



Spectrum for 4G and 5G

Qualcomm Technologies, Inc.
July, 2017



Using all available spectrum types and spectrum bands

Licensed spectrum

Exclusive use

Over 40 bands globally for LTE



Shared spectrum

New shared spectrum paradigms

Example: 2.3 GHz Europe / 3.5 GHz USA



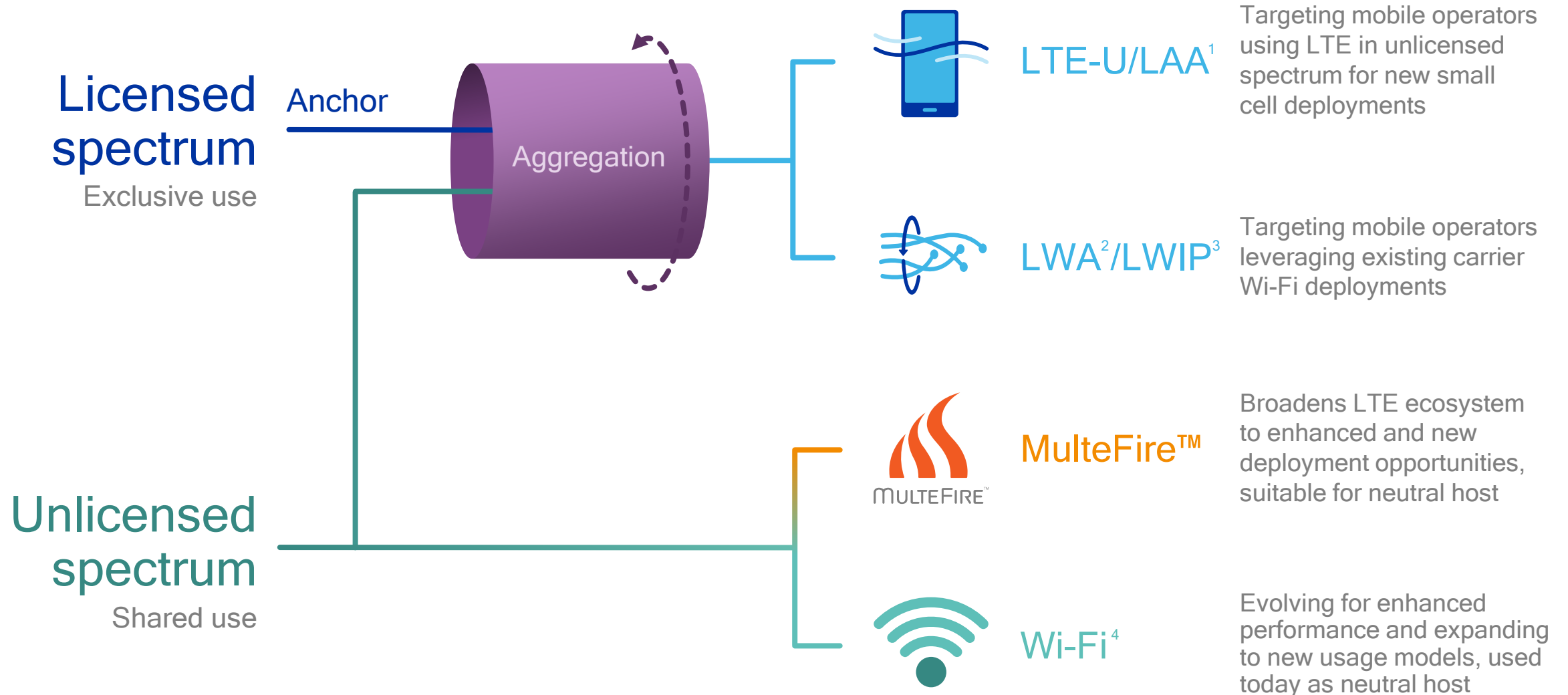
Unlicensed spectrum

Shared use

Example: 2.4 GHz / 5 GHz / 60 GHz global



Making best use of shared/unlicensed spectrum

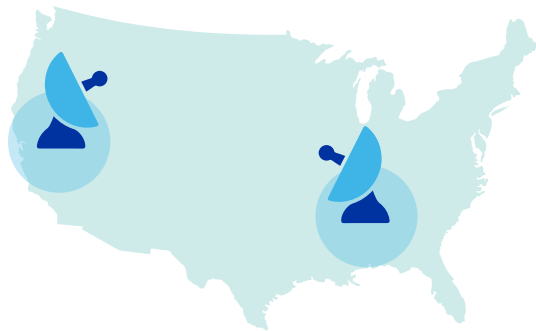


1. Licensed-Assisted Access (LAA), also includes enhanced LAA (eLAA); 2. LTE WLAN Link Aggregation (LWA); 3. LTE WLAN radio level integration with IPsec tunnel (LWIP); 4. 802.11ac / .11ad / .11ax / .11ay

New opportunities with shared/unlicensed spectrum

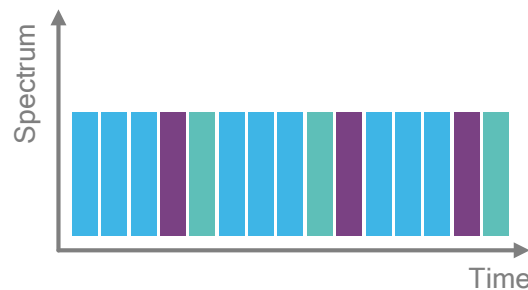
Unlocking more spectrum

Shared spectrum can unlock spectrum that is lightly used by incumbents



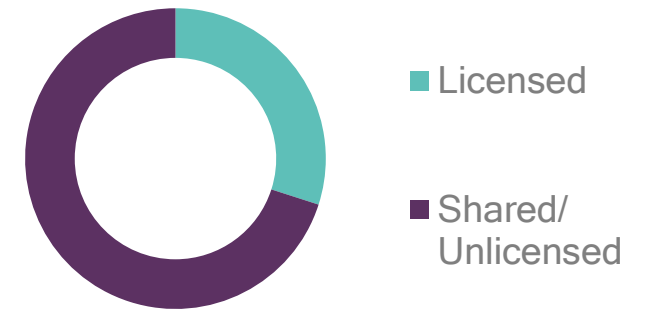
New spectrum sharing innovations

Spectrum sharing has the potential to increase spectrum utilization



A lot of spectrum may be shared/unlicensed

FCC 2016 decision on high-band spectrum included a significant portion of shared/unlicensed¹



¹ FCC ruling FCC 16-89 on 7/14/2016 allocated 3.25 GHz of licensed spectrum and 7.6 GHz of shared/unlicensed spectrum.

Spectrum sharing valuable for wide range of deployments

More spectrum to aggregate

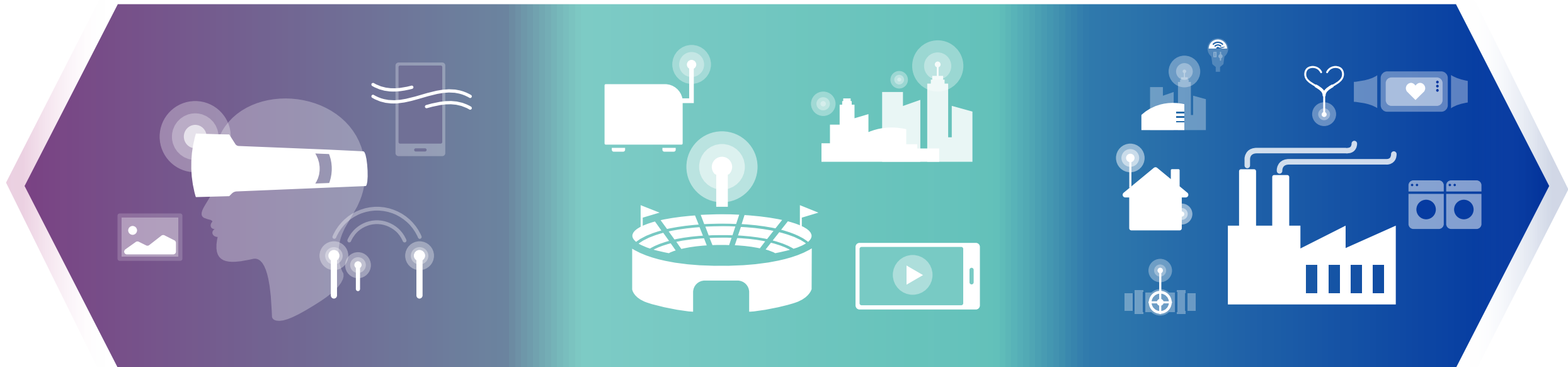
Extreme bandwidths and more capacity

Enhanced local broadband

Neutral host, neighborhood network...

Private networks

Enterprise, Industrial IoT...

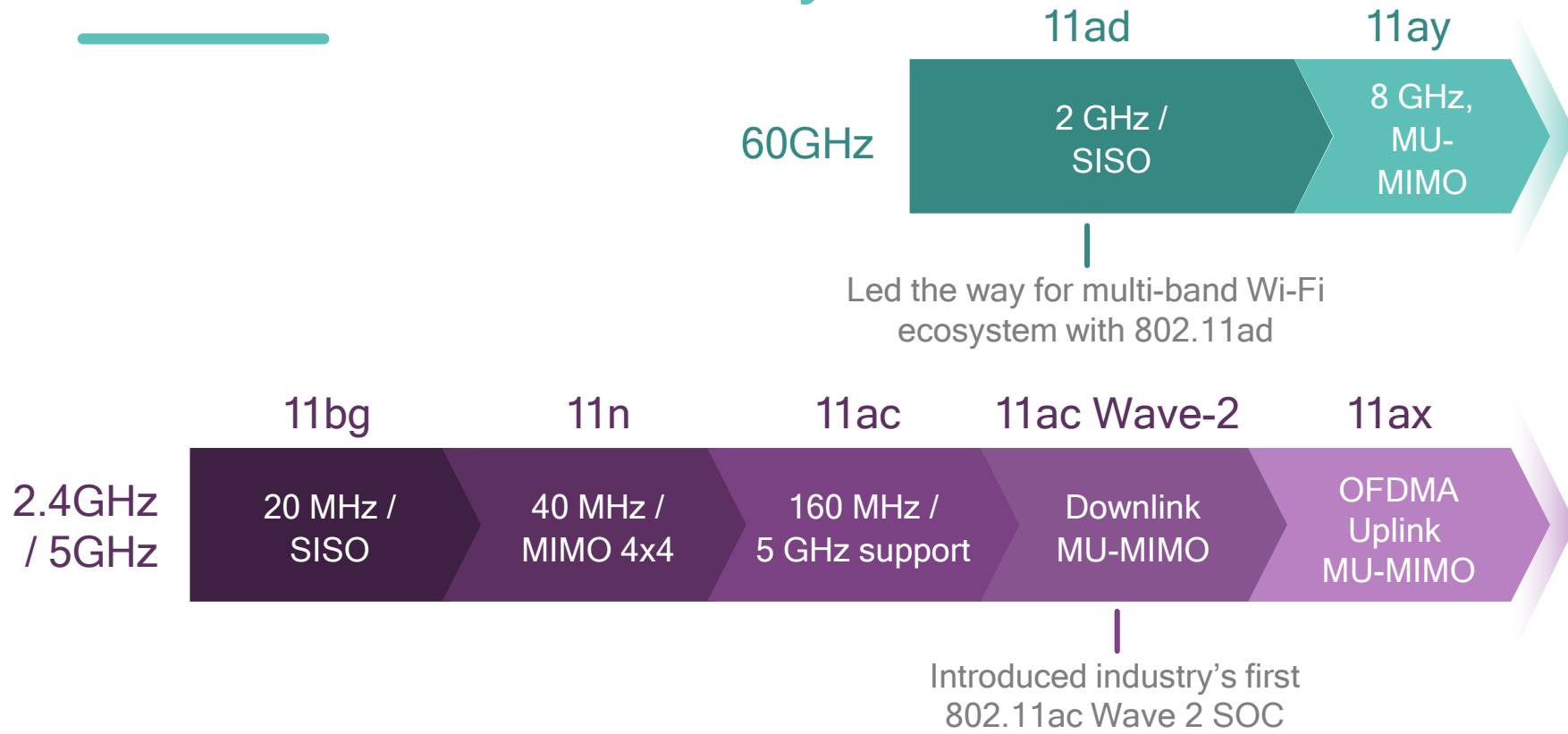


← Enhancing existing deployments, e.g., LAA¹ →

← New types of deployments, e.g., MulteFire™ or LTE-based tech. in CBRS² →

1) Licensed-Assisted Access (LAA); 2) Citizen Broadband Radio Service (CBRS)—a 3-tier shared spectrum where multiple LTE-based technologies are supported: LTE-TDD, MulteFire and LAA

Qualcomm Technologies leading the way with Wi-Fi in the mobile industry



Pioneering shared spectrum technologies in LTE



LSA¹

Technically extensive pilot in France with Ericsson and Red in Jan 2016



LTE-U

We designed the original technology which was then commercialized by the LTE-U Forum, and is now being deployed by T-Mobile US



LAA²

First over-the-air trials, LAA with DT Nov. 2015 and eLAA with SKT Sep. 2016



MULTEFIRE™

A founder of the MulteFire Alliance, first OTA connection Oct. 2016 & Release 1.0 specification Jan. 2017



A founder of the CBRS³ Alliance and a key contributor to coexistence

LTE-U and LAA are ready for commercial deployment

Specifications ready, FCC authorized, LBT globally, and available in products



Specifications finalized and published

LTE-U Forum published the LTE-U specs in Q1 2014, 3GPP published Rel. 13 standard with LAA in Q1 2016



FCC authorized devices for US deployments

FCC has granted equipment authorization for both LTE-U¹ and LAA²



LAA for global deployments

Listen-before-talk (LBT) is used by both LAA and Wi-Fi globally in the 5 GHz unlicensed band

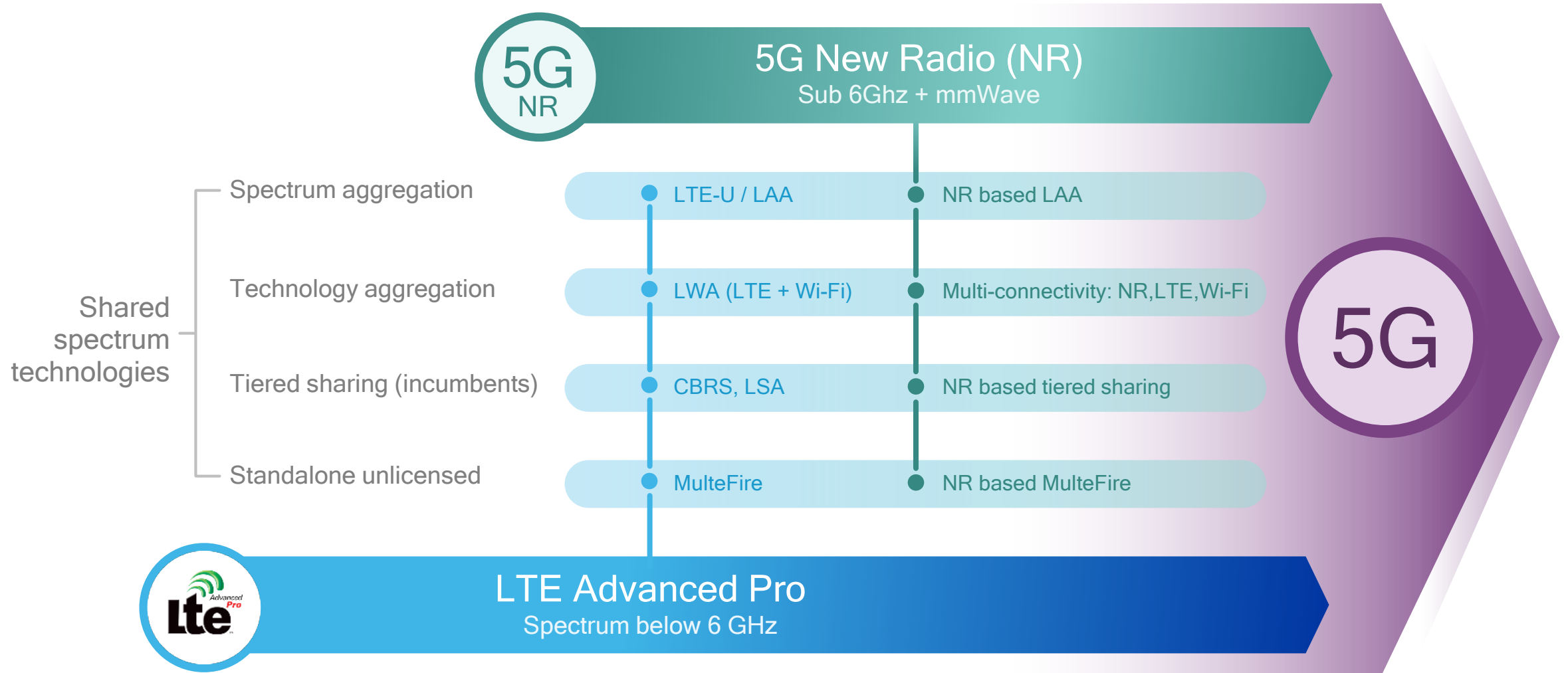


Supported by Qualcomm[®] Snapdragon[™] LTE modems

LTE-U starting with X12 LTE modem; LAA starting with X16 LTE modem in Snapdragon 835 mobile platform

Ushering in new spectrum sharing paradigms with 5G

Pioneering spectrum sharing technologies with LTE today



Learn more at: <http://www.qualcomm.com/spectrum-sharing>

5G NR

5G NR will natively support all different spectrum types

NR shared spectrum will support new shared spectrum paradigms



Licensed Spectrum

Exclusive use



Shared Spectrum

New shared spectrum paradigms



Unlicensed Spectrum

Shared use

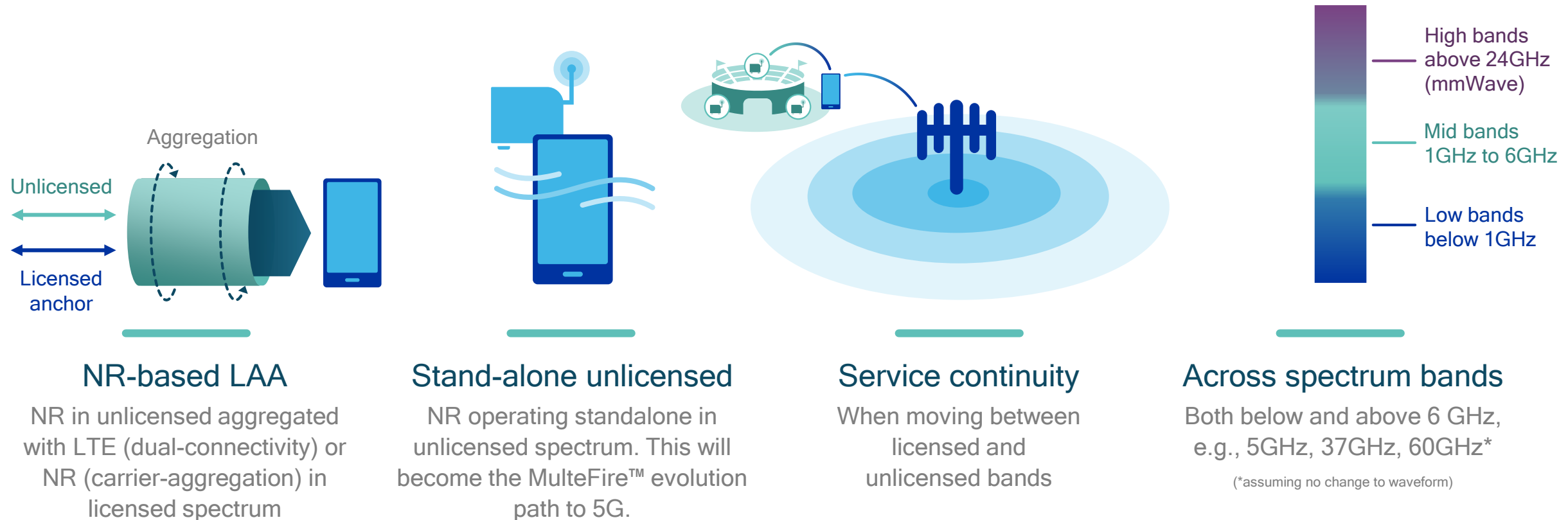
High bands above 24 GHz (mmWave)
Extreme bandwidths

Mid bands 1GHz to 6 GHz
Wider bandwidths for e.g. enhanced mobile broadband & mission-critical

Low bands below 1 GHz
Longer range for e.g. mobile broadband and massive IOT

3GPP study on 5G NR operation in unlicensed spectrum

First time 3GPP studies cellular technology operating stand-alone in unlicensed¹



Designing with fair co-existence in any unlicensed spectrum: NR/NR, NR/LTE, NR/Wi-Fi

¹ Study item in Rel. 15 (RP-170828), which could be followed by a work item that is completed in Rel. 16.

Global 4G & 5G spectrum update



Opening more spectrum for 5G is a global effort

5G spectrum status in key Asian markets and Australia



China

- Currently focusing on sub-6 GHz; approved trials at 3.4-3.6 GHz & 4.8-5 GHz, probably approve frequency planning in 3.3-3.4 GHz (indoor only)
- mmWave in longer term. Chinese gov't solicited public opinion for candidate bands of 24.75-27.5 GHz & 37-42.5 GHz non-exclusively in Jun'17
- Chinese government approved small scale trial frequencies usage in 24.75-27.5 GHz & 37-42.5 GHz mmWave ranges in Jul'17



Korea

- Phase 1 (2018+): 27.5-28.5 GHz & 3.4-3.7 GHz, also 26.5-29.5 GHz if 3GPP assigns it to 5G, auction expected in 2018
- Phase 2 (2018-2021): 2 GHz BW in 26.5-27.5 GHz, 28.5-29.5 GHz, or WRC-19 bands
- Phase 3 (2021-2026): Looking at another 1 GHz allocation



Japan

- Trials have started at 4.4-4.9 GHz & also looking at 3.6-4.2 GHz; mmWave: 27.5-29.5 GHz
- Official 5G bands: 3.7 GHz, 4.5 GHz (max 500 MHz in sub-6 GHz), and 28 GHz (max 2 GHz)
- Actual band(s) allocation and technical rules are expected in 2018



Singapore

- Regulator issued a public consultation on 5G spectrum, including bands below 1 GHz, between 1 and 6 GHz, and above 6 GHz.



Hong Kong

- Regulator announced plan to allocate low-band, mid-band (3.4-3.7 GHz) and mmWave (24.25-28.35 GHz) spectrum



Indonesia

- With recent 5G demonstration, the Indonesia minister hopes to allocate 2 GHz at 28 GHz
- Government would like to have a 5G demo/showcase for its hosting of the Asian Games in August 2018



Australia

- Planning for 3.4 to 3.7 GHz and also investigating mmWave bands
- Telstra has already announced trials in 2018 at the Commonwealth Games, using 28 and 39 GHz
- Many other governments in the region initiating 5G stakeholder consultations this year

Asia Pacific Telecommunity also driving 4G & 5G spectrum

Working on regional spectrum allocation, harmonization, and innovation



- Established in 1979, headquartered in Bangkok, Thailand
 - Founded on joint initiative of the UNESCAP¹ and ITU
 - 38 member countries and 130+ associate/affiliate members
- We are working within APG² with our ecosystem partners and regulators on planning for the next World Radio Conference (WRC-19) to develop regional proposals.
 - Also actively working within AWG³ to help drive regional spectrum harmonization, spectrum sharing studies, and to encourage innovation.

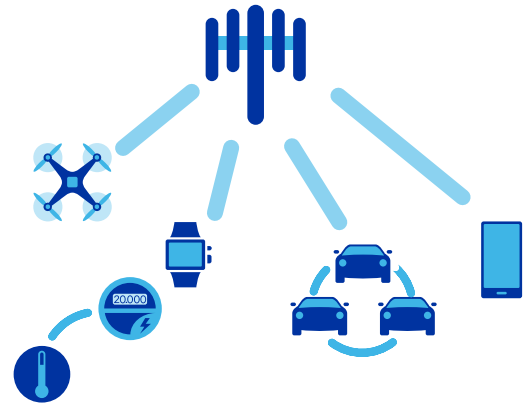
Anyone can talk
about 5G.
We are creating it.



Qualcomm Research 5G NR end-to-end prototype systems

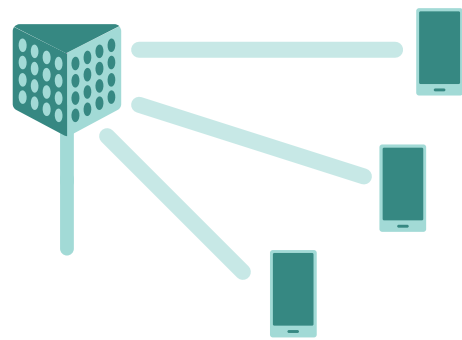
Sub-6 GHz

Ubiquitous coverage and capacity for a wide-range of 5G use cases



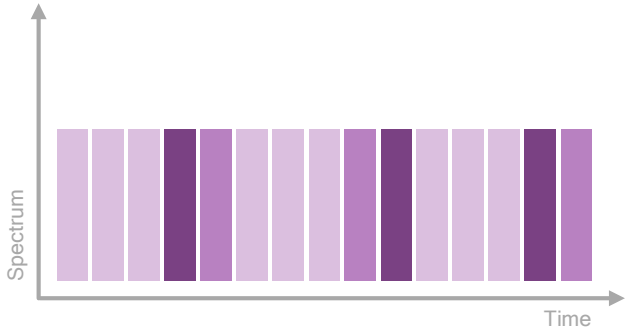
Mobilizing mmWave

Large bandwidths for extreme throughput and capacity



Spectrum sharing

More efficient utilization of, and access to, scarce resources



Accelerating 5G NR commercialization

Test, demonstrate and verify our 5G designs

Drive and track 3GPP 5G NR standardization

Achieve impactful trials with network operators

Drive timely commercialization

Thank you

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