Cisco Cooperative Project

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Multicarrier LBT: Option 1

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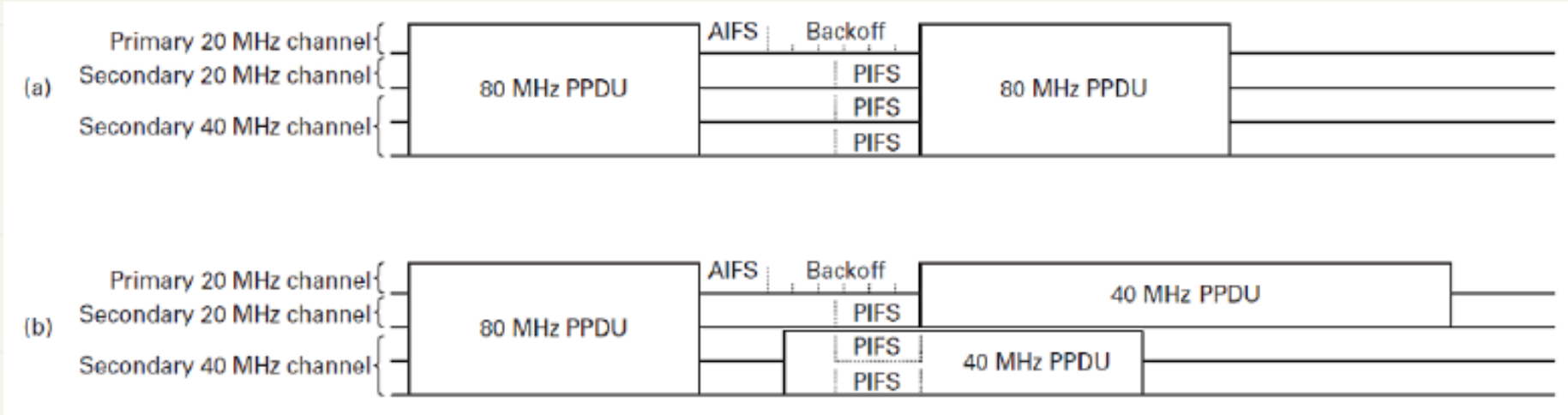
Outline

- Multi-carrier LBT: Alt 1
- Simulation Results
  - ✓Different arrival rates
  - ✓LAA with channel bonding
- Next Steps

Multi-carrier LBT

- 802.11ac's channel bonding



- ✓ The backoff procedure is only performed on the primary channel, secondary channel(s) perform a one-shot CCA.
- ✓ Only certain channel bonding configurations are allowed.
- ✓ The designated primary channel should always be part of the channel bonding configurations.

Multi-carrier LBT, Al 1

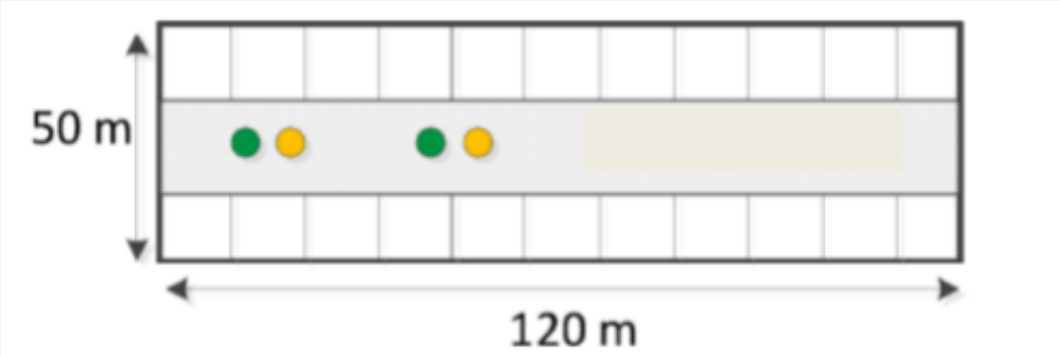
- Multi-carrier LBT, Alt 1: eNB performs LBT Cat 4 on only one unlicensed carrier (Wi-Fi like) [1]

- Multi-carrier LBT, Alt 2: eNB performs LBT Cat 4 on more than one unlicensed carriers [1]

[1] Nokia, Alcatel-Lucent, “R1-160915: Discussion on Multi-Carrier LBT for LAA DL,” Feb. 15, 2016

Simulation Results

- Simulation Setting
  - ✓ 2 APs, 2 eNBs, and each AP/eNB has five users (each UE uniformly and randomly distributed around its associated transmitter)



  - ✓ 4 subchannels available
  - ✓ FTP file size: 0.5 Mbytes, Poisson process: lambda = 2.5/10
  - ✓ One LAA eNB serves different UEs one by one.
  - ✓ Adaptive MCS

Simulation Results

- Single Channel, lambda = 2.5

LAA ED	WiFi #1	WiFi #3	LAA #2	LAA #4
-62 dBm	18.69	14.21	35.18	38.75
-72 dBm	36.65	15.59	11.19	37.47

- ✓ The nodes in the margin have some advantages;
- ✓ Decreasing LAA ED improves WiFi's performance, degrades LAA's performance

Simulation Results

- Multi-carrier LBT, all transmitters share the same primary channel, lambda = 2.5

LAA ED	WiFi #1	WiFi #3	LAA #2	LAA #4
-62 dBm	47.27	48.20	47.46	47.21
-72 dBm	47.67	47.53	47.61	47.65

- Multi-carrier LBT, the primary channels are different (1, 2, 3, 4), lambda = 2.5

LAA ED	WiFi #1	WiFi #3	LAA #2	LAA #4
-62 dBm	47.64	47.57	47.70	47.71
-72 dBm	47.76	47.64	47.76	47.88

- ✓ Since there are 4 subchannels available, it will be not so congested, and different transmitters have similar performance.

Simulation Results

- Multi-carrier LBT, all transmitters share the same primary channel, lambda = 10

LAA ED	WiFi #1	WiFi #3	LAA #2	LAA #4
-62 dBm	75.03	50.85	134.87	154.68
-72 dBm	84.16	75.22	109.45	134.46

- Multi-carrier LBT, the primary channels are different (1, 2, 3, 4), lambda = 10

LAA ED	WiFi #1	WiFi #3	LAA #2	LAA #4
-62 dBm	67.20	44.64	126.72	142.74
-72 dBm	92.75	69.40	84.04	128.29

- ✓ Choosing the same primary channel offer even better performance?
- ✓ In these cases, all APs and LAA eNBs only transmit with 80 MHz bandwidth or not, even though channel bonding and carrier aggregation are adopted. (Greedy)

Simulation Results

- Even though there are multiple channels available, AP/eNB will only occupy the primary channel (no extension), and the probability is p_1 (voice, or we can assume there are 802.11a/n nodes)

- Multi-carrier LBT, all transmitters share the same primary channel, p_1 = 0.3, lambda = 10, LAA ED = -72 dBm

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	104.82	45.72	46.39	123.09
80/60/40/20 MHz	48724/0/0/20885		43970/0/0/18831	

Simulation Results

- Multi-carrier LBT, the primary channels are different (1, 2, 3, 4), p_1 = 0.3, lambda = 10

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	66.71	64.36	119.49	94.92
80/60/40/20 MHz	6110/0/10230/114940		6228/26101/30539/65550	

- ✓ Better overall performance, WiFi nodes occupy only one subchannel at most of time.

- Multi-carrier LBT, the primary channels are different (1, 3, 1, 3), p_1 = 0.3, lambda = 10

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	78.49	45.72	120.04	130.18
80/60/40/20 MHz	21968/0/24470/34940		37203/21185/18996/33191	

- ✓ Best overall performance, LAA is more aggressive.

Simulation Results

- We assume LAA also adopts channel bonding as 802.11ac does

- Multi-carrier LBT, all transmitters share the same primary channel, p_1 = 0.3, lambda = 10, LAA ED = -72 dBm

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	111.59	39.77	40.76	141.19
80/60/40/20 MHz	49239/0/0/21146		49172/0/0/W21098	

Simulation Results

- Multi-carrier LBT, the primary channels are different (1, 2, 3, 4), p_1 = 0.3, lambda = 10

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	65.47	65.50	75.08	78.23
80/60/40/20 MHz	3630/0/8540/122460		5990/0/6310/122840	

- Multi-carrier LBT, the primary channels are different (1, 3, 1, 3), p_1 = 0.3, lambda = 10

	WiFi #1	WiFi #3	LAA #2	LAA #4
Throughput	87.11	63.03	73.67	92.15
80/60/40/20 MHz	35239/0/18039/22601		34079/0/22674/24492	

✓ More fair, but the overall performance is worse than the case of CA.

Next steps

- Evaluate a larger network (4 APs and 4 eNBs)
- Evaluate the performance of multi-carrier LBT with Option 2
- Study the channel selection problem