

Coexistence of WiFi and LAA: Traffic, Detection, Multi-Carrier LBT

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- ❖ Mixed Traffic
- ❖ Energy detection for LAA
- ❖ Multi-Carrier LBT
- ❖ Next Steps

Mixed Traffic

❖ EDCA: different contention window for different traffic [1]

✓ FTP: $CW_{\min} = 15$, $CW_{\max} = 63$ (1023)

✓ VoIP: $CW_{\min} = 3$, $CW_{\max} = 7$

❖ Traffic Model

✓ FTP Model 3 (poisson process): file size: 0.5 Mbytes; mean = 5 s;
10 UEs per carrier [2]

✓ VoIP, based on G.729A: packet inter-arrival time: 20 ms, packet size:
60 bytes [2]

✓ In current simulation (with scaling): FTP: 800 slots/400 slots, VoIP:
20 slots/1 slot (Single channel, same location)

[1] IEEE Std 802.11TM -2012, “Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.”

[2] 3GPP TR 36.889 V13.0.0 (2015-06).

Mixed Traffic

❖ FTP traffic/VoIP traffic: 1/0

	WiFi				LAA			
M=2								
M=4	0.2069		0.2101		0.2127		0.2112	
M=8	0.0928	0.0936	0.0916	0.0946	0.0896	0.0966	0.0909	0.0948

Mixed Traffic

❖ FTP traffic/VoIP traffic: 0.9/0.1

	WiFi				LAA			
M=4	0.2042		0.2066		0.2022		0.02025	
M=8	0.0846	0.0869	0.0844	0.0872	0.0819	0.0898	0.0839	0.0793

❖ FTP traffic/VoIP traffic: 0.7/0.3

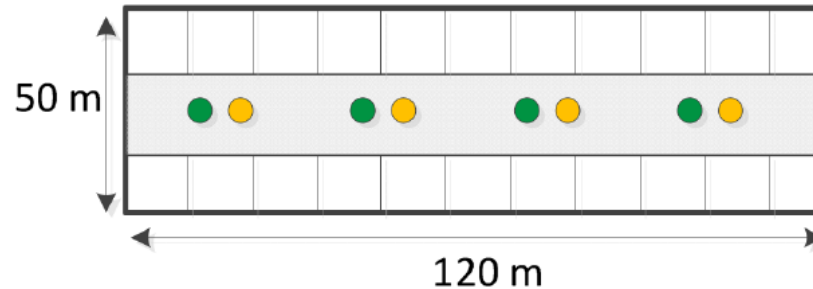
	WiFi				LAA			
M=4	0.1828		0.1907		0.1953		0.1935	
M=8	0.0779	0.0670	0.0751	0.0699	0.0683	0.0719	0.0763	0.0745

- In all cases, LAA coexists with WiFi very well;
- As VoIP increases, performance decreases. High collision probability with small contention window.

Energy Detection for LAA

❖ Simulation setting

- ✓ 4 APs (green) and 4 eNBs (yellow) are equally spaced [1]



- ✓ Transmit power: 18 dBm, with path loss, shadowing and Rayleigh fading
- ✓ FTP traffic with load rate of 0.5
- ✓ WiFi: CCACS = -82 dBm, CCAED = -62 dBm; LAA: CCAED = -65/-70/-75 dBm
- ✓ $q_{\text{WiFi}} = [15, 63]$, $q_{\text{LAA}} = [15, 63]$

Energy Detection for LAA

❖ LAA CCAED: -65 dBm

	WiFi				LAA			
M=8	0.3198	0.1837	0.2070	0.2661	0.3339	0.3264	0.3312	0.3333

❖ LLA CCAED: -70 dBm

	WiFi				LAA			
M=8	0.3011	0.1190	0.1750	0.2694	0.3287	0.3129	0.3158	0.3317

❖ LLA CCAED: -75 dBm

	WiFi				LAA			
M=8	0.2884	0.0843	0.0923	0.2380	0.3083	0.2972	0.2727	0.3177

Energy Detection for LAA

- ✓ The nodes in the margin have more opportunities to access the channel than the nodes in the middle (better performance), especially for WiFi.
- ✓ Counterintuitively, decreasing the LAA CCAED will decrease the performance of both WiFi and LAA.

Energy detection for LAA

❖ LAA CCAED: -65 dBm

✓ Radius in average

WiFi		LAA	
1	2,3	2	1
3	1,4,5	4	3
5	3,6,7	6	5
7	5,8	8	7

✓ Block times

WiFi		LAA	
1	2	2	1
3	3	4	1
5	3	6	1
7	2	8	1

❖ LAA CCAED: -70 dBm

✓ Radius in average

WiFi		LAA	
1	2,3	2	1,3
3	1,4,5	4	3,5
5	3,6,7	6	5,7
7	5,8	8	7

✓ Block times

WiFi		LAA	
1	2	2	1
3	4	4	1
5	4	6	1
7	3	8	1

Energy detection for LAA

❖ LAA CCAED: -75 dBm

✓ Radius in average

WiFi		LAA	
1	2,3	2	1,3,4
3	1,4,5	4	1,2,3,5,6
5	3,6,7	6	3,4,5,7,8
7	5,8	8	5,6,7

✓ Block times

WiFi		LAA	
1	3	2	2
3	5	4	3
5	5	6	3
7	3	8	2

- This analysis matches the simulation results pretty well:
 - ✓ From -65 to -70 dBm, WiFi nodes in the middle become worse;
 - ✓ For -75 dBm, all nodes' performance decreases.

Energy Detection for LAA

- ❖ A fixed energy detection threshold for LAA may have a negative impact on WiFi nodes in this layout.
- ❖ Need to consider the impact of interference, **low threshold means high interference**; this will decrease the successful transmission probability and may change the results.

Multi-carrier LBT

❖ Option 1: WiFi-like LBT (same location, same CW)

- ✓ Single subchannel, effective bandwidth

WiFi		LAA	
4.24	4.17	4.18	4.21

- ✓ 4 subchannels, AC: 1,2; LAA: 3,4

WiFi		LAA	
17.2	16.8	17.1	17.8

- ✓ 4 subchannels, AC: 1,2; LAA: 1,2

WiFi		LAA	
17.1	16.8	17.3	17.5

Multi-carrier LBT

- ✓ WiFi-like LAA coexist with 802.11ac pretty well.
- ✓ In this case, both WiFi and LAA will either work in the entire 80 MHz or not work. Thus, same results are obtained for Table 2 and Table 3.
- ✓ How to avoid this? 1) There are some nodes working only with 20 MHz and 40 MHz (802.11b, 802.11n); 2) Are there any services will not occupy 80 MHz even it's available? Like voice, small packet size.

Next steps

- ✓ Study the adaptive detection threshold problem, and consider the impact of interference.
- ✓ Simulate multi-carrier LBT with different locations, and continue to study the channel selection problem.