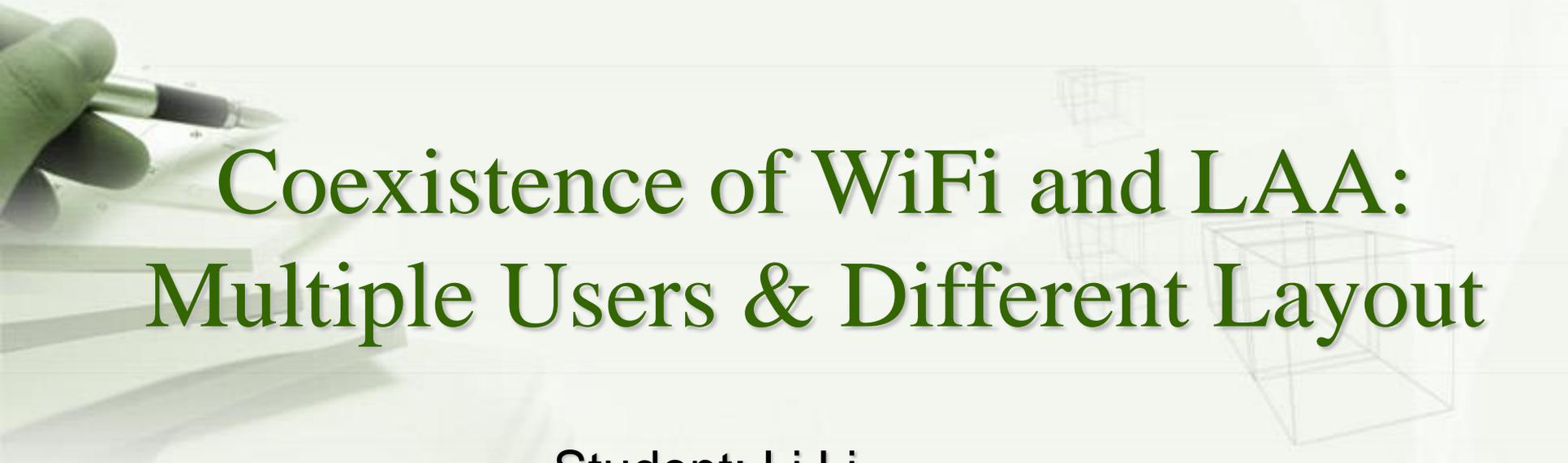# Cisco Cooperative Project

Coexistence of WiFi and LAA: Multiple Users & Different Layout

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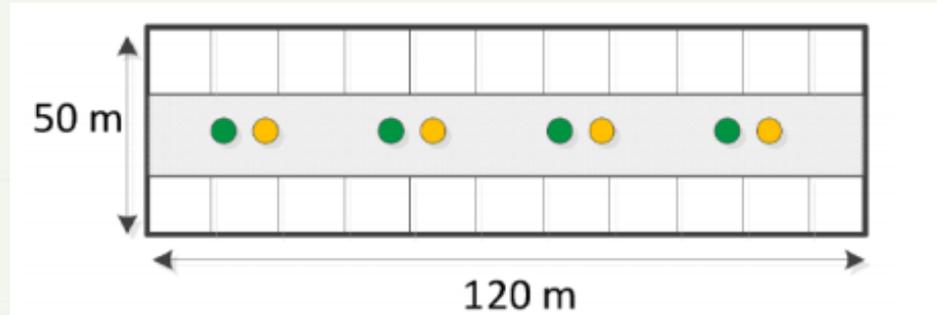Feb. 25, 2016

Outline

➢Results with Multiple Users

➢Different Layout

➢Next Steps

➢Appendix

❖ Simulation Setting

  ✓ 4 APs, 4 eNBs, and each AP/eNB has five users

  ✓ Load ratio: 0.5/0.8

  ✓ LAA energy detection threshold: -65/-70/-75 dBm

  ✓ LAA SNR threshold: 17.5 (75.6 Mbps); WiFi SNR threshold: 20 dB
    (65 Mbps)

Results with Multiple Users

❖ Simulation Setting

  ✓ Traffic model: eNB/AP generates data according to Possion process, a UE/client is picked at random for data transmission. (Is it equivalent to the traffic model in 3GPP?)

### Table A.2.1.3.1-1. FTP Traffic Model 1

Parameter	Statistical Characterization
File size, S	2 Mbytes (0.5 Mbytes optional) (one user downloads a single file)
User arrival rate λ	Poisson distributed with arrival rate λ

  ✓ Only downlink, there is also no competition among clients connected with one AP.

Results with Multiple Users: WiFi/WiFi

❖ Load ratio of 0.8

WiFi/WiFi	1	3	5	7	2	4	6	8
Throughput (Mbps)	21.23	9.58	9.46	20.22	20.11	9.87	9.77	21.34
Delay (ms)	9.48	19.53	20.06	10.33	10.35	18.65	18.69	9.42
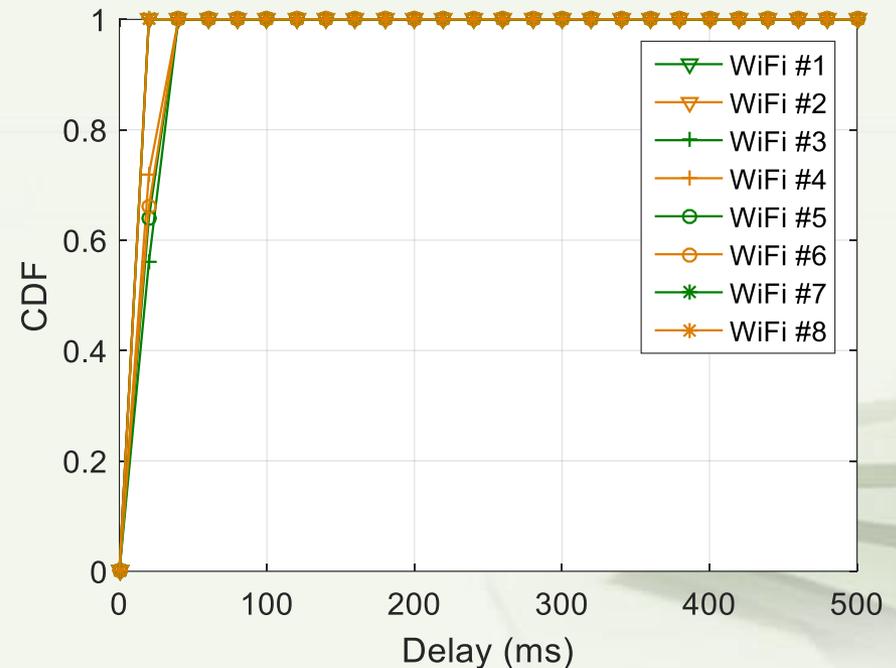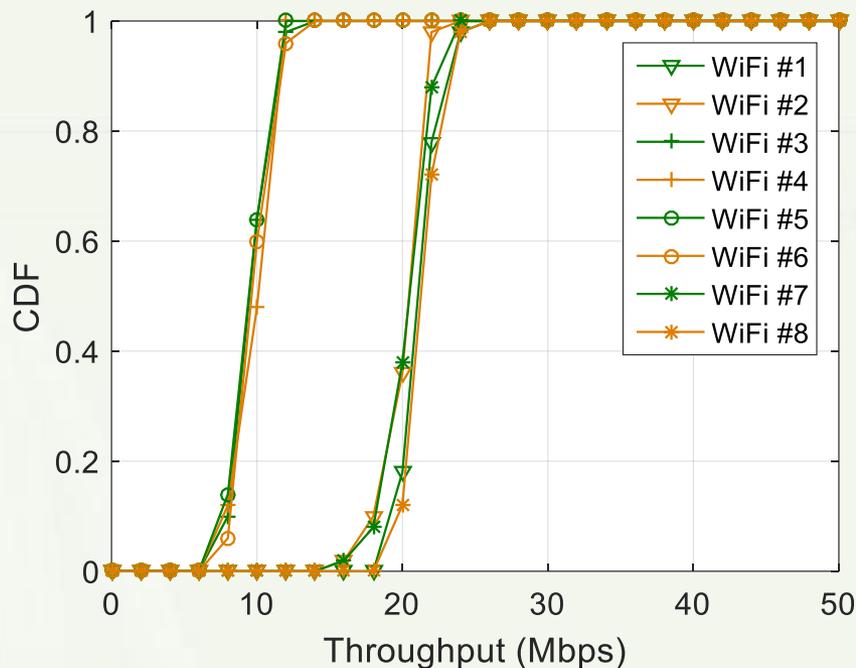
Results with Multiple Users: WiFi/LAA

❖ Load ratio of 0.8

WiFi/WiFi	1	3	5	7	2	4	6	8
-	21.23	9.58	9.46	20.22	20.11	9.87	9.77	21.34

WiFi/LAA	1	3	5	7	2	4	6	8
-65 dBm	21.50	7.27	7.46	12.79	26.16	21.06	18.75	30.03
-70 dBm	23.26	9.04	9.46	17.69	24.55	19.30	15.01	32.10
-75 dBm	27.59	13.20	18.17	22.57	18.94	6.82	6.00	23.52

✓ Due to this specific layout, nodes in the margin have some advantages.

✓ At -70 dBm, Operator A (WiFi) in Step 1 has similar performance as in Step 2 in terms of "mean".
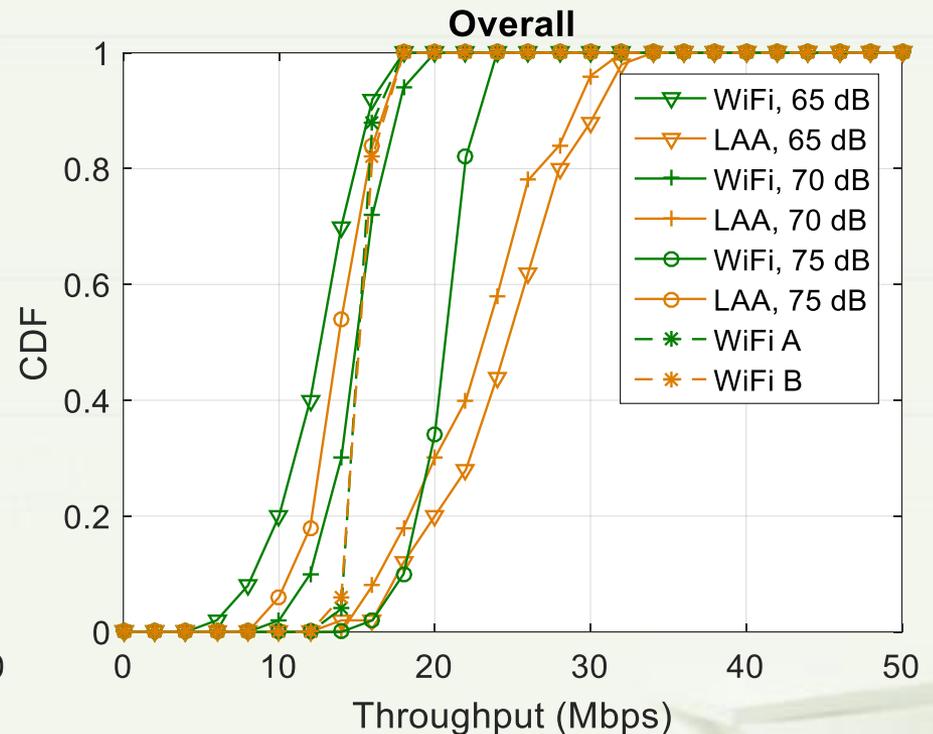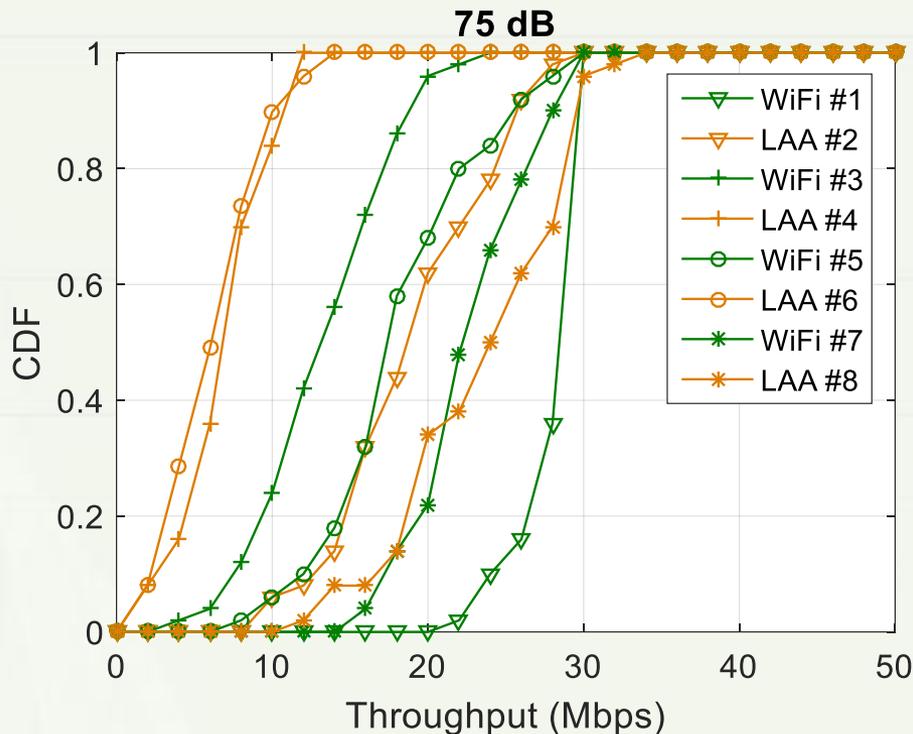
Results with Multiple Users: WiFi/LAA

❖ Load ratio of 0.8: - 65/70 dB (throughput)
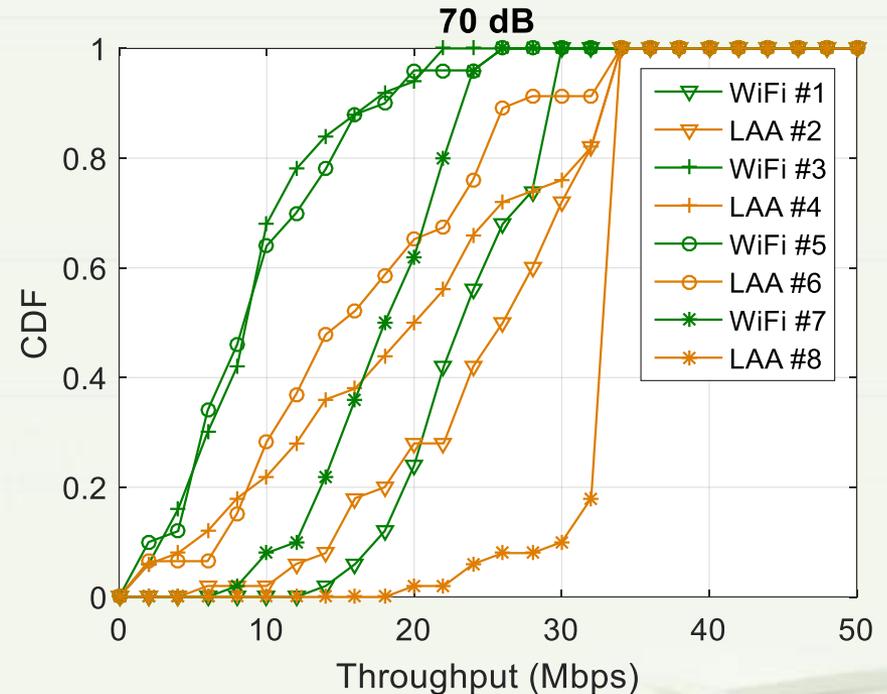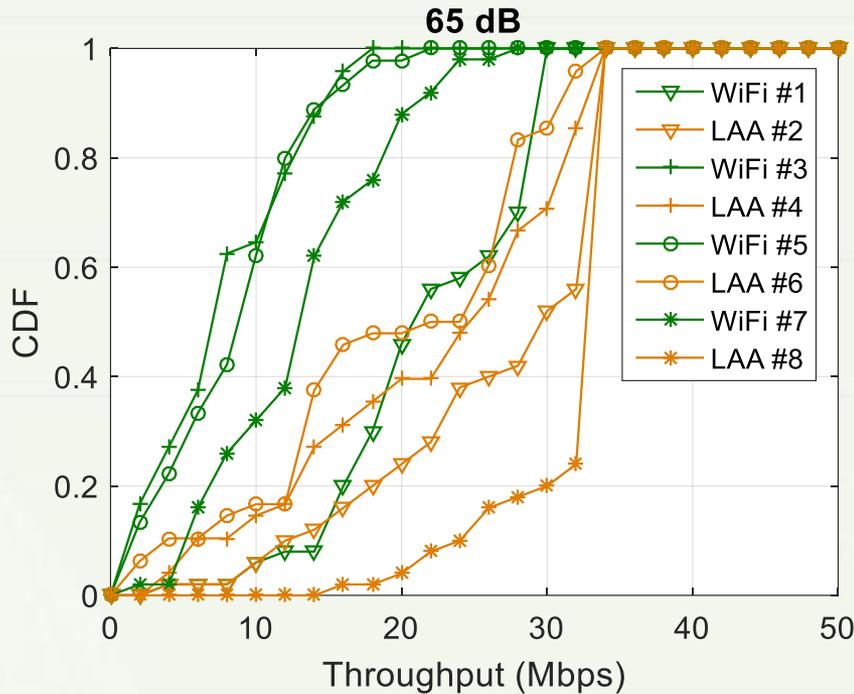
✓ Collisions may happen, the curves look not so "neat" as the pure WiFi case (more values in the middle).

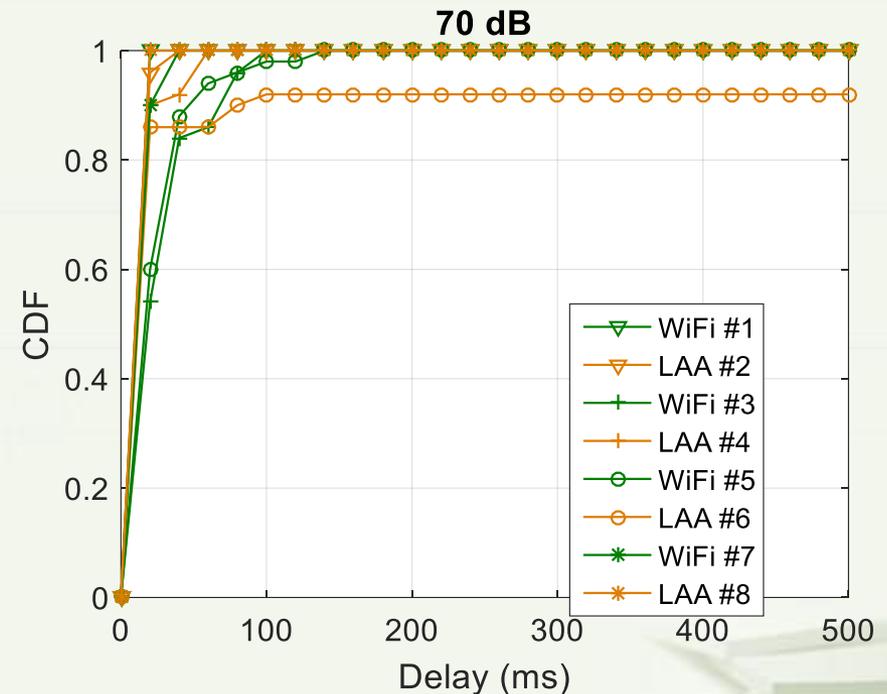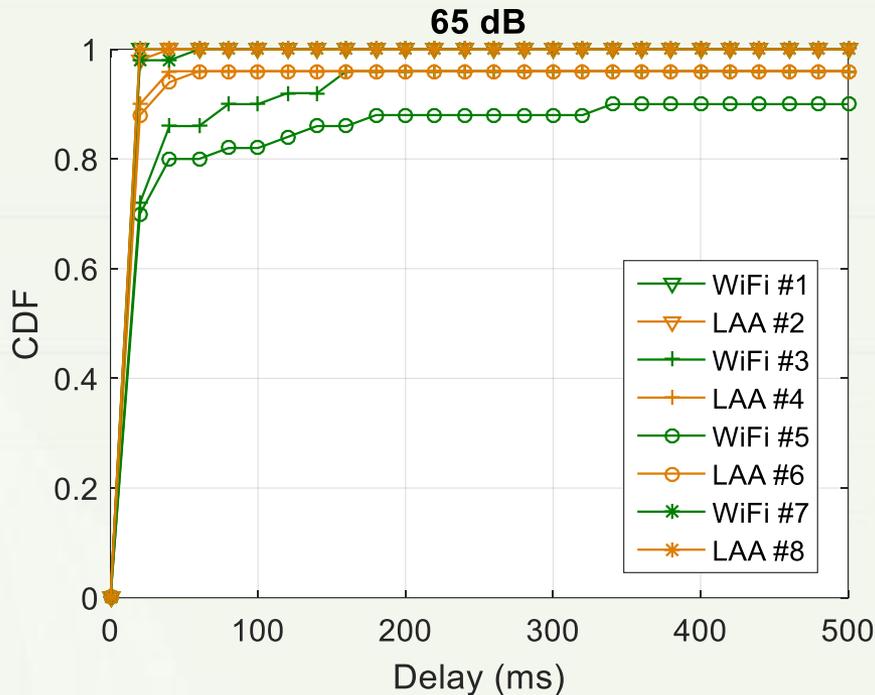❖ Load ratio of 0.8: - 75dB, overall (throughput)

✓ The "overall" performance is the performance for Operator A or Operator B, not for individual AP or eNB.

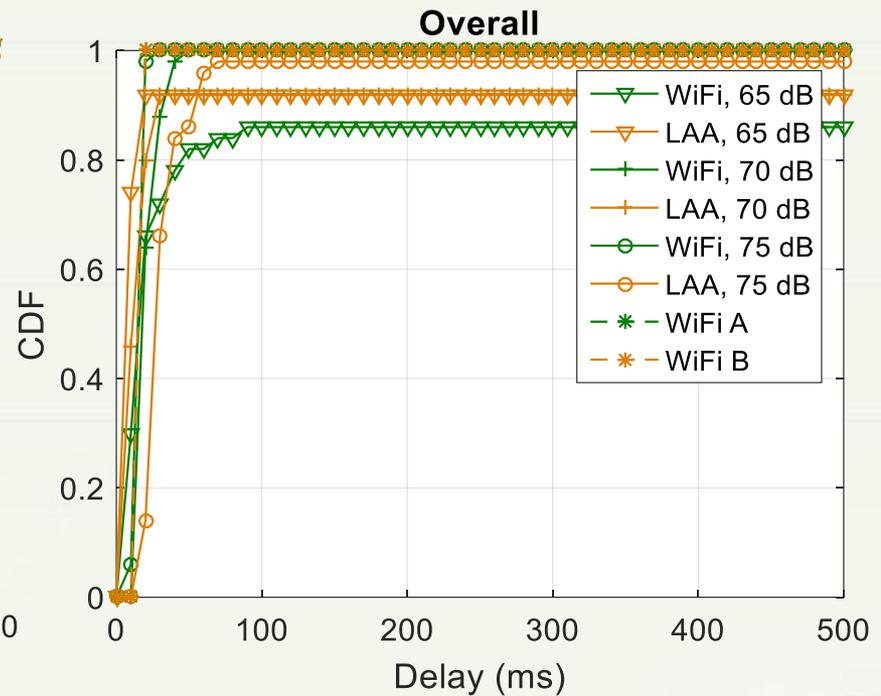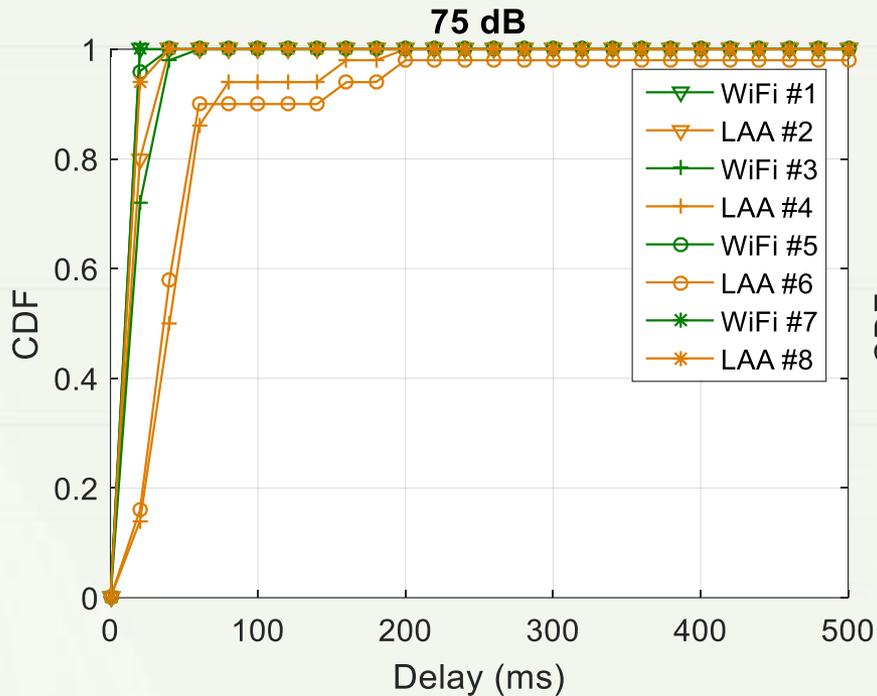✓ "-70 dBm" is a good choice in terms of throughput and fairness.

Results with Multiple Users: WiFi/LAA

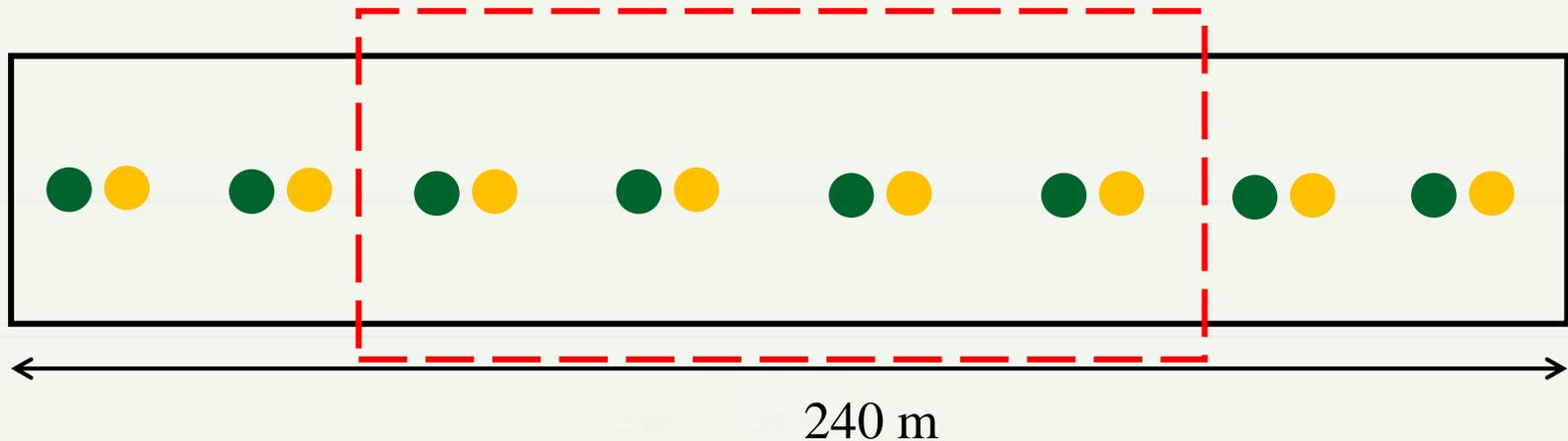❖ Load ratio of 0.8: - 65/70 dB (delay)

❖ Load ratio of 0.8: - 75dB, overall (delay)

✓ In terms of delay, "-65 dBm" is not a good choice (a lot of collision in this case).

Different Layout

❖ To deal with the "edge effect", we consider a layout with 16 transmitters, but only care about the performance of 8 transmitters in the middle.

240 m

❖ Simulation Setting

✓ 8 APs, 8 eNBs, and each AP/eNB has five users

✓ Load ratio: 0.5/0.8

✓ LAA energy detection threshold: -65/-70/-75 dBm

Different Layout

❖ WiFi/WiFi, load ratio of 0.8, throughput

1	3	5	7	9	11	13	15
24.9642	5.5567	18.1506	11.6432	12.1994	17.6875	5.6860	23.9948
2	**4**	**6**	**8**	**10**	**12**	**14**	**16**
24.2348	5.5696	18.1715	11.7581	11.5174	17.9967	5.6247	25.0638

✓ For pure WiFi networks, only preamble decoding works.

✓ There are still some "edge effects": #1 and #2 have some advantages, this means that #3 and #4 will have a bad performance, then, again, it is beneficial to #5 and # 6. (i.e, good, bad, good, bad, …)

✓ For these 8 transmitters in the middle, the "edge effects" are not so obvious as the 3GPP layout.
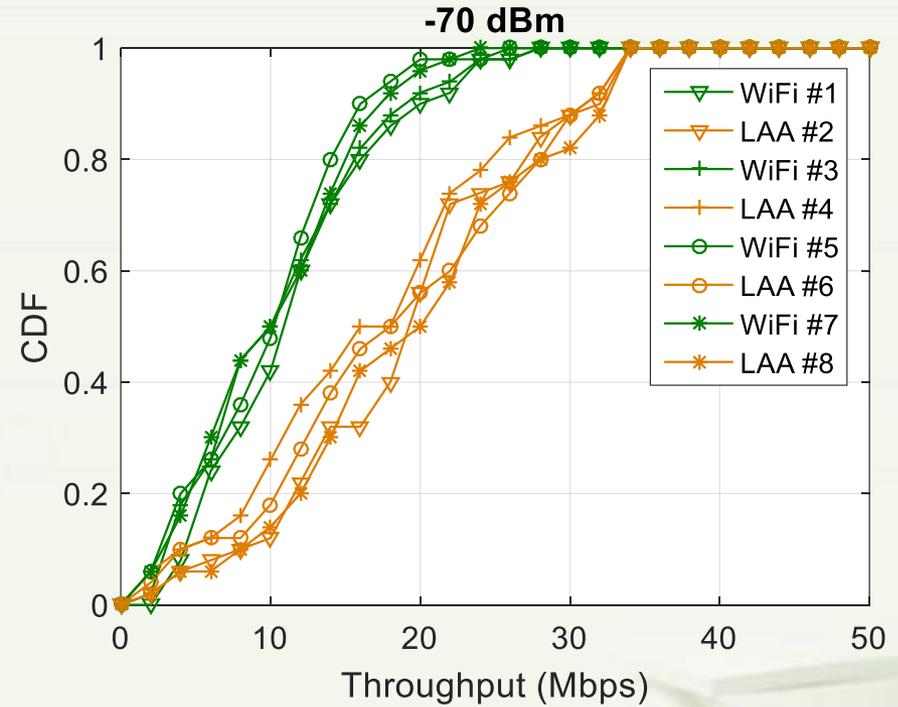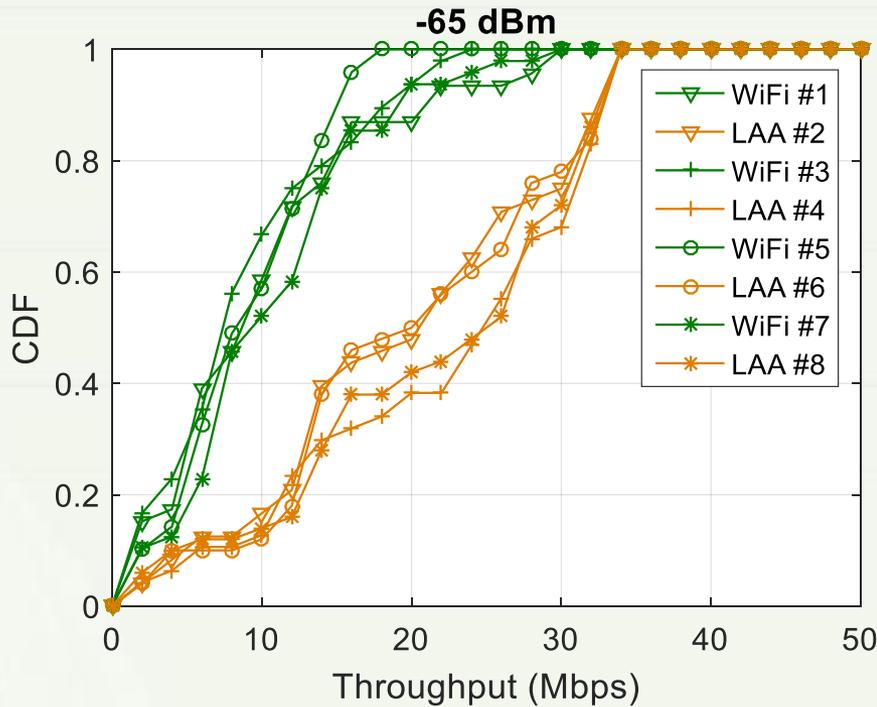
Different Layout

❖ WiFi/WiFi, load ratio of 0.8, CDF curves

Different Layout

❖ WiFi/LAA, load ratio of 0.8, throughput

	1	3	5	7	9	11	13	15
-65	21.4353	6.2263	8.9327	8.0635	8.5726	9.8966	8.1618	15.1514
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**
	25.8295	23.0946	18.7828	20.4888	19.6241	21.3248	18.3022	30.9290
-70	23.7044	7.7788	11.3839	10.3863	9.8131	9.9635	11.2961	18.7975
	23.7182	18.7574	18.9551	16.5522	18.2063	19.2454	14.5758	31.4537
-75	27.2079	13.6216	18.7804	17.6430	17.4971	17.8117	16.2320	22.8876
	19.1365	5.2889	9.0384	6.6382	8.3746	9.1514	5.0652	24.4959

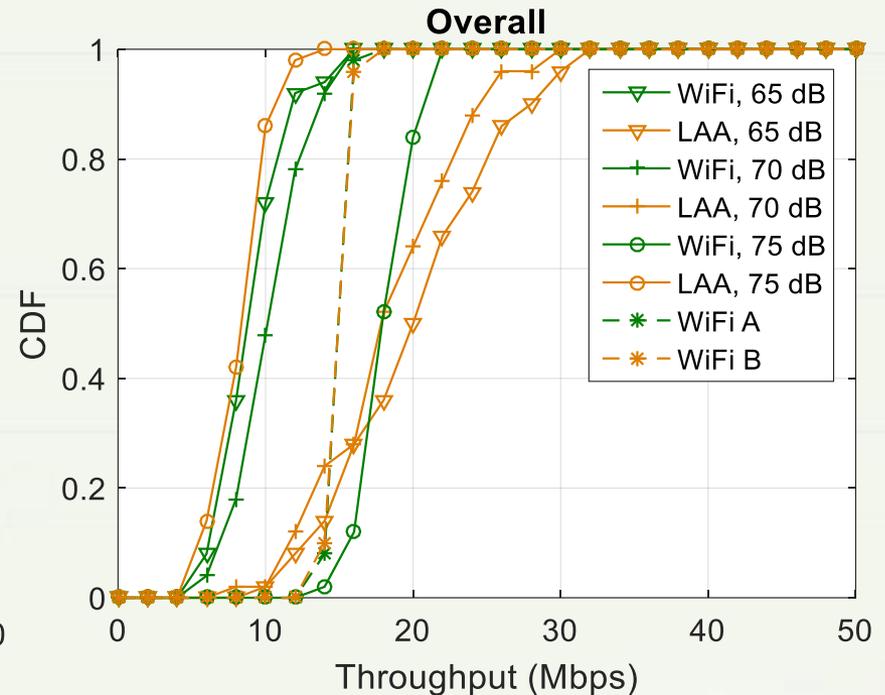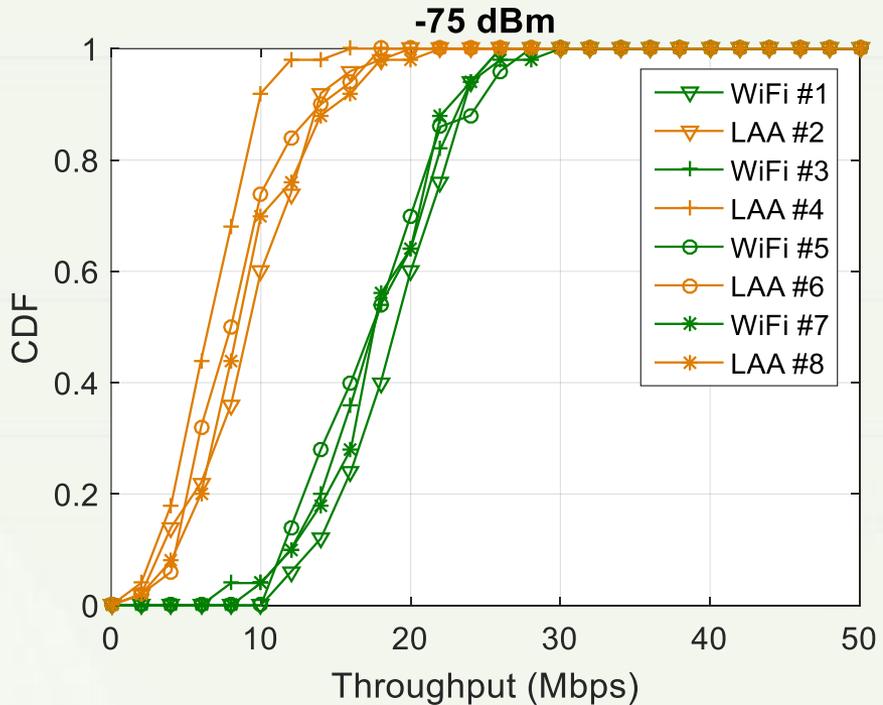✓ Throughputs of different APs (eNBs) in the middle are quite close to each other (fairness?)

Different Layout

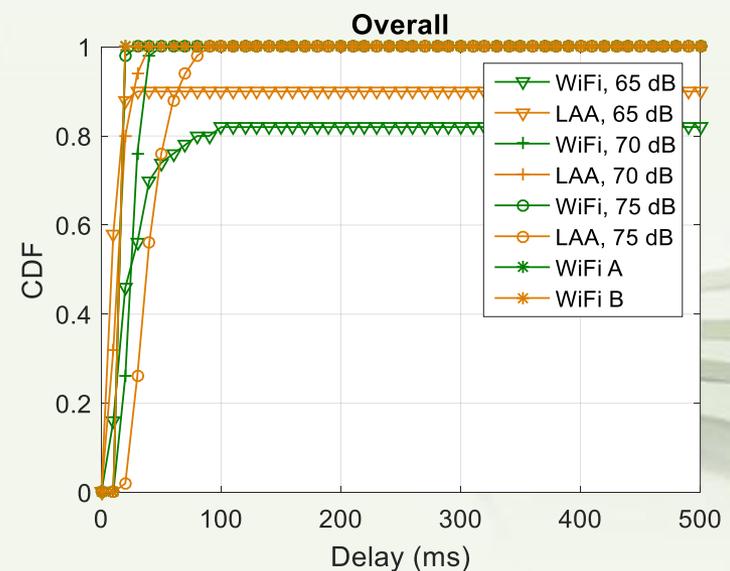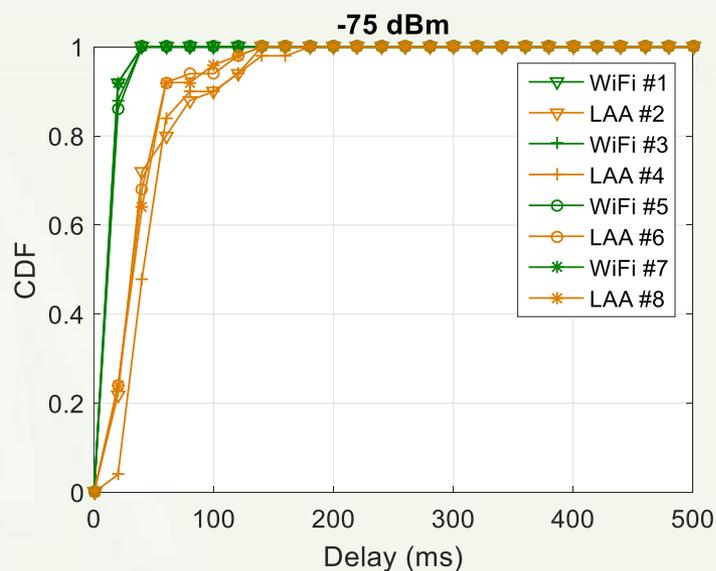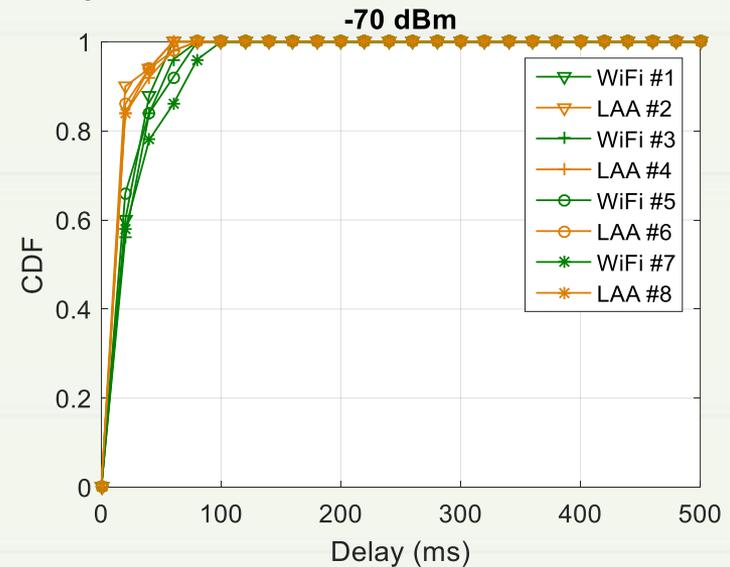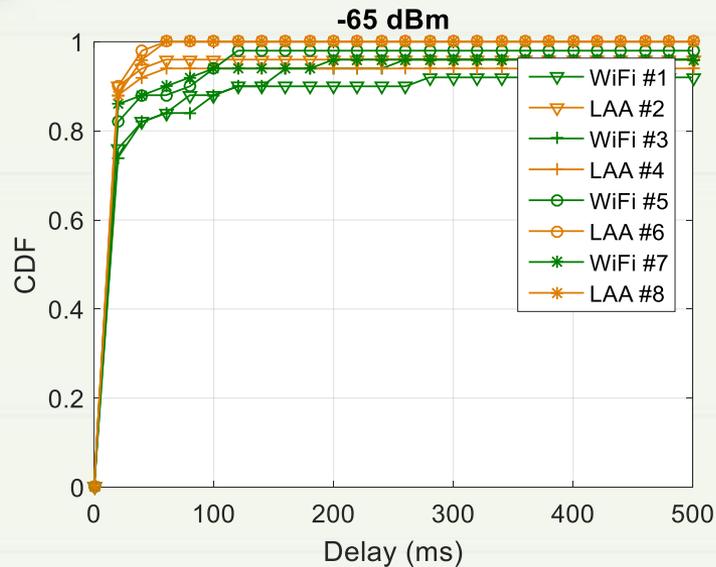❖ WiFi/LAA, load ratio of 0.8, throughput

Different Layout

❖ WiFi/LAA, load ratio of 0.8, throughput

✓ Need to find a (combination of) threshold that do no harm to WiFi and provide good performance to LAA.

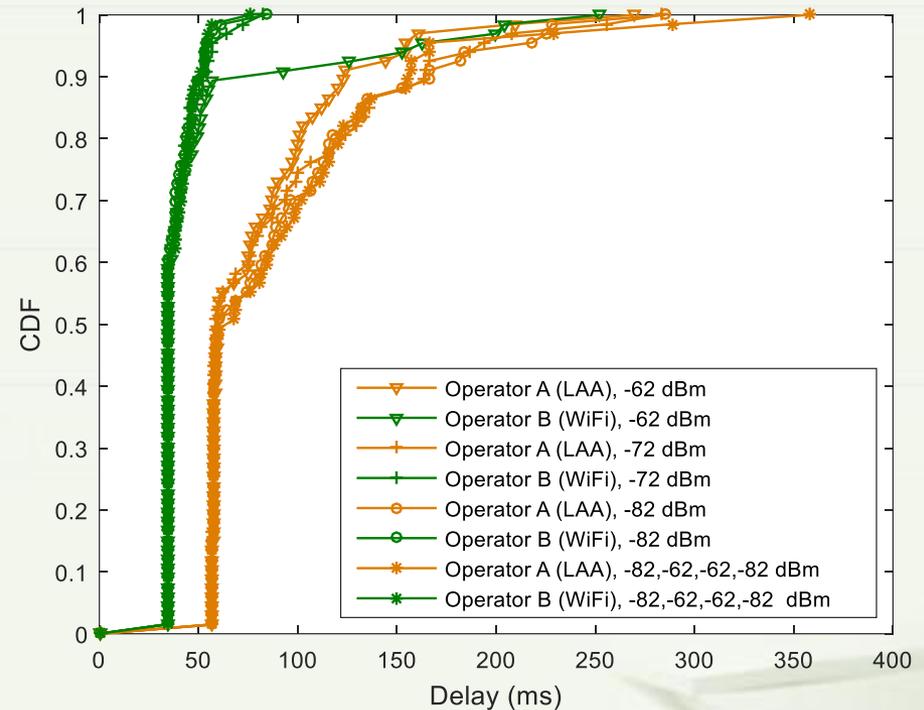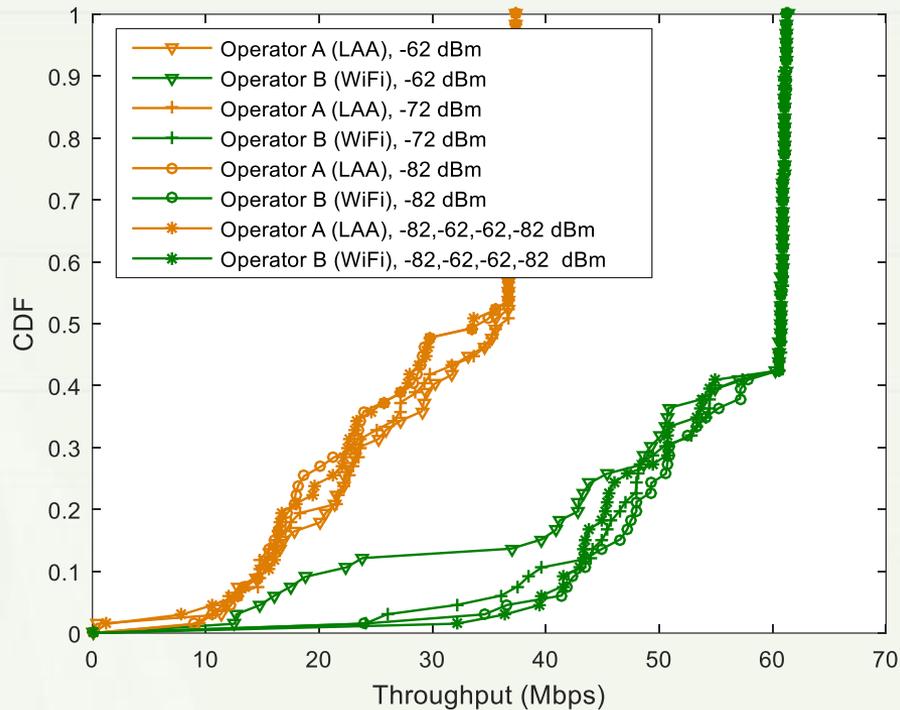# Different Layout

❖ WiFi/LAA, load ratio of 0.8, delay

Next Steps

❖ To deal with "edge effects", consider other layouts, like put base stations on grids, or randomly drop base stations.

❖ To do some analysis, consider the case two pairs: one is AP, and the other is LAA eNB?
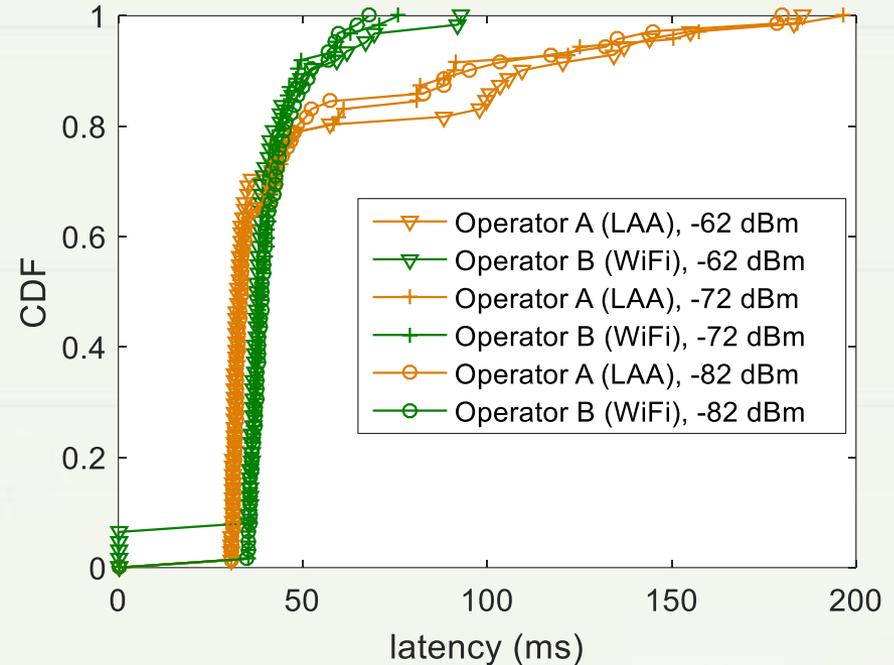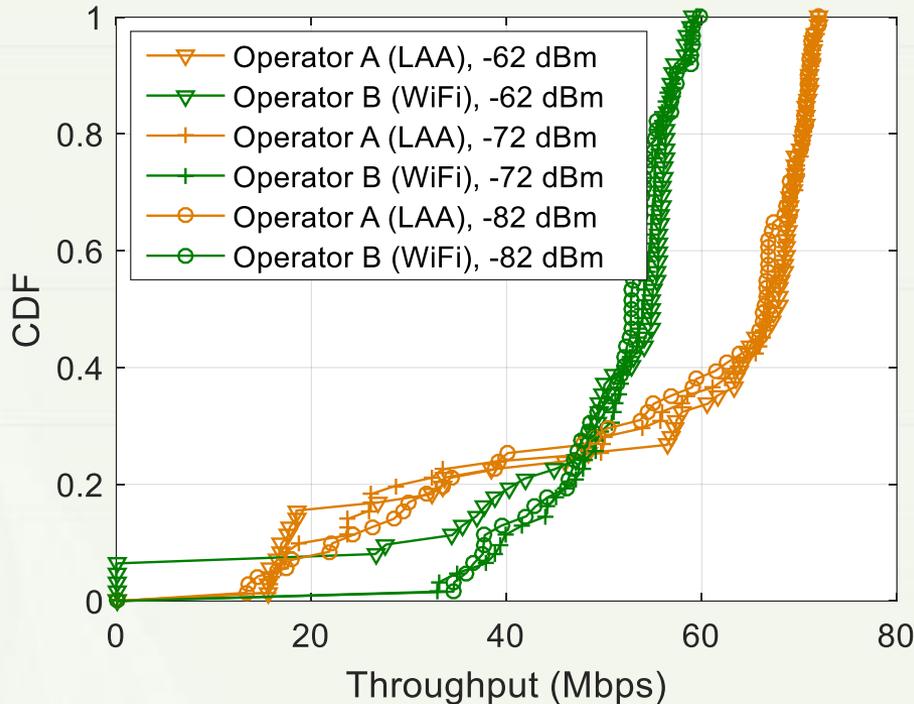
❖ Previous results

✓ LAA is worse than WiFi in terms of both throughput and latency.

❖ Updated results

✓ LAA has a significant improvement in throughput (fix bugs, more efficient in implementing reservation signals, …)

✓ However, changing threshold does not have a big impact on the performance, which is not consistent with our and other companies' results.