Cisco Cooperative Project

Start Recording

LAA with Multicarrier LBT

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Outline

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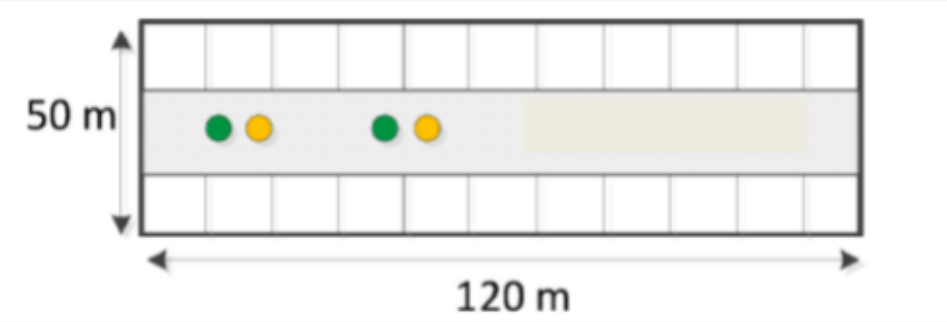
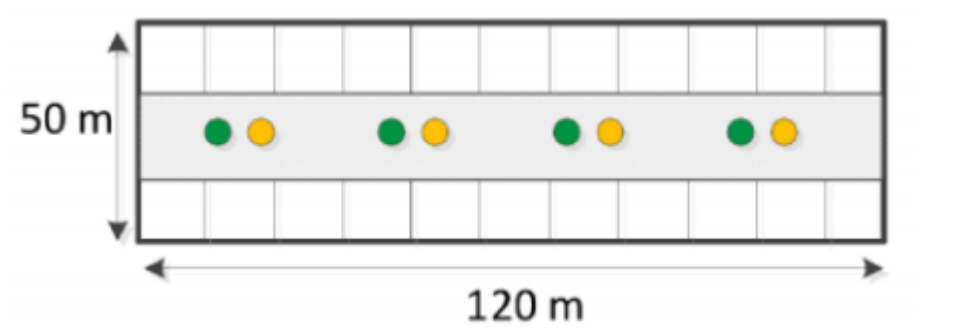
Overview

❖Simulation Setting

- ✓2 APs + 2 eNBs, or 4 APs + 4 eNBs
- ✓ Each AP/eNB has five users, and each UE uniformly and randomly distributed around its associated transmitter





- ✓9 or 8 channels in total (U-NII 1 and U-NII 3)
- ✓FTP file size: 0.5 Mbytes, Poisson process: lambda = 25
- ✓Transmit power: 200 mW (23 dBm) for all transmitters
- ✓Multi-carrier LBT: Option 1 (WiFi-like), and LAA randomly choose idle channels (at most 3) as secondary channels per transmission

Simulation Results

❖4 Transmitters + 9 subchannels

✓Case I: Primary Channel: 1,4,5,9

	WiFi #1	WiFi #3	Op. A	LAA #2	LAA #4	Op. B	Total
-70 dBm	110.99	221.16	332.15	154.53	267.04	421.57	**753.72**
-75 dBm	116.18	235.75	351.93	130.05	206.47	336.52	**688.45**

✓Case II: Primary Channel: 1,2,5,6

	WiFi #1	WiFi #3	Op. A	LAA #2	LAA #4	Op. B	Total
-70 dBm	72.24	84.98	157.22	231.13	216.96	448.09	**605.31**
-75 dBm	97.93	103.16	201.09	176.85	180.35	357.20	**558.29**

- In Case I, WiFi #3 has some advantages since LAA #4's PC is 9, not in {5,6,7,8}
- Case I is better than Case II in terms of overall performance, WiFi has more opportunities to transmit with a 40 MHz bandwidth
- Adapting LAA-ED can help to achieve fairness

Simulation Results

❖4 Transmitters + 8 subchannels

✓Pure WiFi: Case I: 1,4,5,8; Case II: 1,2,5,6

	WiFi #1	WiFi #3	Op. A	WiFi #2	WiFi #4	Op. B	Total
Case I	120.84	119.92	240.76	120.25	120.31	240.56	**481.32**
Case II	120.28	120.14	240.42	119.31	120.87	240.18	**480.60**

- In pure WiFi networks, WiFi only transmit with a bandwidth of 80 MHz.
- WiFi #1 and #3 compete {1,2,3,4}, and WiFi #2 and #4 compete with {5,6,7,8}. Therefore, all WiFi transmitters have similar performance in both two cases.

Simulation Results

❖4 Transmitters + 8 subchannels

✓Case I: Primary Channel: 1,4,5,8

	WiFi #1	WiFi #3	Op. A	LAA #2	LAA #4	Op. B	Total
-70 dBm	112.99	119.49	232.48	201.22	220.21	421.43	**653.91**
-75 dBm	114.48	121.18	235.66	164.43	200.37	364.80	**600.46**

✓Case II: Primary Channel: 1,2,5,6

	WiFi #1	WiFi #3	Op. A	LAA #2	LAA #4	Op. B	Total
-70 dBm	72.79	81.15	153.94	230.80	223.16	453.96	**607.90**
-75 dBm	98.42	102.56	200.98	179.69	178.77	358.46	**559.44**

- In this case, different WiFi transmitters have similar performance
- The overall performance is worse than the case of 9 subchannel, especially for case I.

Simulation Results

❖8 Transmitters + 8 subchannels

✓Pure WiFi

- Case I: PC: 1,4,5,8,1,4,5,8
- Case II: PC: 1,5,4,8,1,5,4,8 (best case?)
- Case III: PC: 1,2,3,4,5,6,7,8 (worst case?)

	WiFi #1	WiFi #3	WiFi #5	WiFi #7	Op. A	WiFi #2	WiFi #4	WiFi #6	WiFi #8	Op. B	Total
Case I	138.79	139.57	102.45	95.13	475.94	102.51	97.71	132.23	138.63	471.08	**947.01**
Case II	170.27	85.24	59.05	188.28	502.83	169.55	86.73	59.38	190.67	506.33	**1009.16**
Case III	67.80	58.10	66.89	59.77	252.56	58.18	66.98	57.46	71.75	254.37	**506.94**

- WiFi only transmits with a bandwidth of 80 MHz
- Different from the case of 4 transmitters, different WiFi transmitters will have different performance, depending on the locations and primary channels

Simulation Results

❖8 Transmitters + 8 subchannels

✓Pure WiFi

- Case I, PC: 1,4,5,8,1,4,5,8)
  - WiFi #1, #2, #5 and #6 compete with{1,2,3,4}: #1 and #6 will have some advantages;
  - WiFi #3, #4, #7 and #8 compete with{5,6,7,8}: #3 and #8 will have some advantages
- Case II, PC: 1,5,4,8,1,5,4,8 (best case?)
  - WiFi #1, #3, #5 and #7 compete with{1,2,3,4}: #1 and #7 will have some advantages;
  - WiFi #2, #4, #6 and #8 compete with{5,6,7,8}: #2 and #8 will have some advantages
  - Compare to Case I, the two closest transmitters are in different 80 MHz channel (for example, WiFi #1 and WiFi #2): better performance
- Case III, PC: 1,2,3,4,5,6,7,8 (worst case?)
  - WiFi #1, #2, #3 and #4 compete with{1,2,3,4}: #1 and #4 will have some advantages;
  - WiFi #5, #6, #7 and #8 compete with{5,6,7,8}: #5 and #8 will have some advantages
  - Compare to Case I and II, transmitters choosing the same 80 MHz are all close to each other: frequent backoff, worst performance.

Simulation Results

❖8 Transmitters + 8 subchannels

✓Case I （PC: 1, 4, 5, 8, 1, 4, 5, 8 ）

	WiFi #1	WiFi #3	WiFi #5	WiFi #7	Op. A	LAA #2	LAA #4	LAA #6	LAA #8	Op. B	Total
-70	104.60	110.25	84.33	113.13	412.32	200.94	160.71	180.87	224.30	766.83	**1179.15**
-75	103.44	101.97	99.31	111.31	416.04	187.36	157.52	154.24	219.56	718.69	**1134.73**
-80	115.73	146.27	108.67	115.27	485.94	142.82	108.84	146.98	150.43	549.07	**1035.01**

- The overall performance is better than that of pure WiFi networks: 1) higher physical rate for LAA; 2) CCA-CS is the only sensing threshold in pure WiFi networks
- Adapting LAA-ED can help to achieve fairness
- At -80 dBm, both Operator A and Operator B’s performance get improved.

Simulation Results

❖8 Transmitters + 8 subchannels

✓Case II （PC: 1, 5, 4, 8, 1, 5, 4, 8）

	WiFi #1	WiFi #3	WiFi #5	WiFi #7	Op. A	LAA #2	LAA #4	LAA #6	LAA #8	Op. B	Total
-70	151.28	65.92	86.08	125.52	428.80	228.67	199.29	191.75	238.88	858.59	**1287.39**
-75	144.27	71.06	77.30	145.58	438.21	216.93	159.12	162.97	234.29	773.31	**1211.52**
-80	160.80	77.54	73.73	169.24	481.31	185.25	127.05	118.19	183.75	614.24	**1095.55**

- The performance is even better than that of Case I (the two closest transmitters are in different 80 MHz channel).

Simulation Results

❖8 Transmitters + 8 subchannels

✓Case III （PC: 1, 2, 3, 4, 5, 6, 7, 8）

	WiFi #1	WiFi #3	WiFi #5	WiFi #7	Op. A	LAA #2	LAA #4	LAA #6	LAA #8	Op. B	Total
-70	62.84	55.22	57.61	59.01	234.67	226.99	204.80	178.66	225.50	835.96	**1070.63**
-75	83.71	72.18	80.27	80.15	316.30	180.94	156.24	113.07	185.77	636.02	**952.33**
-80	100.03	89.94	97.09	95.76	382.81	133.19	94.41	72.05	121.74	421.40	**804.21**

- Even though it is not a good choice for PC setting, introducing LAA can significantly improve the overall performance in this case.

Discussion & Future Work

❖One possible way to help to achieve fairness

✓PC selection:

- Choose the channel with the least interference;
- LAA-ED is determined using adaptive energy detection for the single channel case;

✓SC selection:

- Check the patterns used in 802.11ac first
- If not successful, try to follow the patterns and choose the 3 closest idle channels
- For each secondary channel, LAA-ED is determined using adaptive energy detection for the single channel case;
- If collisions happen too often in certain secondary channels, discard these secondary channels in carrier aggregation