Cisco Cooperative Project

Start Recording

LAA with Multicarrier LBT

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July 1, 2016

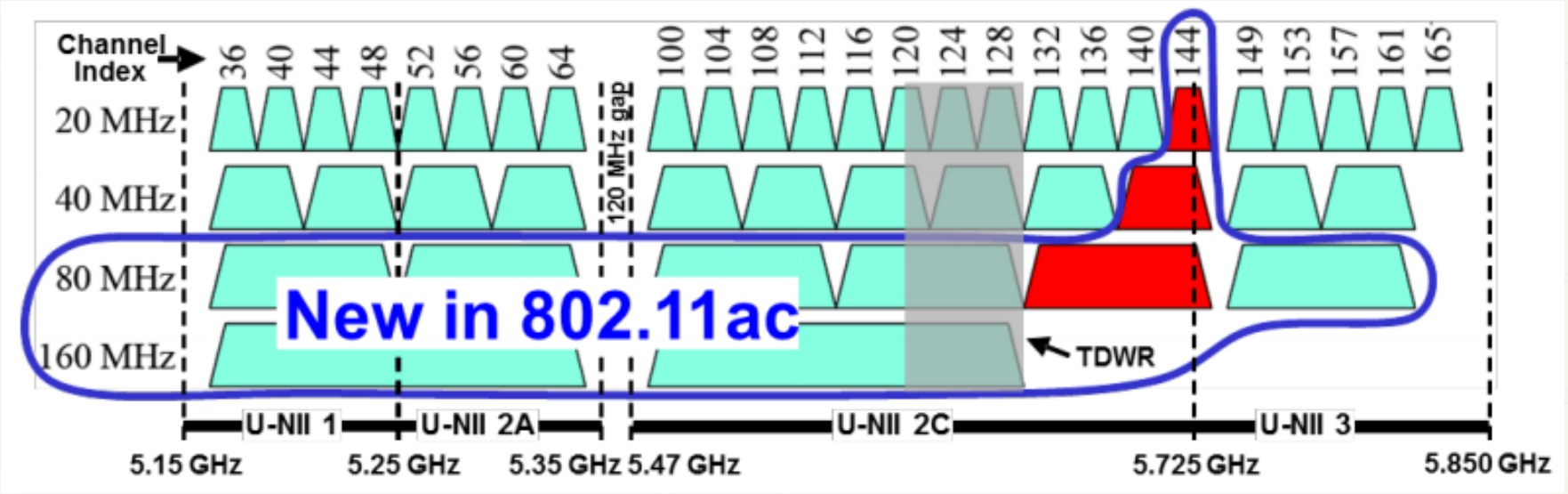
Outline

- Paper about adaptive ED
- 5-6 GHz Band
  - ✓802.11ac
  - ✓LTE-U band
  - ✓Power limitation
- Simulation Results
- Next Steps

Paper about adaptive ED

5-6 GHz Bands

❖ Operating channels for 802.11ac in U.S.[1]



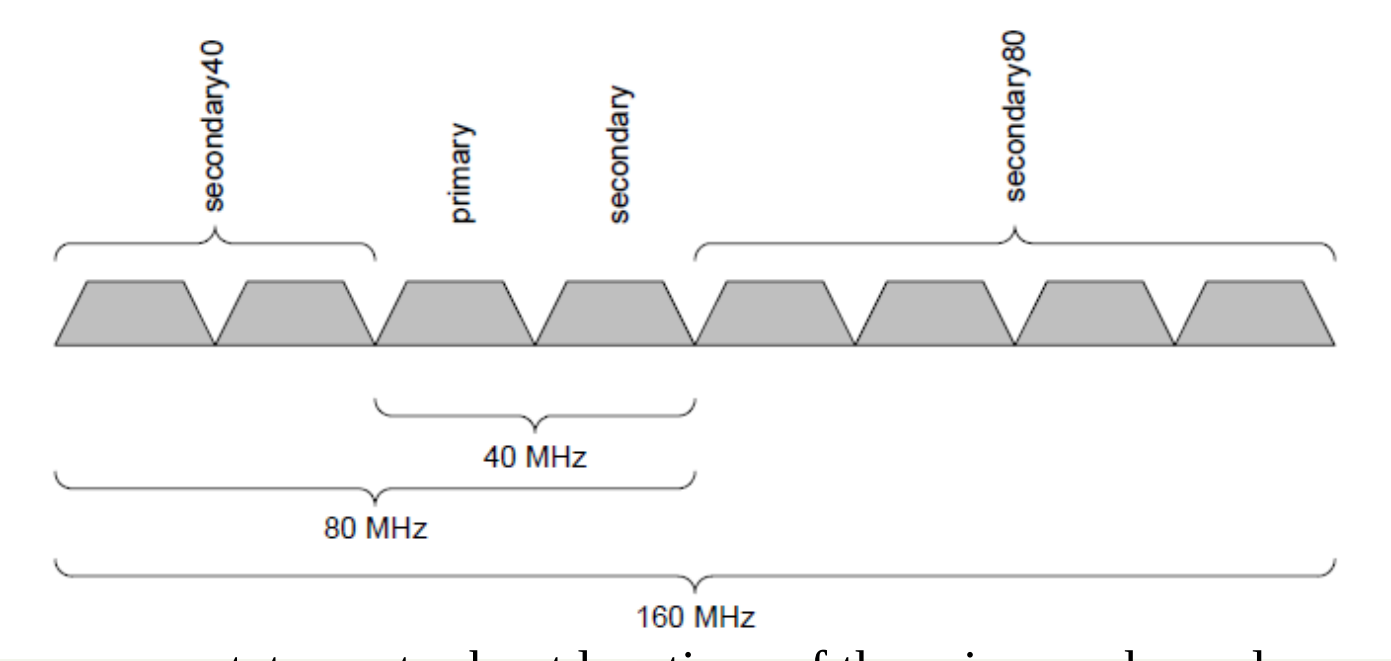
✓ Four bands: U-NII 1, U-NII 2A, U-NII 2C, U-NII 3

✓ The standard permits operation in any of the channels shown, as well as simultaneous operation in any two non-adjacent 80-MHz channels.

[1] FCC, "*Guidance for IEEE Std 802.11ac™ Devices Emission Testing*", Aug. 14, 2014.

5-6 GHz Bands

- Channel bonding for 802.11ac[2]

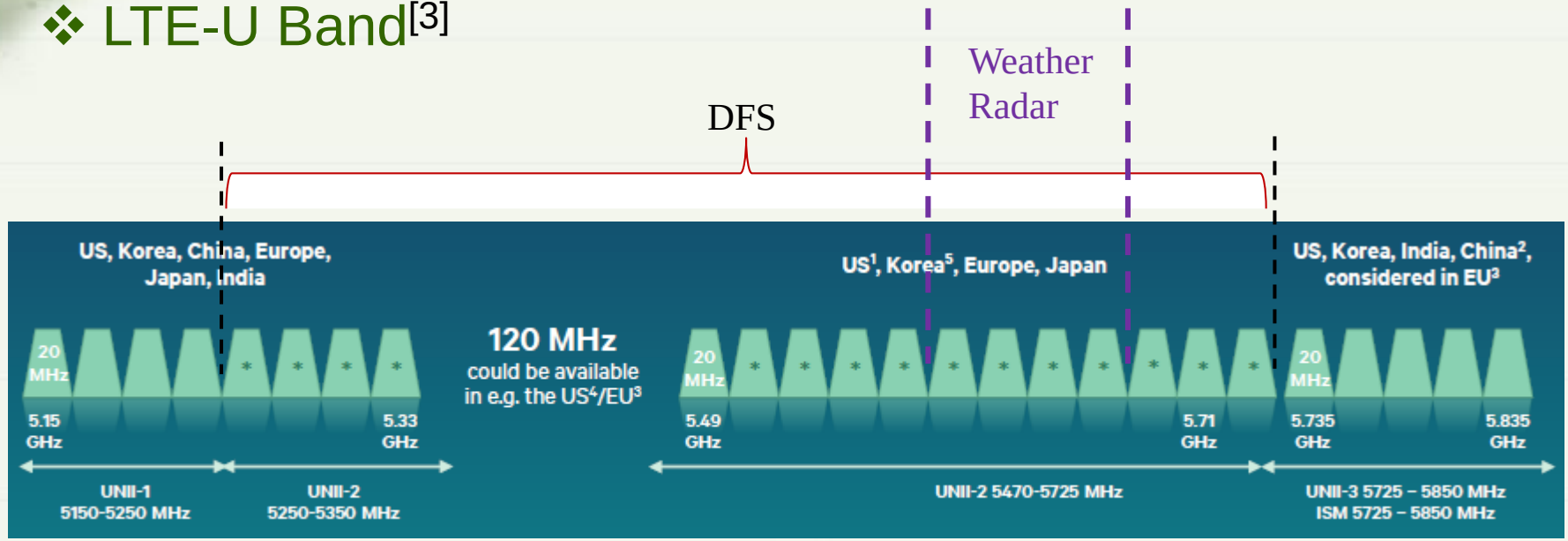


- ✓ There are no statements about locations of the primary channels. However, in three examples ([2], pp. 297), for the bandwidth of 80, 160 and 80+80 MHz, PC index are 36, 56, and 161, respectively. Thus, PC could be any 20 MHz channel.

[2] *Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE Std 802.11ac™-2013.*

5-6 GHz Bands

- LTE-U Band[3]

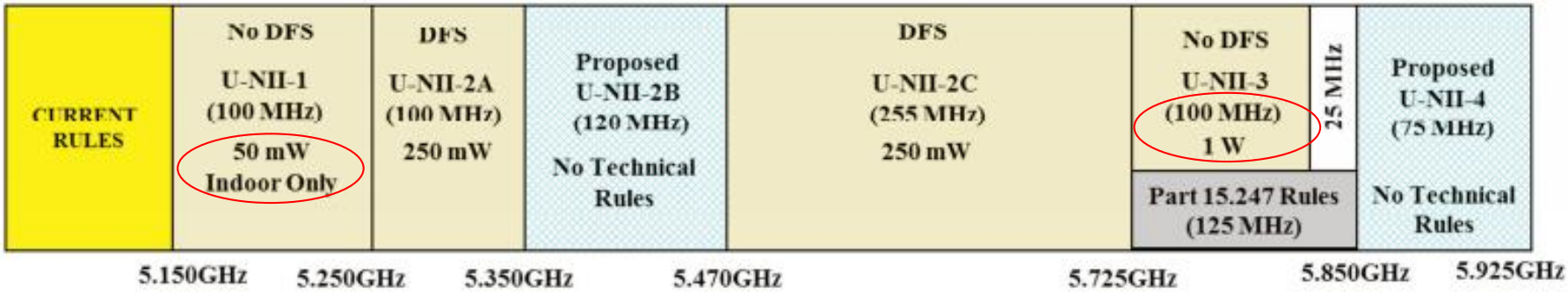


- ✓ LTE-U will use UNII-1 & UNII-3 (200MHz) per LTE-U forum
- ✓ LAA is expected to cover additional 5 GHz bands

[3] Qualcomm, *"LTE-U/LAA, MuLTEfire™ and Wi-Fi; making best use of unlicensed spectrum"*, Sept. 2015.

5-6 GHz Bands

- Power limitations in U.S.[4][5]



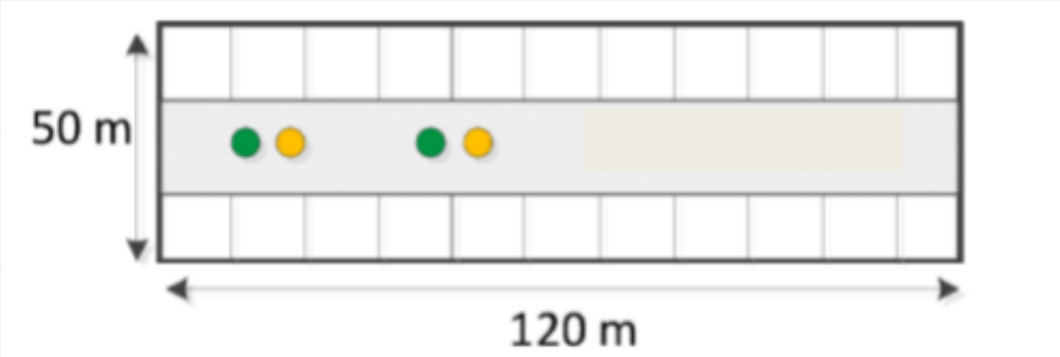
- ✓ In [4], the total power limit is 50 mW (17 dBm) and 1 W (30 dBm) for U-NII 1 and U-NII 3.
- ✓ In [5], the power limit for U-NII 1 is increased to 250 mW (24 dBm) for indoor devices, and 1 W (30 dBm) for outdoor devices.

[4] FCC, "*Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*", Apr. 1, 2014 (https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-30A1.pdf)

[5] FCC, "*Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*", May 1, 2014. (https://www.federalregister.gov/articles/2014/05/01/2014-09279/unlicensed-national-information-infrastructure-u-nii-devices-in-the-5-ghz-band)

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)



  - ✓ 9 channels in total (U-NII 1 and U-NII 3)
  - ✓ FTP file size: 0.5 Mbytes, Poisson process: lambda = 25
  - ✓ LAA can aggregate channels in different bands
  - ✓ Transmit power: 200 mW (23 dBm) for all transmitters (?)

Simulation Results: 9 channels

- PC: 1,4,5,9, LAA randomly choose 3 channels as SC in each trial
  - ✓Throughput

	WiFi #1	WiFi #3	LAA #2	LAA #4
-70 dBm	143.43	202.05	108.96	212.55
-75 dBm	138.55	223.23	87.65	168.52

  - ✓Bandwidth

	WiFi	LAA
-70 dBm	82368/0/33910/19236	39968/30423/32940/14755
-75 dBm	86234/0/36171/12850	15627/26445/39046/41234

- WiFi #3's performance is better than that of WiFi #1: there are no competitions among WiFi #1 and WiFi #3, but LAA #4's PC is not within WiFi #3's 80 MHz band

Simulation Results: 9 channels

- PC: 1,4,5,9, LAA choose any idle channels (at most 3) as SC per transmission
  - ✓Throughput

	WiFi #1	WiFi #3	LAA #2	LAA #4
-70 dBm	110.99	221.16	154.53	267.04
-75 dBm	116.18	235.75	130.05	206.47

  - ✓Bandwidth

	WiFi	LAA
-70 dBm	89349/0/41840/2377	99571/4324/8436/18035
-75 dBm	90308/0/37147/3079	64595/8798/11336/42331

- LAA's performance is better: 1) one more channel, 2) flexible carrier aggregation
- Decreasing LAA ED can help to achiever fairness

Simulation Results: 9 channels

- PC: 1,2,5,6, LAA choose any idle channels (at most 3) as SC per transmission
  - ✓Throughput

	WiFi #1	WiFi #3	LAA #2	LAA #4
-70 dBm	72.24	84.98	231.13	216.96
-75 dBm	97.93	103.16	176.85	180.35

  - ✓Bandwidth

	WiFi	LAA
-70 dBm	22510/0/30/112680	113370/14300/20/10
-75 dBm	51748/0/6/52323	83819/18448/66/14

- WiFi suffers from performance loss, the number of transmissions with 80 MHz decreases.

Discussions

- Adapting LAA's energy detection thresholds can help to achieve fairness between WiFi (channel bonding) and LAA (carrier aggregation). Due to higher physical rate of LAA, the overall performance may decrease.

- There are 9 channels but only 4 transmitters. PC selection is very straightforward, what about 8 or even more transmitters?

Next steps

- Speed up the simulation, and simulate a larger network size
- Work on adapting LAAED (together with bandwidth) to achieve fairness
- Work on the problem of PC and SC selection