Qualcomm®

Cellular Shared Technologies
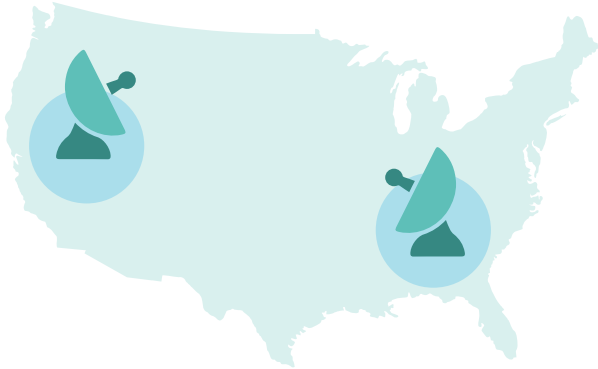
August 2017

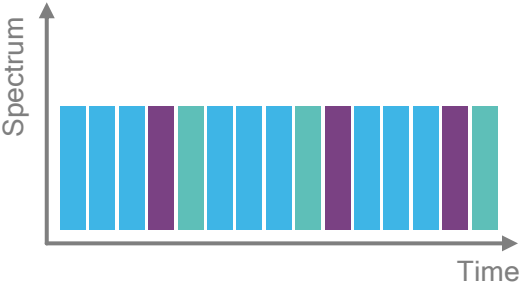# Shared/unlicensed spectrum is important for 5G

Unlocking more spectrum

Shared spectrum can unlock spectrum that is lightly used by incumbents
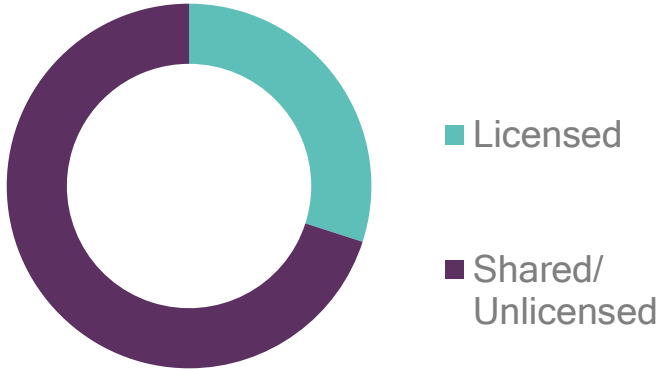
Higher spectrum utilization

Spectrum sharing has the potential to increase spectrum utilization

A lot of spectrum may be shared/unlicensed

FCC recent decision on high-band spectrum included a significant portion of shared/unlicensed[1]

Licensed

Shared/ Unlicensed

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.
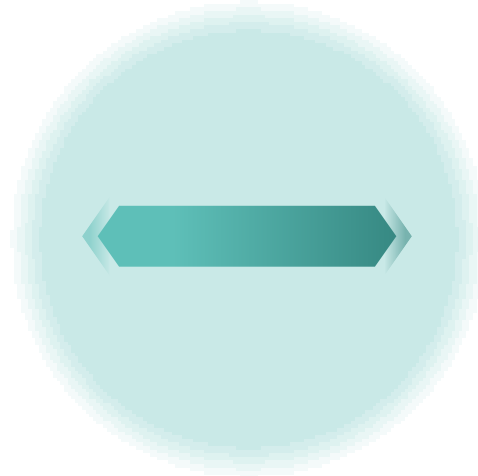
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Multiple dimensions of spectrum sharing

Vertical sharing

Multiple deployments in the same geographical area operating at different priority tiers, where lower tiers are not interfering higher tiers.

Ex. LSA[2]

Horizontal sharing

Multiple deployments in the same geographical area are sharing the spectrum with the same priority.
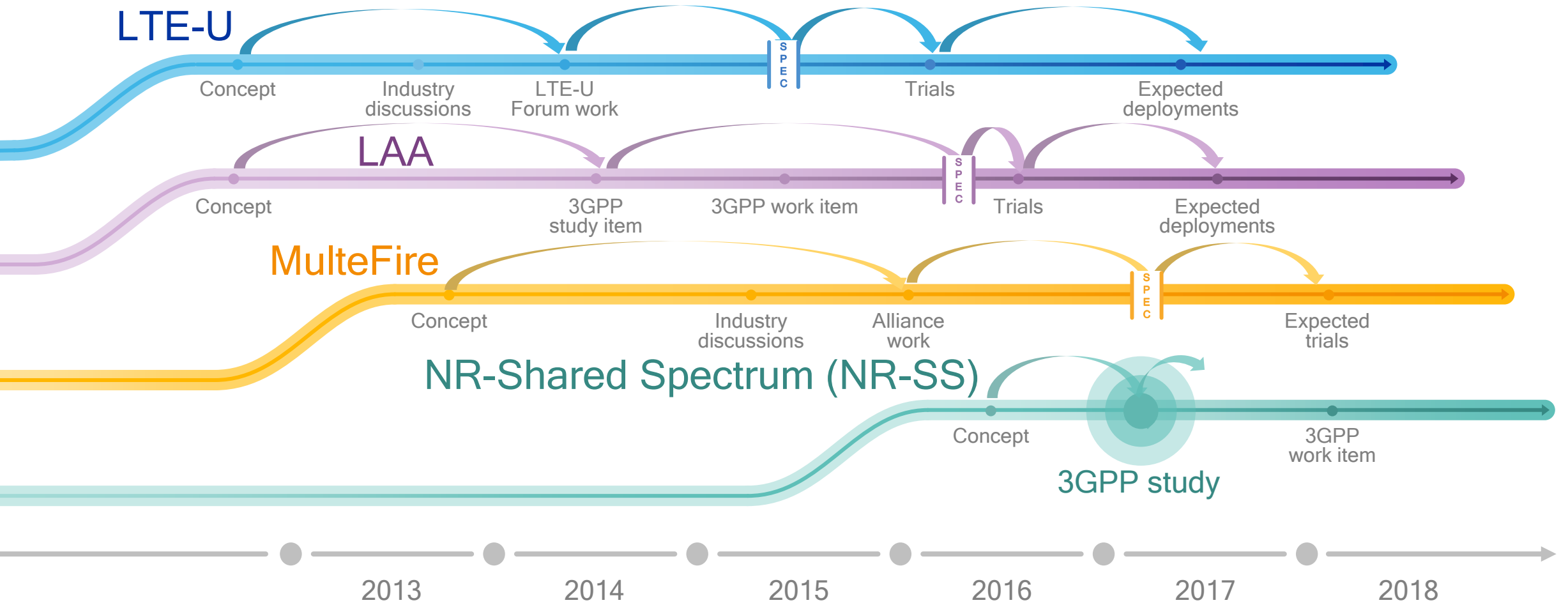
Ex. MulteFire with LBT[1]

Combined sharing

Vertical sharing with multiple priority tiers, where horizontal sharing is used in at least one of the tiers.
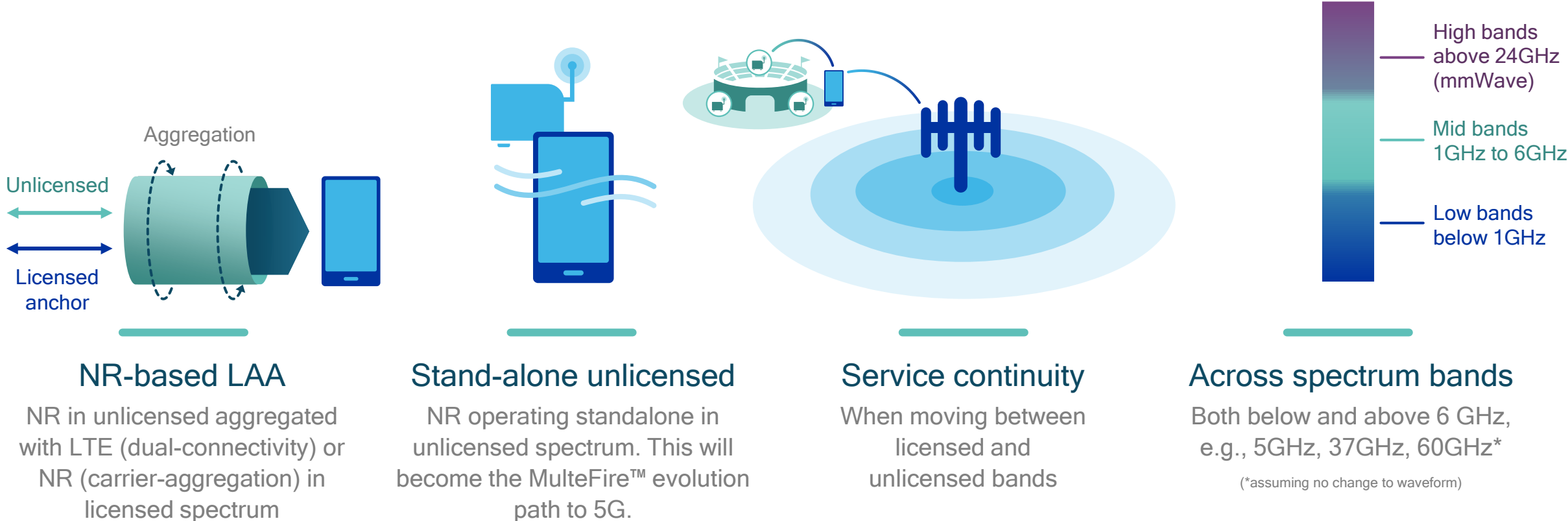
Ex. US CBRS[3]

1. Listen before talk (LBT); 2. Licensed Shared Access (LSA); 3. Citizen Broadband Radio Service (CBRS)

Mobile industry already benefiting from LTE in unlicensed

LTE-U

Concept — Industry discussions — LTE-U Forum work — SPEC — Trials — Expected deployments

LAA

Concept — 3GPP study item — 3GPP work item — SPEC — Trials — Expected deployments

MulteFire

Concept — Industry discussions — Alliance work — SPEC — Expected trials

NR-Shared Spectrum (NR-SS)

Concept — 3GPP study — 3GPP work item

2013   2014   2015   2016   2017   2018

3GPP study on 5G NR operation in unlicensed spectrum

First time 3GPP studies cellular technology operating stand-alone in unlicensed[1]

Unlicensed

Licensed anchor

Aggregation

High bands above 24GHz (mmWave)

Mid bands 1GHz to 6GHz

Low bands below 1GHz

NR-based LAA

NR in unlicensed aggregated with LTE (dual-connectivity) or NR (carrier-aggregation) in licensed spectrum

Stand-alone unlicensed

NR operating standalone in unlicensed spectrum. This will become the MulteFire™ evolution path to 5G.

Service continuity

When moving between licensed and unlicensed bands

Across spectrum bands

Both below and above 6 GHz, e.g., 5GHz, 37GHz, 60GHz*

(*assuming no change to waveform)

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.
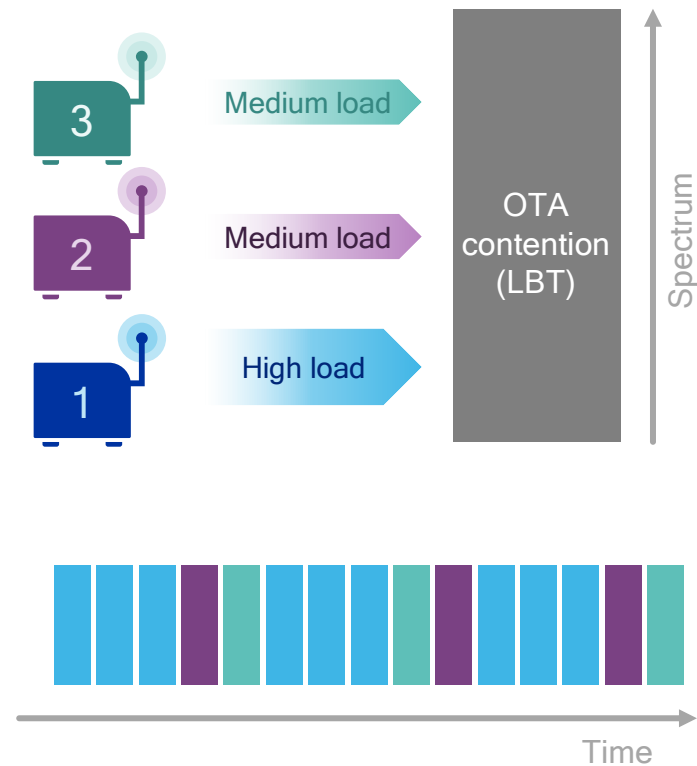
Dynamic Sharing Time Scale

The more the system copes with network dynamics the better the performance

Multiple LTE-TDD deployments with reduced channel size, spectrum may become underutilized[1,2]
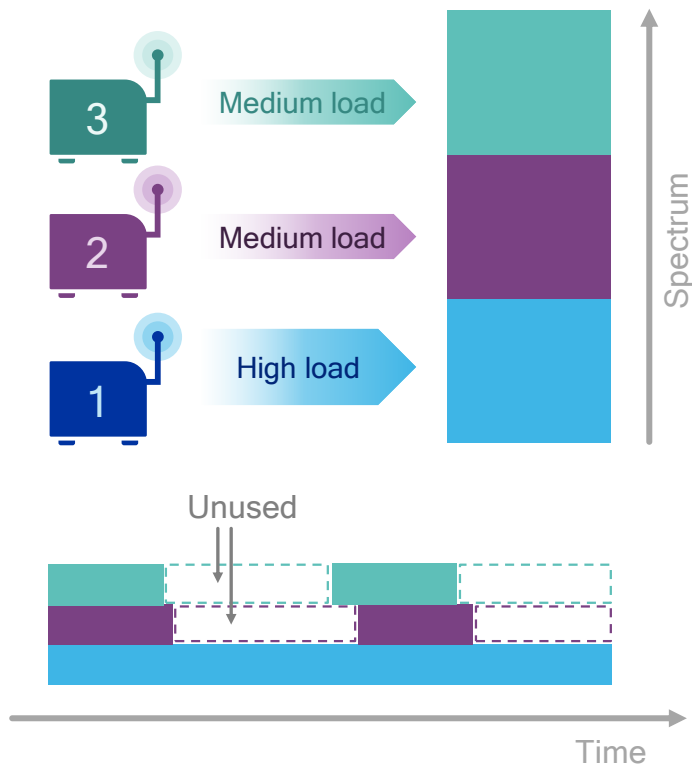
(e)LAA/MulteFire brings trunking efficiency from sharing a wide channel to improve user experience (peak rate and response time)[1,3]

Example From LTE systems of sharing gains

- LTE over-the-air (OTA) sharing performs better and converges to orthogonal as load increases

- Gains mainly from trunking efficiency

User perceived
data rate

LTE - OTA sharing[1]

LTE - no sharing[2]
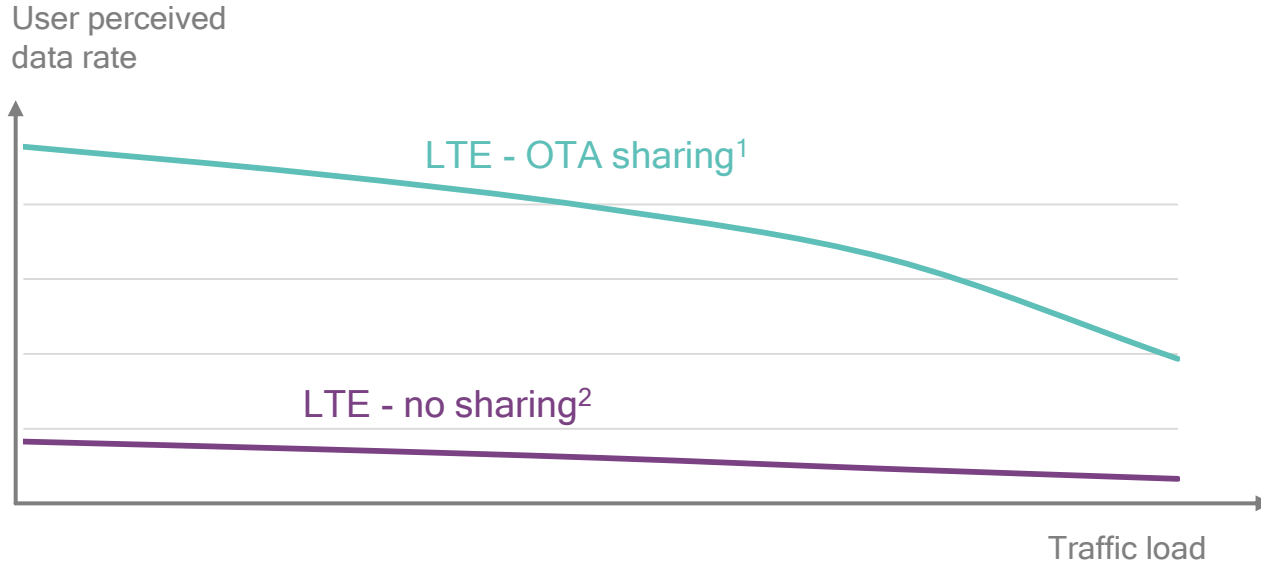
Traffic load

What's needed?

- **Dynamic:** Allocate more resources when more data

- **Fair:** In heavy loads, fairly share resources
  - Important enhancement: Avoid interference when strong, mitigate interference when tolerable

- **Adaptive to traffic:** DL or UL as needed

1) Two operators use MulteFire OTA sharing of a total 40MHz spectrum in 3.5GHz band; 2) Two operators divide the 40MHz spectrum between themselves using LTE-TDD with static TDD configuration matching long-term traffic pattern. 3GPP bursty traffic model. Indoor scenario: 3GPP Indoor model, 50:50 DL/UL traffic split, 4 small cells per operator in a single floor building

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Enhancing Existing sharing schemes

Building on LTE spectrum sharing, i.e. uncoordinated

Operator 1

Busy | Wait

LBT eCCA

Operator 2

Optimized contention
E.g. Collision reduction

Co-existence
With Wi-Fi, LAA and MulteFire in existing unlicensed spectrum bands

HetNet enhancements
E.g. enable different power classes

Optimizations and innovations for spectrum sharing, e.g. self-contained sub frames

Leverage 5G NR air-interface with extreme data rates and low latency access

Build on LTE spectrum sharing technologies: LAA and MulteFire

New bands→ Opportunity to do better→ Coordinated sharing

Guaranteed spectrum access and increased spectrum utilization

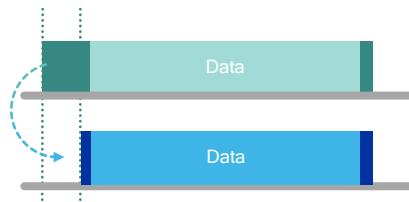## More suitable with few number of operators using the spectrum

Operator 1

CTRL | DATA   CTRL | DATA   CTRL | DATA

Operator 2

CTRL | DATA   CTRL | DATA
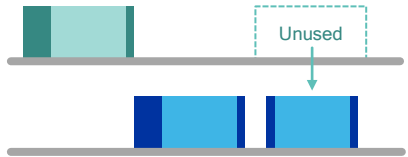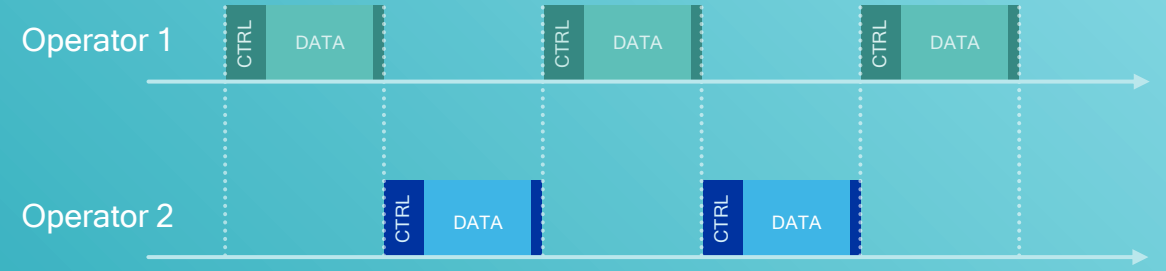
Opportunistic use
If one operator is not using 'his' slot, another operator can use it

Unused
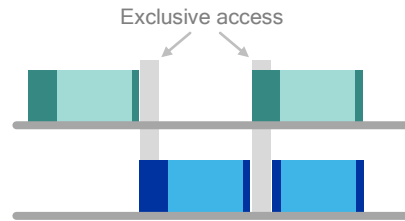
QoS enhancements
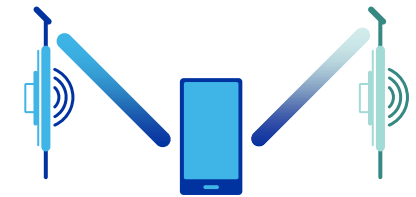Exclusive access slots for enhanced QoS control and guaranteed latencies

Exclusive access

Dynamic reuse
Advanced interference management enables higher reuse when radio conditions permits

Data

Data

Vertical sharing
Native support for vertical sharing with multiple priority tiers

Lower priority yields

CoMP
Coordinated multipoint with joint transmission, beam steering, etc.

Spatial Dimension – new sharing paradigm
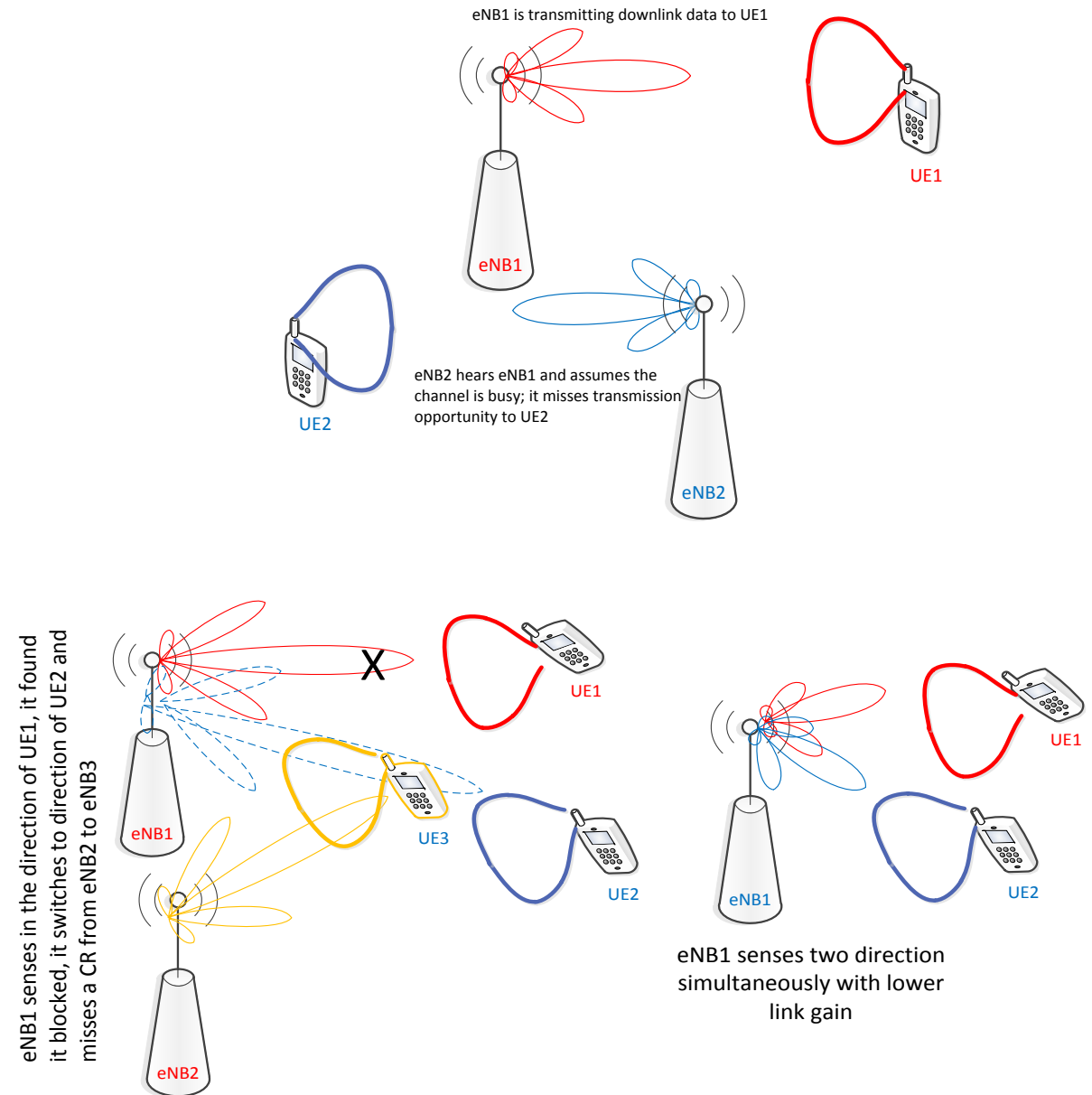## As opposed to Omni

- A third dimension that can be orthogonalized with large number of antennas
  - In general sharing is easier with mmW due to spatial isolation

- Channel reservations is still needed to protect the subset of users under severe interference
  - Can be directional to improve network reuse
  - Can be On-Demand for further reuse gains

CR
CR
CR

eNB1
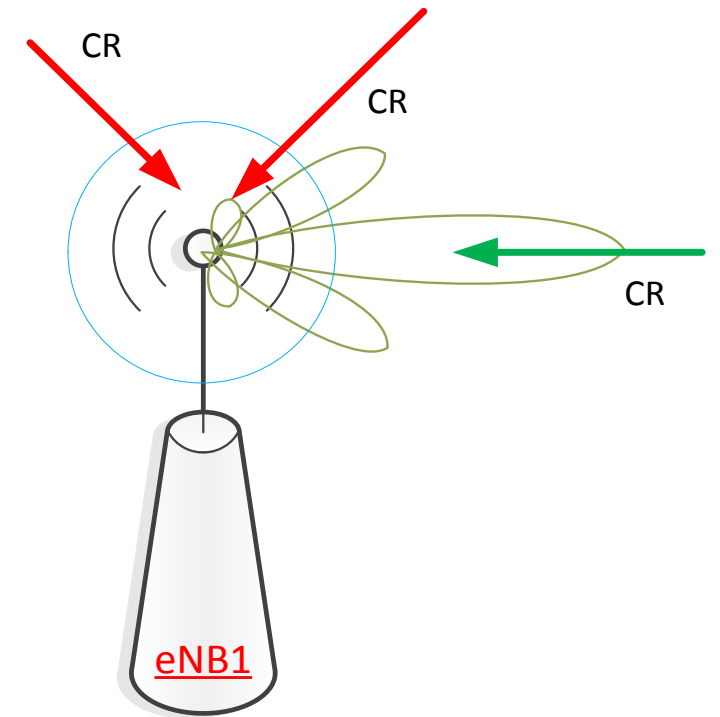
CR: Channel Reservation

More Design Considerations

- Silence the right node in the reserved region → Use a receiver based protection
  - With directed beams, there is a high chance interference dynamics at transmitter and Receiver are different, hence focusing on receiver side as opposed to transmit one

- With eNB serving multiple UEs, directed sensing can cause deafness on other beams
  - There is a tradeoff between spatial reuse and deafness

eNB1 is transmitting downlink data to UE1

UE1

eNB1

eNB2 hears eNB1 and assumes the channel is busy; it misses transmission opportunity to UE2

UE2

eNB2

eNB1 senses in the direction of UE1, it found it blocked, it switches to direction of UE2 and misses a CR from eNB2 to eNB3

X

UE1

eNB1

UE3

UE2

eNB2

UE1

eNB1

UE2

eNB1 senses two direction simultaneously with lower link gain

Thank you

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