34.65	-57.65	-57.6452	38.34	0.14	0.20
325	-44.88	-67.88	-67.8768	28.11	0.46	0.65
500	-48.63	-71.63	-71.6094	24.38	0.71	1.00
1000	-54.65	-77.65	-77.5827	18.41	1.41	1.99
2000	-60.67	-83.67	-83.4193	12.57	2.75	3.89
5000	-68.63	-91.63	-90.2706	5.72	6.06	8.54
10000	-74.65	-97.65	-93.729	2.26	8.76	10.42

- Absurd situation: the BS may be blocked for d<350m
  - For d>500m the BS will not “detect” other BS
  - Needed much more than 5km separation for acceptable cell size degradation

Second Adjacent Channel Interference: 802.11y BS into 802.16h BS

Distance between 802.11 BS and 802.16 BS	Interference in the alternate channel (dBm)	Interference translated into channel (dBm)	I+N (dBm)	RSL degradation (dB)	New cell size at QPSK3/4 (km)	New cell size at QPSK1/2 (km)
10	-14.65	-56.65	-56.6454	39.34	0.13	0.18
20	-20.67	-62.67	-62.6644	33.33	0.25	0.36
50	-28.63	-70.63	-70.6126	25.38	0.63	0.89
100	-34.65	-76.65	-76.5956	19.39	1.25	1.77
325	-44.88	-86.88	-86.3803	9.61	3.87	5.47
500	-48.63	-90.63	-89.5168	6.47	5.55	7.84
1000	-54.65	-96.65	-93.2951	2.69	8.55	10.16
2000	-60.67	-102.67	-95.1441	0.85	9.51	11.30
5000	-68.63	-110.63	-95.8429	0.15	9.90	11.76
10000	-74.65	-116.65	-95.9525	0.04	9.96	11.84

- Highly problematic situation: interference below threshold, but the BS is blocked!
- The BS will enter the blocking situation, even with hundreds of meter of separation and even on the 2nd adjacent channel!

Conclusions

- The “energy detection” at -72dBm is not suitable for large cell deployments
  - Both 802.11y and 802.16h systems are affected
- 802.11y/D1 does NOT comply with FCC expectations for CBP:
  - “goal of enabling multiple users to share spectrum in the same geographic area **without interference**”
- 802.11y/D1 jeopardize the 802.16 technology and its ability to operate with high cell size
- **A cooperative approach is needed**
  - **The two technologies need to cooperate and coordinate for separation in time**