Cisco Cooperative Project

Start Recording

LAA with Multi-carrier LBT: Option 2

Student: Li Li
Advisors: Len Cimini, Chien-Chung Shen

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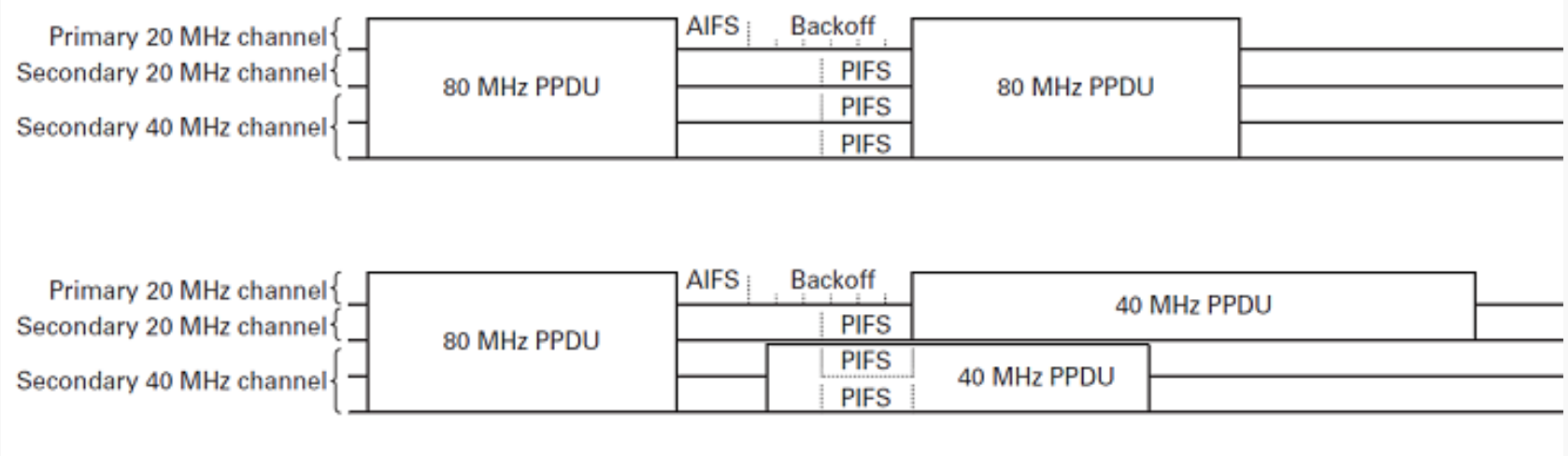
Outline

- Multi-carrier LBT
  - ✓ Option 1 & Option 2
  - ✓ Results
- Simulation Results
- Discussion & Future Work

Multi-carrier LBT

❖Option 1 (Wi-Fi like) [1]-[3]

LAA eNB performs LBT on only one unlicensed carrier (LBT carrier, “primary” channel)



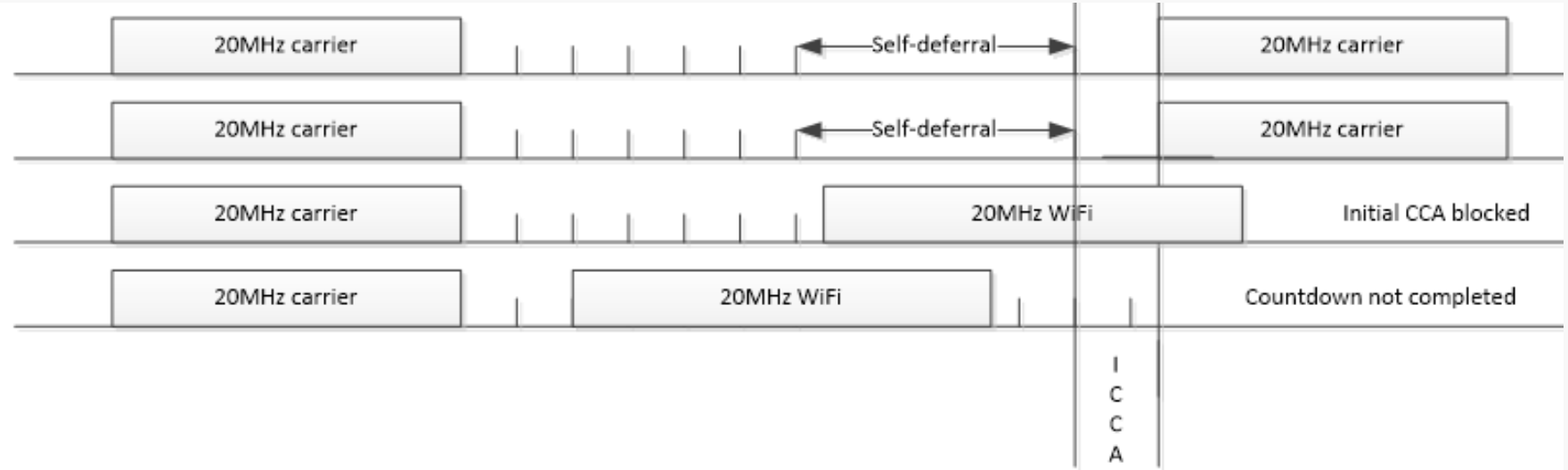
- ✓LBT carrier determination: 1) pre-selection; 2) dynamic selection: the one finished LBT procedure first
- ✓Carrier aggregation: 1) Wi-Fi channel bonding rule; 2) LTE carrier aggregation rule

[1] Qualcomm, “R1-153868: Multi-carrier LBT Operation,” Aug. 24, 2015
[2] Ericsson, “R1-157258: On Channel Access Solutions for LAA Multi-Carrier Transmission,” Nov. 16, 2015
[3] Nokia, Alcatel-Lucent, “R1-160915: Discussion on Multi-Carrier LBT for LAA DL,” Feb. 15, 2016

Multicarrier LBT

❖Option 2

LAA eNB performs LBT Cat 4 on more than one unlicensed carriers



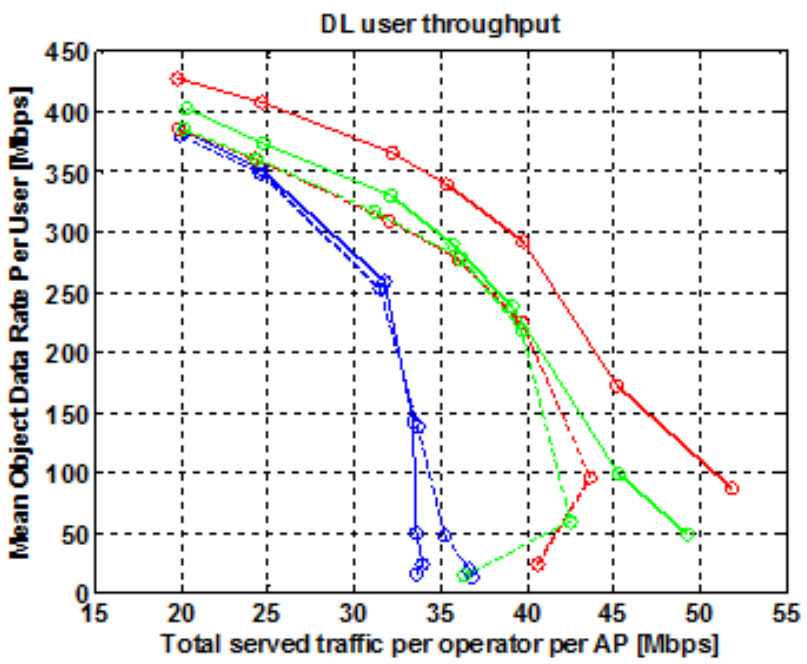
✓Two variations[1]:

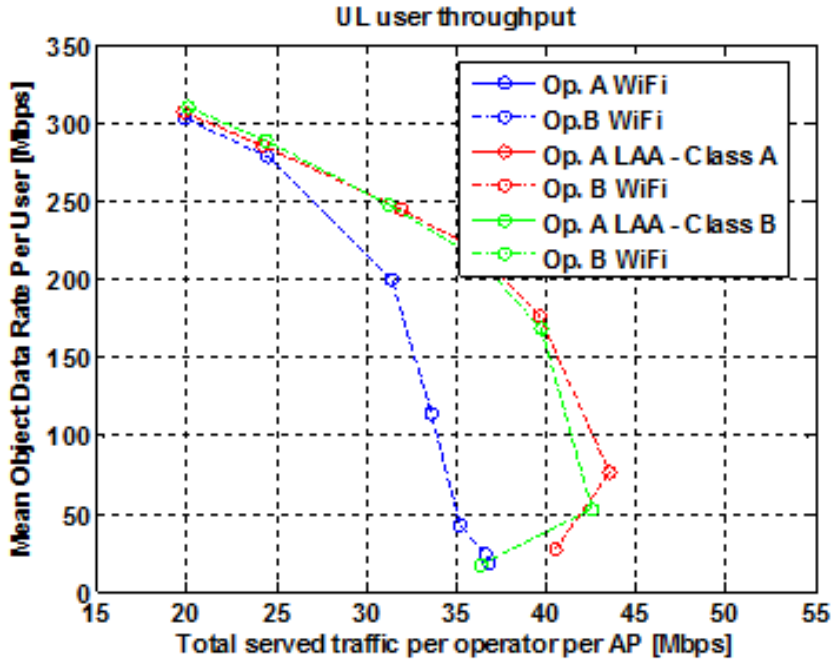
1) LBT scheme exit the self-defer stage if the number of the available channels is equal or larger than the pre-set threshold (early determination);
2) LBT scheme do the final one-shot check at the end of the self-defer stage

[1] Braodcom, "R1-157009: Further Discussion on LAA DL Multi-channel LBT," Nov. 16, 2015

Multicarrier LBT

❖Results[1]-[2]





- Class A (Option 1): dynamic selection, CA
- Class B (Option 2): self-defer period: 15 CCA slots
- 4 carriers
- LAA ED: -72 dBm

✓An LAA network using multi-channel transmissions can coexist well with Wi-Fi networks

✓Class A is a bit better than Class B (Option 1 with dynamic selection is similar to Option 2)

✓Different companies with different simulation settings may have different conclusions

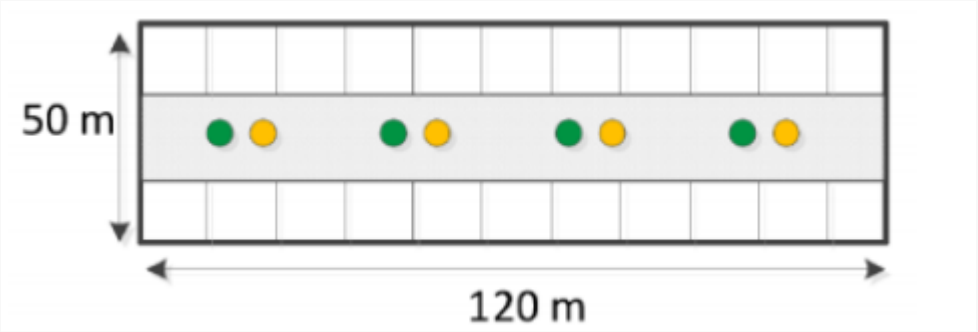
[1] Ericsson, "R1-154624: Discussion on Wi-Fi and DL-only LAA Coexistence for Multi-Channel Transmission," Aug. 24, 2015

[2] Ericsson, "R1-157258: On Channel Access Solutions for LAA Multi-Carrier Transmission," Nov. 16, 2015

Simulation Results

❖Simulation Setting

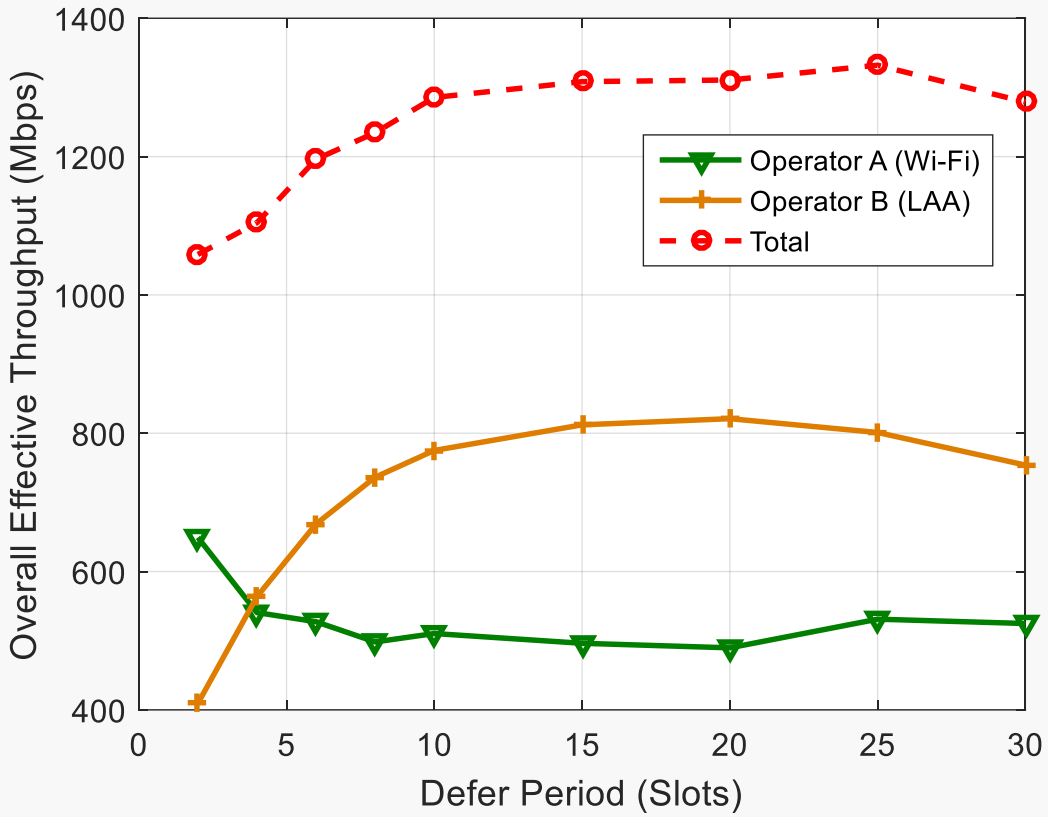
- ✓4 APs + 4 eNBs: each AP/eNB has five users, and each UE uniformly and randomly distributed around its associated transmitter

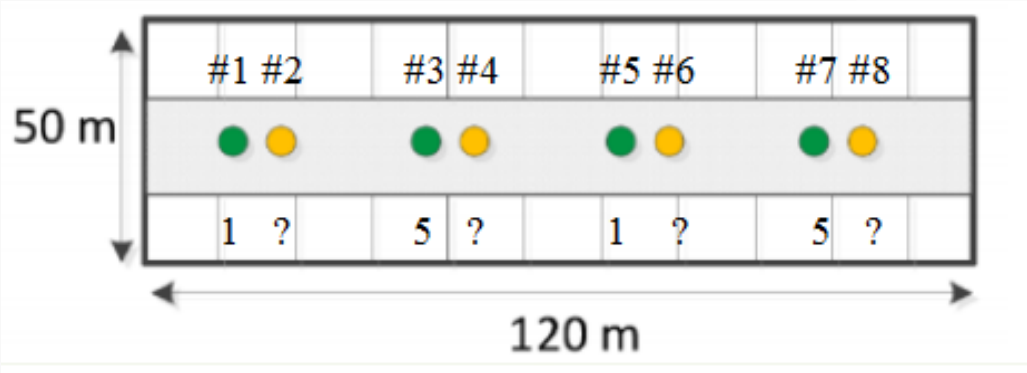


- ✓8 carriers in total (U-NII 1 and U-NII 3)
- ✓FTP file size: 0.5 Mbytes, Poisson process: lambda = 25
- ✓Transmit power: 200 mW (23 dBm) for all transmitters
- ✓Multi-carrier LBT: Option 2.2 (no early determination): one carrier reaches to the defer period, and other carriers are chosen by channel index if idle
- ✓LAA can aggregate at most 4 carriers

Simulation Results

❖LAA-ED: -65 dBm, Wi-Fi's primary channel: 1,5,1,5



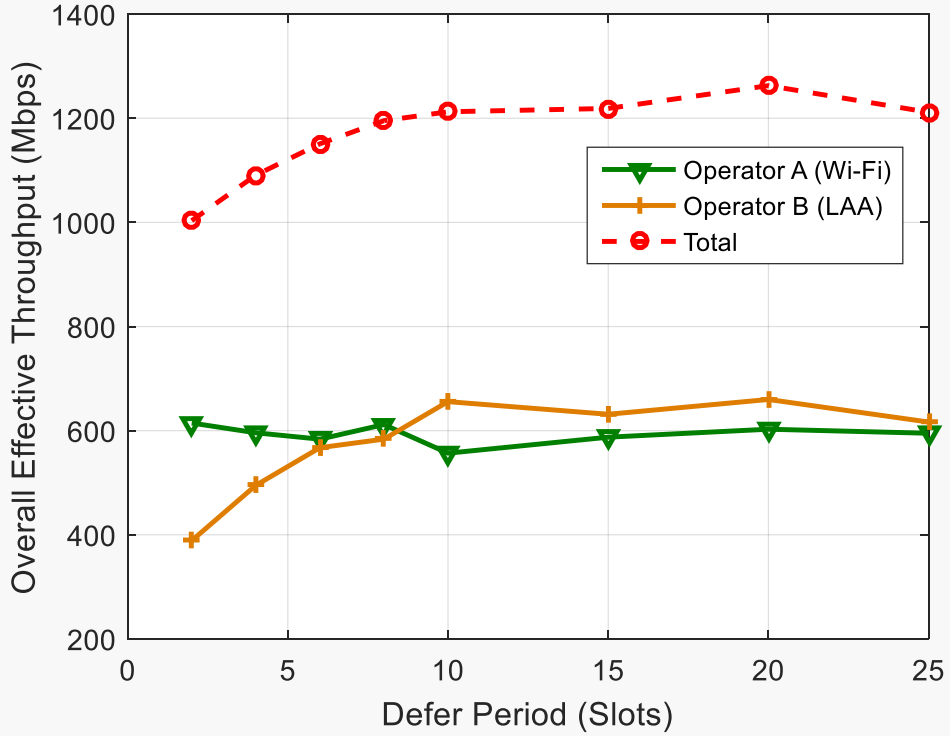


- With a larger self-deferral waiting time, the probability that multiple carriers complete the LBT procedure is greatly enhanced: LAA improves, WiFi degrades
- However, if the waiting time is too long, the system's performance will decrease

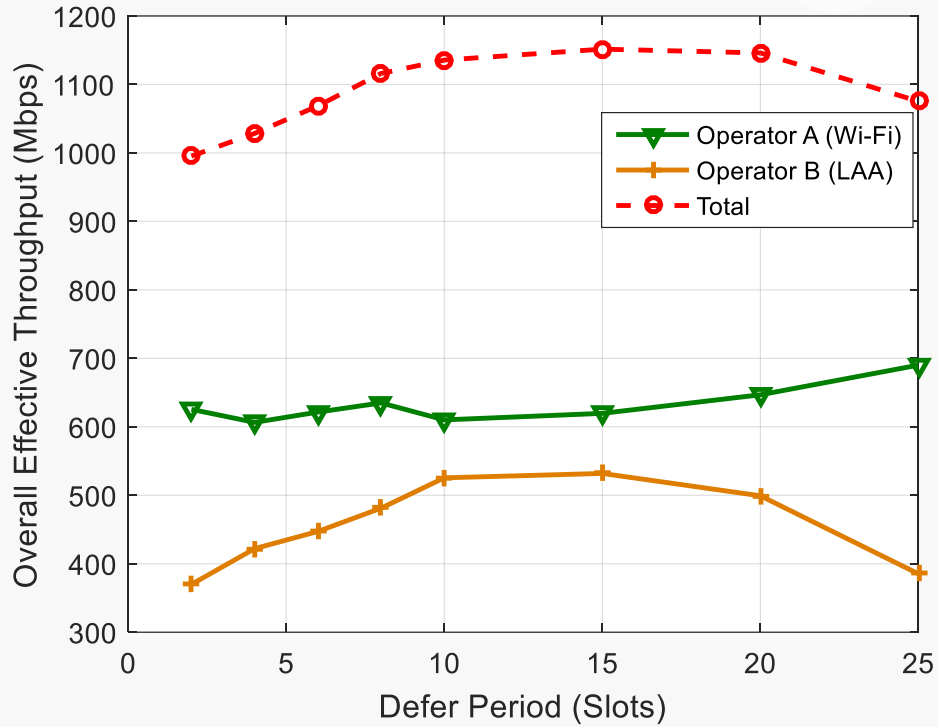
Simulation Results

❖LAA-ED: -70/-75 dBm

-70 dBm



-75 dBm

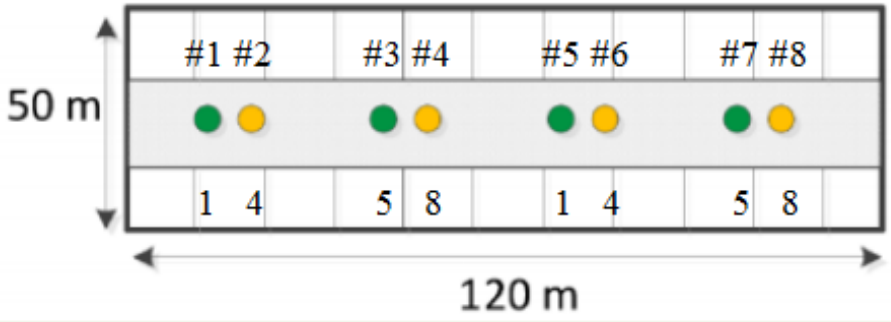


- ✓ Decreasing LAA-ED is beneficial to WiFi; the overall performance also decreases
- ✓ Choosing a defer between 10 and 20 slots may be a good choice in this case. (In Ericsson's simulations, it is 15; in Broadcom's simulations, it is 10)

Simulation Results

❖Option 1 (LBT carrier is pre-selected)

✓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 (947.01): 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

Simulation Results

❖Option 2 (Self-deferral: 15 CCA slots)

✓PC: 1, ?, 5, ?, 1, ?, 5, ?

	WiFi #1	WiFi #3	WiFi #5	WiFi #7	Op. A	LAA #2	LAA #4	LAA #6	LAA #8	Op. B	Total
-65	111.94	145.19	64.24	174.89	496.25	204.91	183.21	181.28	242.72	812.12	**1308.38**
-70	145.98	160.70	89.69	191.10	587.46	151.34	151.63	115.19	213.26	631.43	**1218.89**
-75	135.06	134.61	161.64	188.35	619.66	151.43	106.91	71.40	202.17	531.90	**1151.56**

- In this case, the performance of Option 2 is better than that of Option 1. However, if dynamic selection for LBT carrier is chosen for Option 1, its performance can be improved (Option 1 may even outperform Option 2).
- Generally, Option 1 and Option 2 have similar performance, and they can coexist well with Wi-Fi networks by choosing suitable LAA-ED.

Discussion & Future Work

- ✓Improve simulations
  - There should be a limitation on the total transmit power
  - Wi-Fi can have 160 MHz or 80+80 MHz, LAA can aggrigate 5 carriers
  - Simulate LAA with channel bonding to see the performance difference

- ✓Adapting the LAA-ED to improve the system performance and fairness?

- ✓How to choose the “other” carriers in Option 1 and 2.