

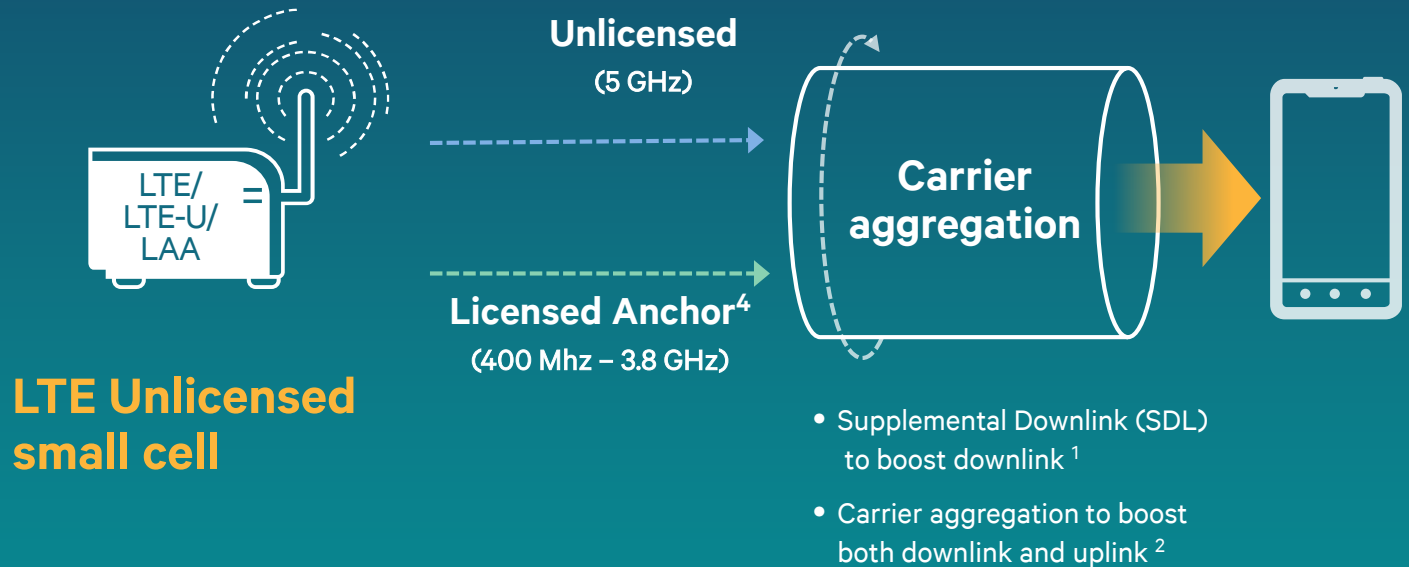
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Qualcomm Technologies, Inc.
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LTE in Unlicensed Spectrum: Innovation and Coexistence

QUALCOMM®



LTE Unlicensed in 5 GHz for new small cell deployments



LTE Unlicensed small cell

~2x capacity and range

Compared to Wi-Fi³

Enhanced user experience

Licensed anchor for control and mobility

Unified LTE network

Common management

A good Wi-Fi neighbor

In many cases, better neighbor to Wi-Fi than Wi-Fi itself

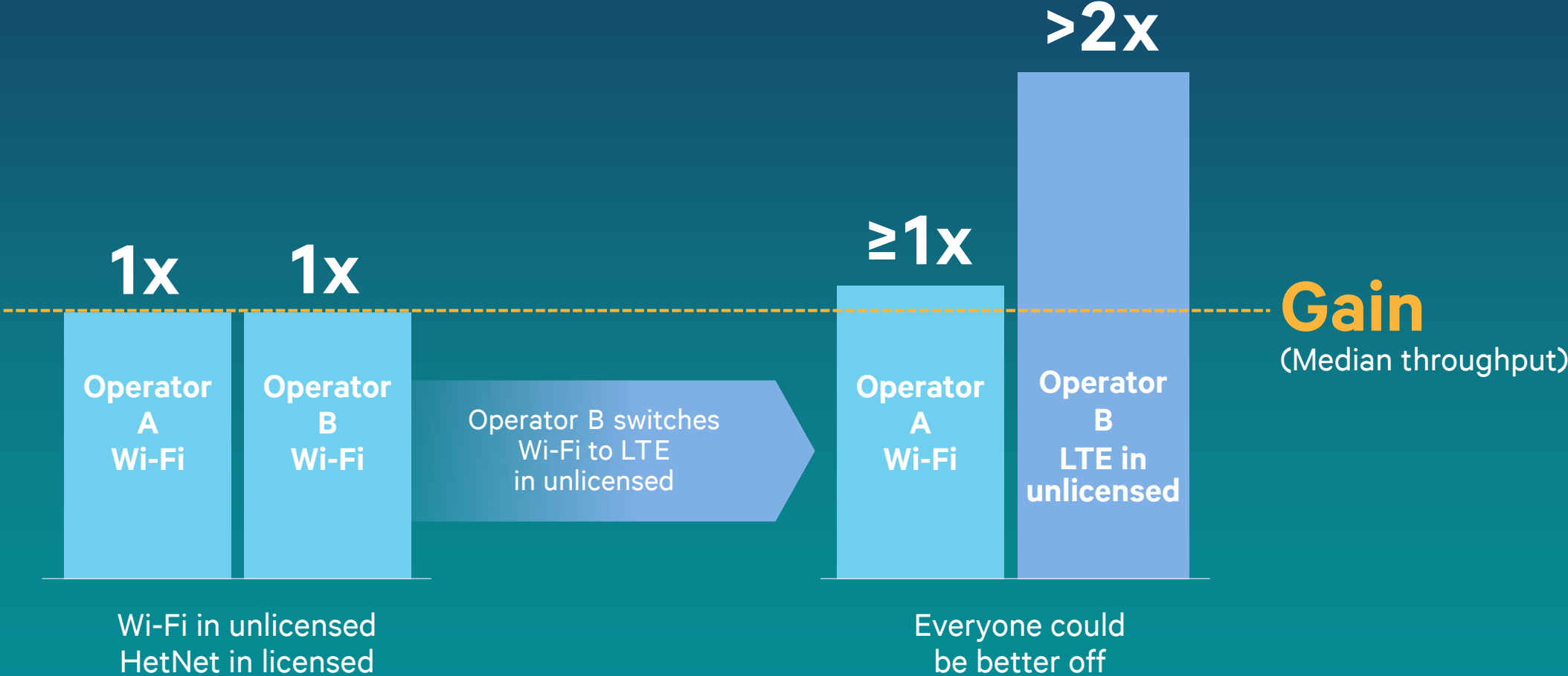
¹Main option for LTE FDD, but the specific band for SDL need to be defined. Either TDD or FDD aggregation is possible with SDL; ²Using TDD + TDD aggregation, or FDD + TDD aggregation with TDD used for unlicensed spectrum

³Assumptions: R10-based LTE-U, two operators, dense Wi-Fi and small cell outdoor deployment, macro cell layout. 120 users per macro cell. 3GPP Bursty model. 4X40MHz channels @ 5GHz for unlicensed spectrum. LTE 10 MHz channel at 2 GHz. 2x2 MIMO for Wi-Fi, LTE and LTE in unlicensed with Rank 2 transmission. Wi-Fi - 802.11ac 2x2 MIMO, LDPC codes and 256QAM.

⁴Note that the standalone version of LTE Unlicensed will not use a licensed anchor channel.

LTE Unlicensed: Higher capacity while being a good neighbor to Wi-Fi

In many cases a better neighbor to Wi-Fi than Wi-Fi itself



Assumptions: Two operators. 48 Pico+108 Femto cells per operator. 300 users per operator with 70% indoor. 3GPP Bursty model. 12x40MHz @ 5GHz for unlicensed spectrum. LTE 10 MHz channel at 2 GHz; 2x2 MIMO, Rank 1 transmission, eICIC enabled; LTE-U R13 LAA, 2x2 MIMO (no MU-MIMO); Wi-Fi - 802.11ac 2x2 MIMO (no MU-MIMO), LDPC codes and 256QAM).

Ensuring fair coexistence between LTE Unlicensed and Wi-Fi

Minimum requirements

Spectrum regulations

- Power and emission levels
- Additional channel occupancy limits: Listen Before Talk (LBT) required in Europe and Japan

Going above and beyond minimum requirements

Standards & specifications

- LTE-U R10 for USA, China, Korea, India and other markets
 - With dynamic channel selection & CSAT¹ for fair coexistence
- R13 LAA² for Europe, Japan and beyond
 - Modified waveform for LBT

Conformance testing

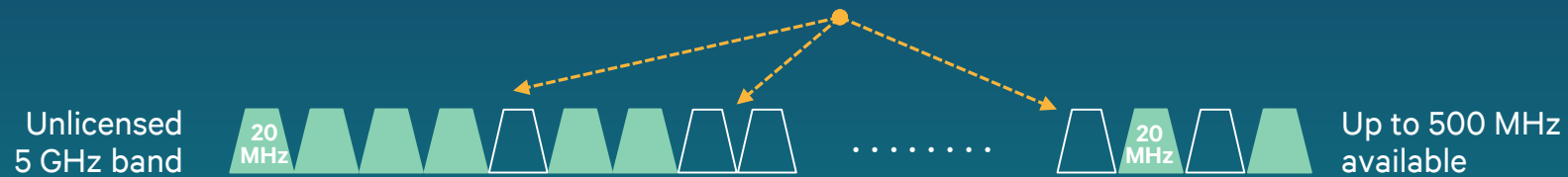
- Coexistence and fairness test
- Expected to be more rigorous than Wi-Fi testing today
- Still allowing for differentiation

¹ CSAT - Carrier Sensing Adaptive Transmission required in the small cell.. ² LAA Licensed Assisted Access being standardized in 3GPP Release 13 . In addition, New RF band support (e.g. 5GHz) needed at both device and small cell

LTE Unlicensed protects Wi-Fi to ensure fair sharing of spectrum

1

Select clear channel : Dynamically avoid Wi-Fi

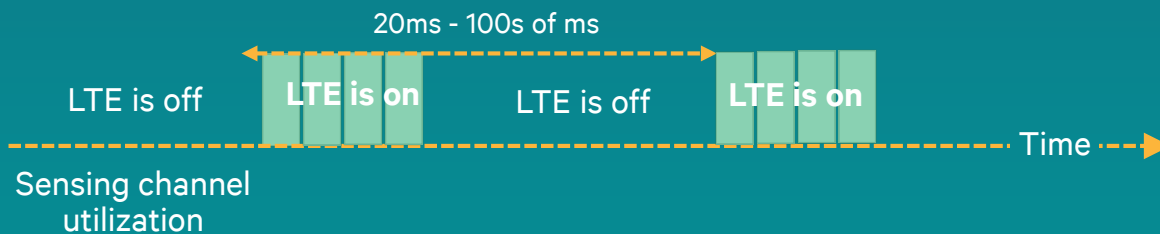


2

If no clear channel : Fair sharing with Wi-Fi on the same channel

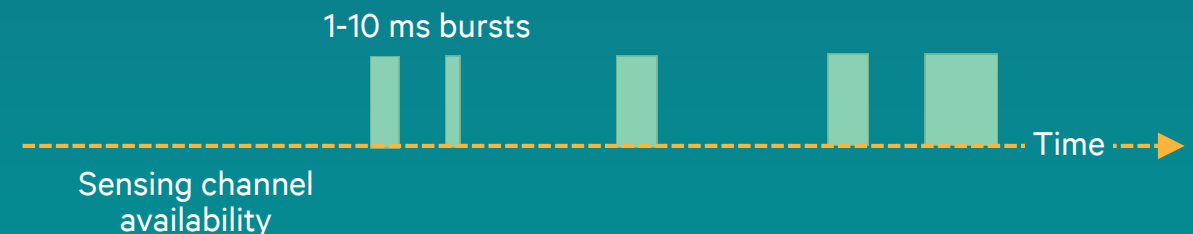
Adaptive duty cycle (CSAT) based¹

for early deployments in USA, Korea, China, India etc. using 3GPP Rel. 10/11/12



Listen Before Talk (LBT) based²

for deployments in Europe, Japan and beyond using 3GPP Rel. 13 LAA



¹ CSAT - Carrier Sensing Adaptive Transmission required in the small cell Meeting regulatory requirements, in addition ensures fairness.

² Part of 3GPP Rel 13, Licensed Assisted Access (LAA) for regions with short channel occupancy requirements, aka Listen Before Talk (LBT)

Thank you

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