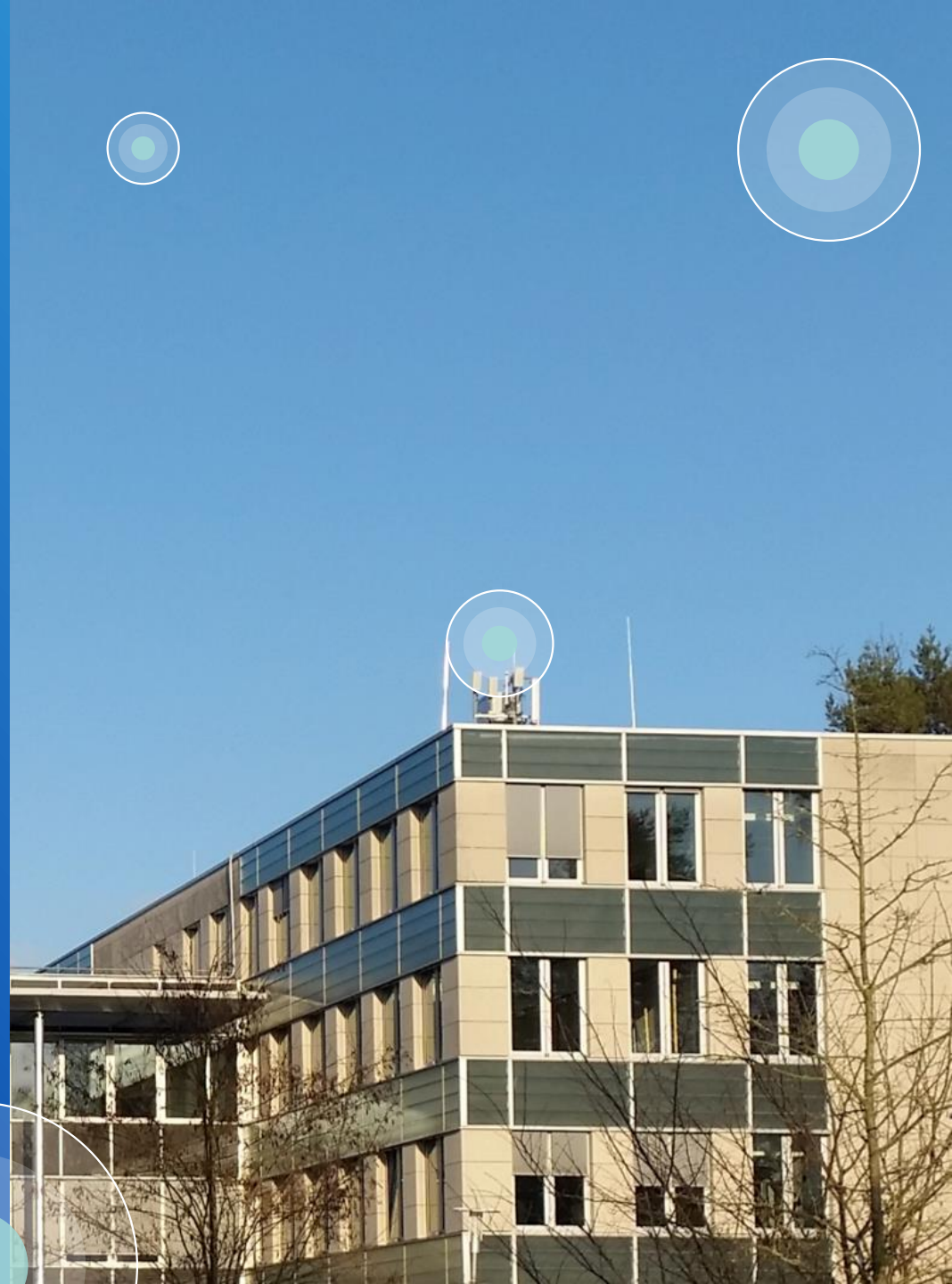
World’s first over-the-air LAA trial

Joint effort by Qualcomm Technologies, Inc.
and Deutsche Telekom AG
in Nuremberg, Germany
during November 2015



Over-the-air trial demonstrates LAA advantages

Increased coverage

Demonstrated LAA's extended range and improved performance in 5 GHz compared to Wi-Fi

Increased capacity

Demonstrated downlink throughput gains over Wi-Fi.

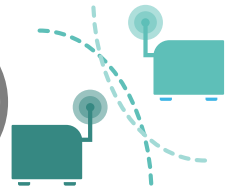
Co-existence benefiting everyone

Demonstrated fair co-existence between LAA, LWA and Wi-Fi with improved performance for everyone.

Completed a wide range of test cases

Covering multiple aspects

1. 
   Different combinations of LAA, LWA and Wi-Fi, mix of above and below ED

2. 
   Handover between multiple small cells

3. 
   Indoor and outdoor deployment scenarios

4. 
   Single or multiple users

5. 
   Different radio conditions, including corner cases such as hidden node

6. 
   Stationary and mobile users

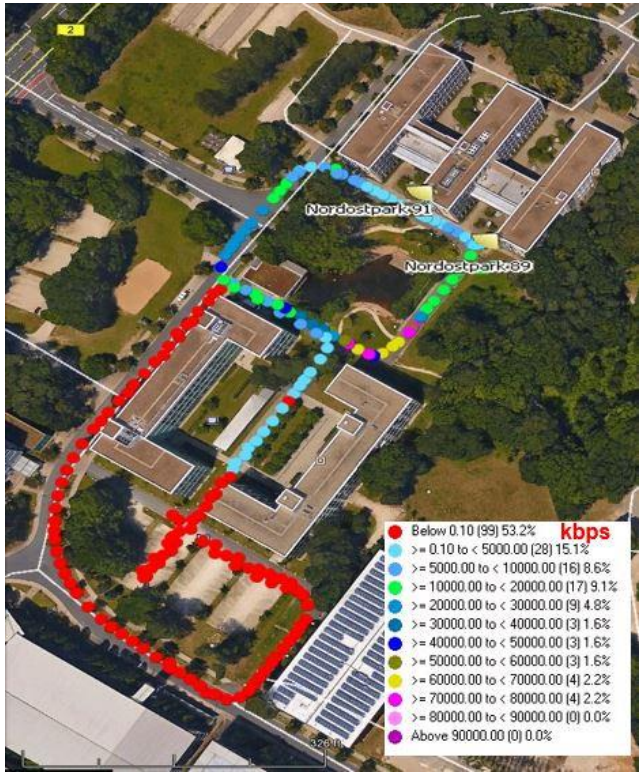
Outdoor test case examples

2 LAA/LWA capable eNB (licensed + unlicensed)
2 Wi-Fi AP (unlicensed)
Same configuration for LAA and Wi-Fi: radio channel, 2x2 MIMO, antennas, transmit power, mobility…

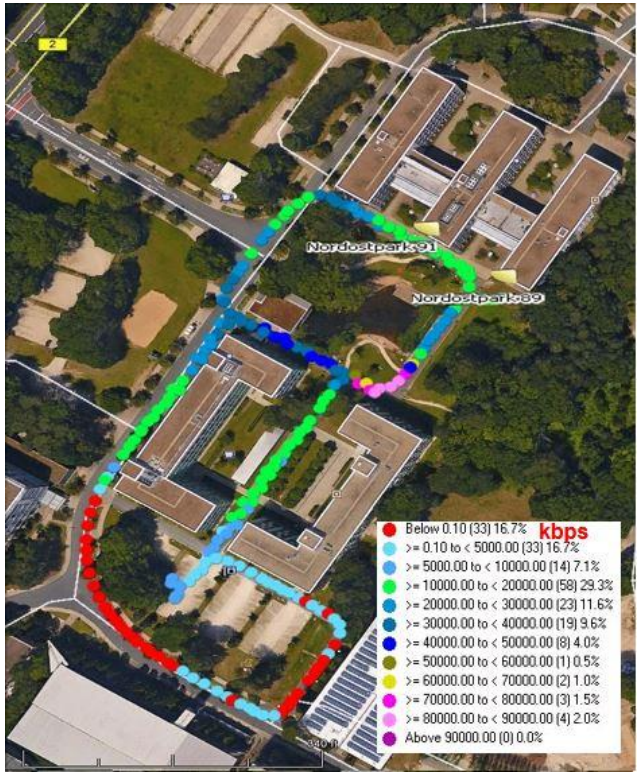
~2X coverage improvement outdoors

Downlink throughput in unlicensed spectrum for each location on test route[1]

LWA (Wi-Fi)



LAA



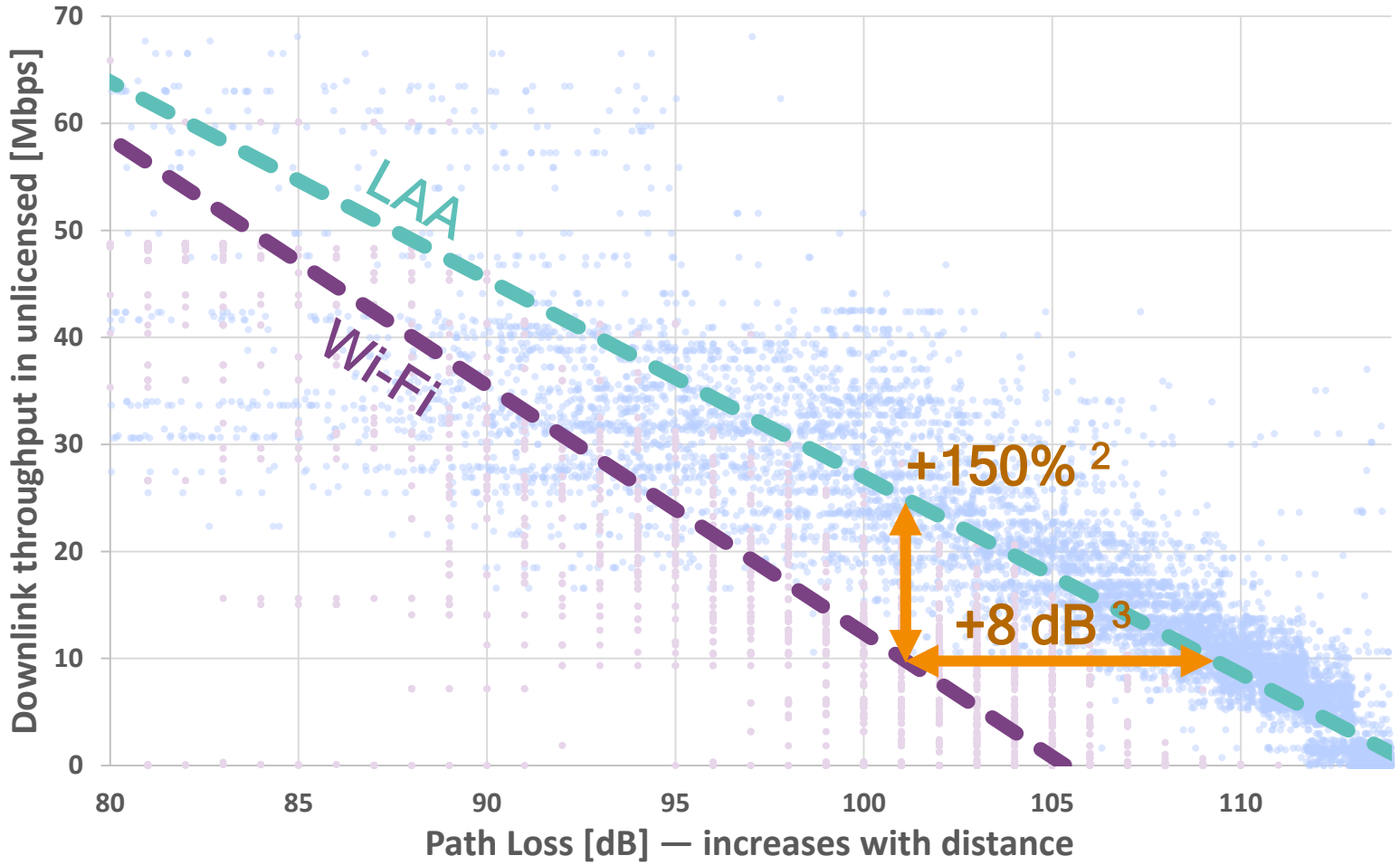
Coverage[2] in unlicensed

Mbps	Wi-Fi	LAA
>10	24% of route	x2.5 60% of route
>1	39% of route	x1.8 71% of route
>0	47% of route	X1.7 82% of route

[1] Single small cell, LAA based on 3GPP release 13; LWA using 802.11ac; LTE on 10 MHz channel in 2600 MHz licensed spectrum with 4W transmit power; the following conditions are identical for LAA and Wi-Fi: 2x2 downlink MIMO, same 20 MHz channel in 5 GHz unlicensed spectrum with 1W transmit power. terminal transmit power 0.2W, mobility speed 6-8 mph; [2] Based on geo-binned measurements over test route

LAA outperforms Wi-Fi in challenging radio conditions

Averaged downlink throughput in 5 GHz during mobility[1]



Performance when it matters

LAA's performance gains grows with more challenging radio conditions, providing more consistent throughput over a larger area.

Increased coverage

Providing same performance at a higher path loss (further distance) contributes to LAA's improved coverage over Wi-Fi.

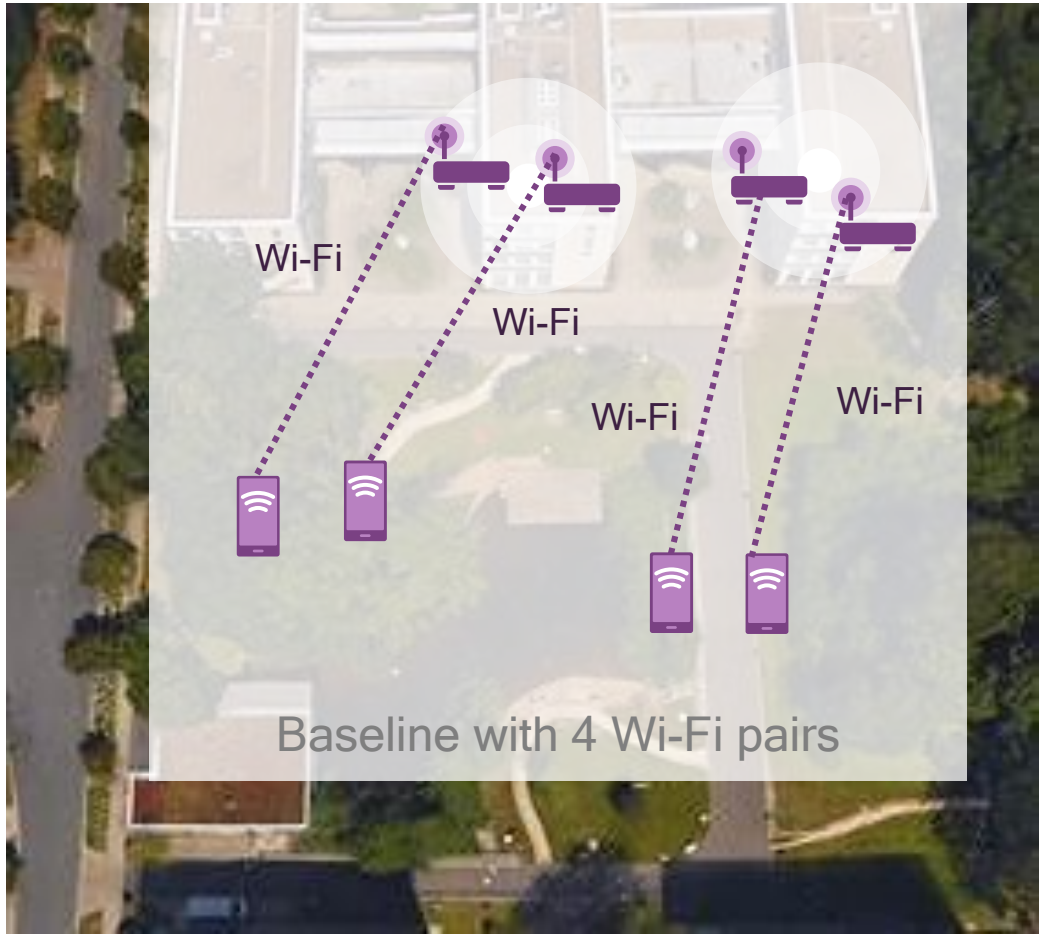
Higher averaged throughput

In challenging radio conditions LAA offers significantly higher averaged throughput at the same distance (same path loss).

[1] Dual cells with handover, LAA based on 3GPP release 13; LWA using 802.11ac; LTE on 10 MHz channel in 2600 MHz licensed spectrum with 4W transmit power; the following conditions are identical for LAA and Wi-Fi: 2x2 downlink MIMO, same 20 MHz channel in 5 GHz unlicensed spectrum with 1W transmit power. terminal transmit power 0.2W, mobility speed 6-8 mph; [2] ~25 Mbps LAA vs ~10 Mbps Wi-Fi at same path loss; [3] At 10 Mbps downlink speed in 5 Ghz

LAA benefits everyone sharing the same 5 GHz channel

A better neighbor to Wi-Fi than Wi-Fi itself



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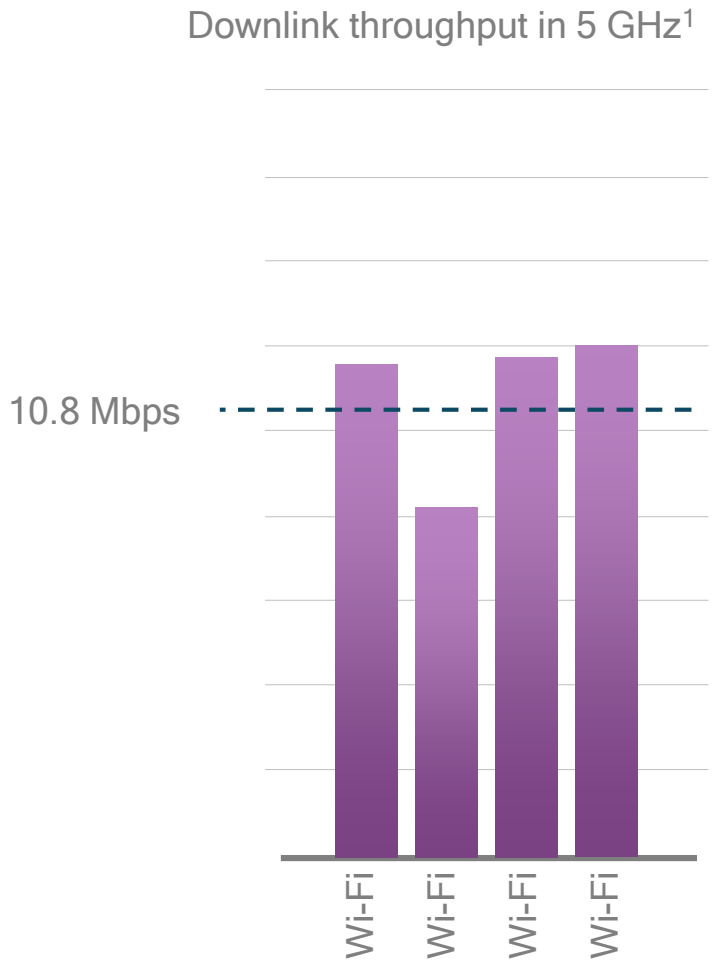
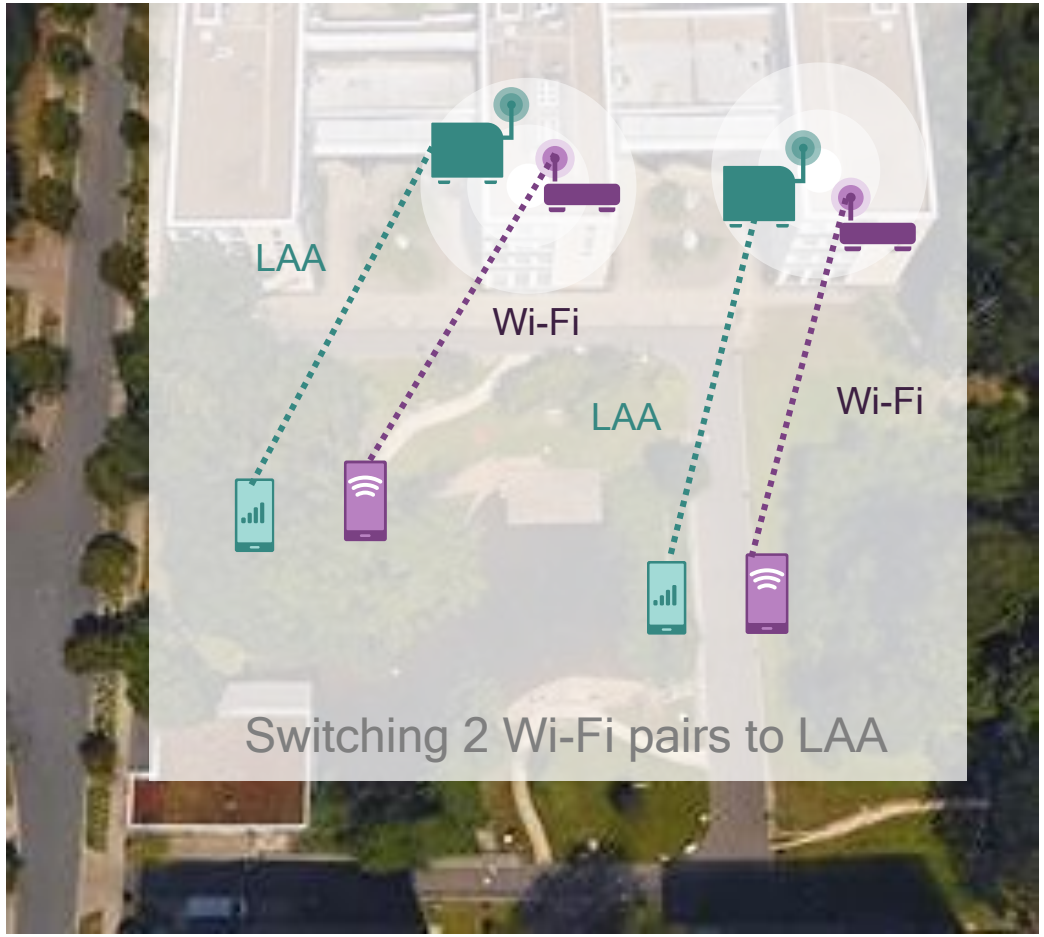


[1] Outdoor, 4 users on 4 different AP/cells, Mix of above and below ED, strong signal level with some interference, LAA based on 3GPP rel. 13; LWA using 802.11ac; LTE on 10 MHz channel in 2600 MHz licensed spectrum with 4W transmit power; the following conditions are identical for LAA and Wi-Fi: 2x2 downlink MIMO, sharing same 20 MHz channel in 5 GHz unlicensed spectrum with 1W transmit power, terminal transmit power 0.2W

LAA benefits everyone sharing the same 5 GHz channel

A better neighbor to Wi-Fi than Wi-Fi itself



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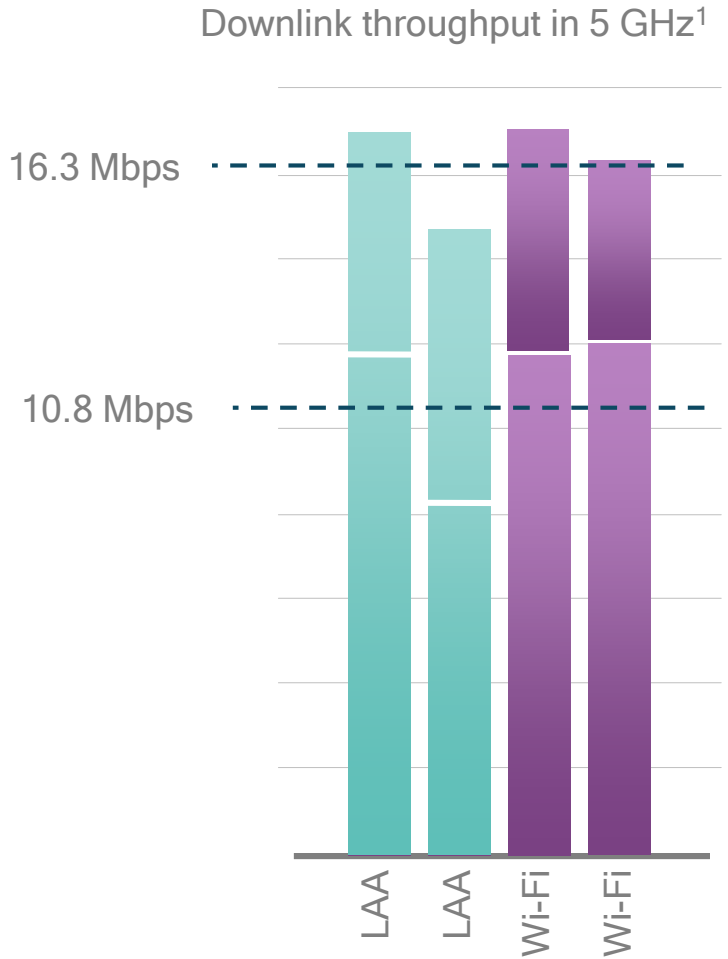

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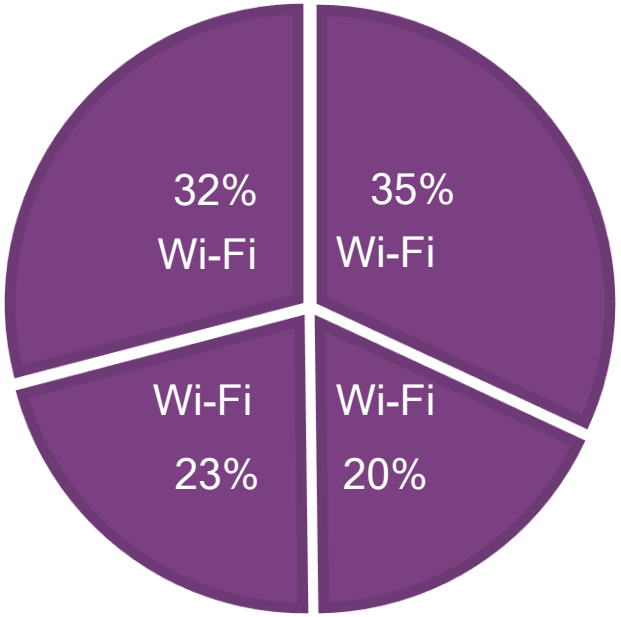
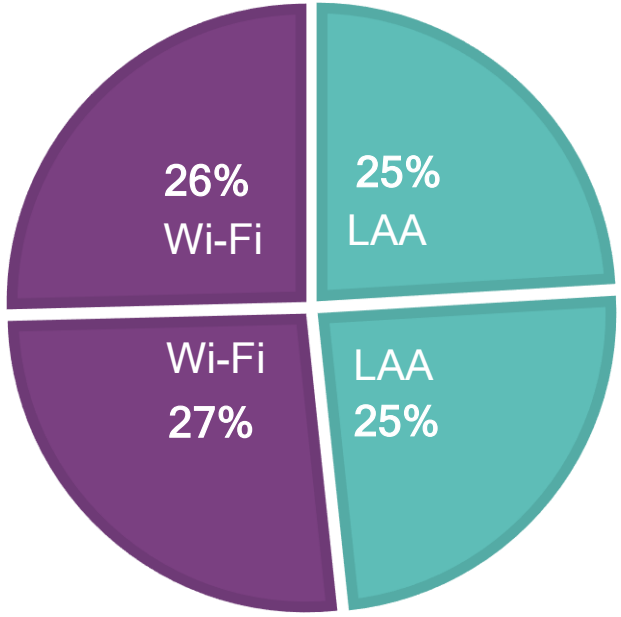
LAA benefits everyone sharing the same 5 GHz channel

LAA promotes fair sharing of the unlicensed channel

Same baseline with 4 Wi-Fi pairs



Switching 2 Wi-Fi pairs to LAA



Numbers in pie charts show channel occupancy[1],
the total is not 100% due to over utilization.

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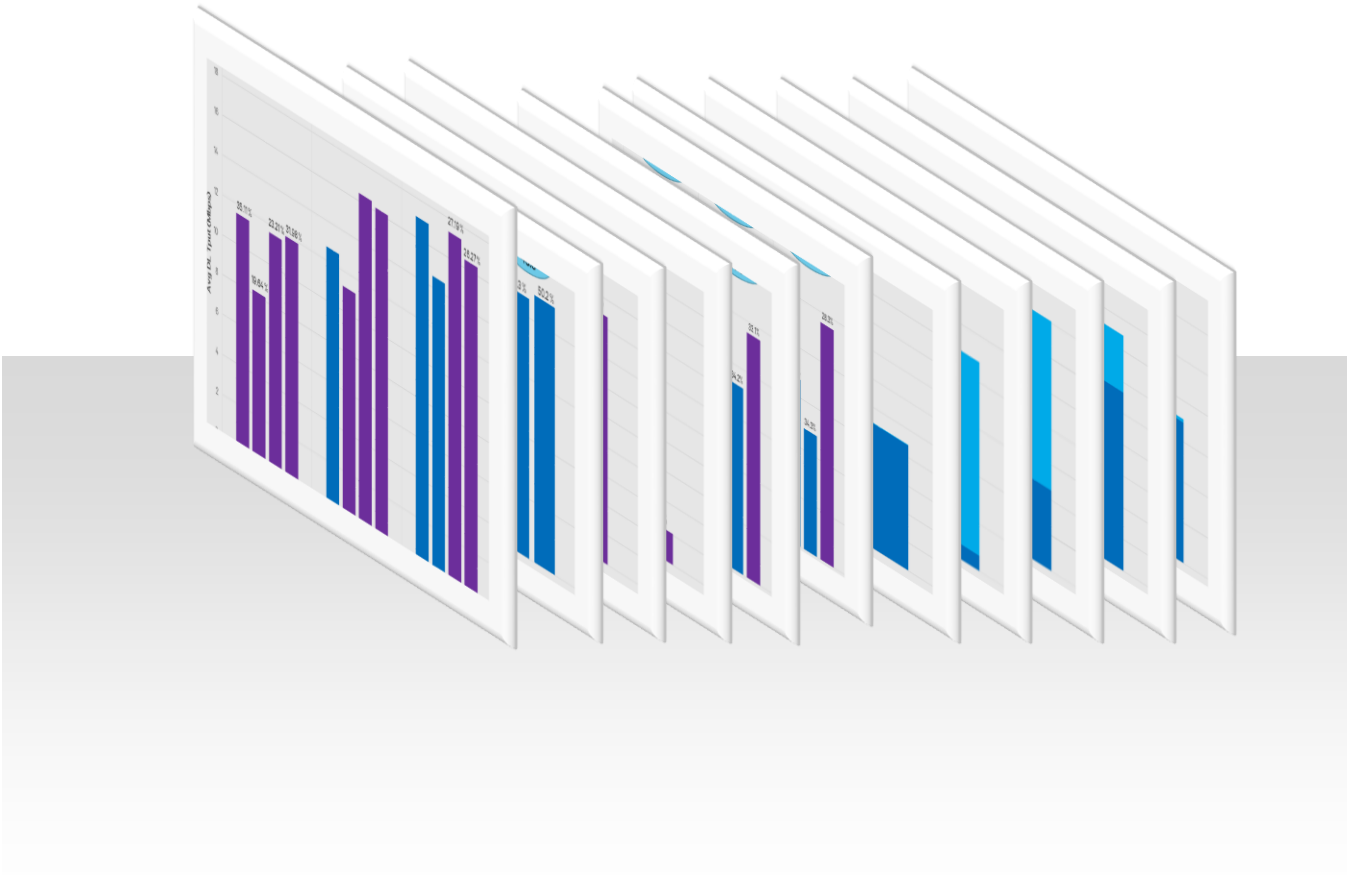
[1] Outdoor, 4 users on 4 different AP/cells, Mix of above and below ED, strong signal level with some interference, LAA based on 3GPP rel. 13; LWA using 802.11ac; LTE on 10 MHz channel in 2600 MHz licensed spectrum with 4W transmit power; the following conditions are identical for LAA and Wi-Fi: 2x2 downlink MIMO, sharing same 20 MHz channel in 5 GHz unlicensed spectrum with 1W transmit power, terminal transmit power 0.2W

LAA fairly coexists with Wi-Fi

Summary from a large number of test cases over a diverse set of conditions

1. Switching a Wi-Fi AP with a LAA small-cell results in overall increased network capacity and higher throughput for all users.

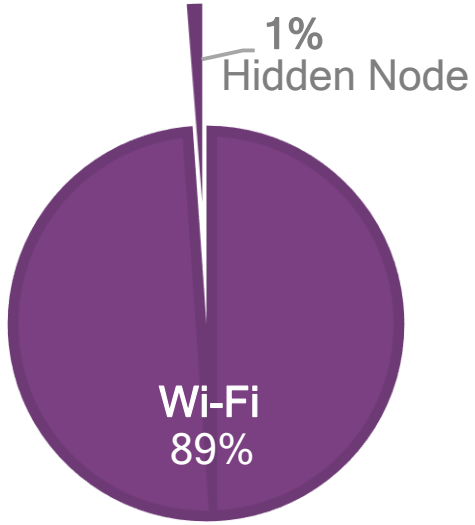
2. LBT ensures that the channel is shared fairly between the users and LAA is overall a better neighbor to Wi-Fi than Wi-Fi itself.



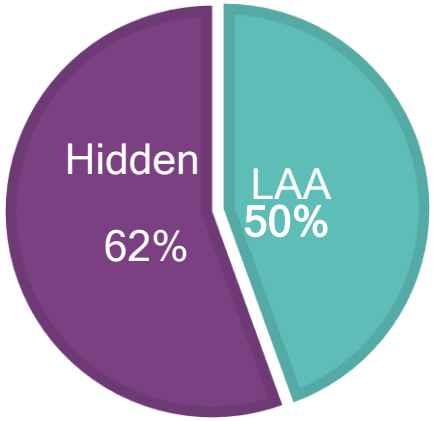
LAA shares the channel fairly also in corner cases

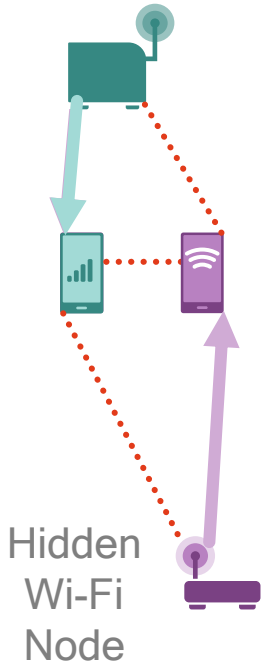
LAA is a better neighbor to a hidden Wi-Fi node

Baseline with 2 Wi-Fi pairs



Switching 1 Wi-Fi pair to LAA





Numbers in pie charts show channel occupancy[1], the total is not 100% due to over/under-utilization.

[1] Outdoor, 2 users on 2 different AP/cells, LAA based on 3GPP rel. 13; Wi-Fi using 802.11ac; the following conditions are identical for LAA and Wi-Fi: 2x2 downlink MIMO, sharing same 20 MHz channel in 5 GHz unlicensed spectrum with 1W transmit power, terminal transmit power 0.2W; downlink traffic only in unlicensed; first user has strong signal strength while the second users on the hidden AP has around 20 dB lower signal strength.

Thank you

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