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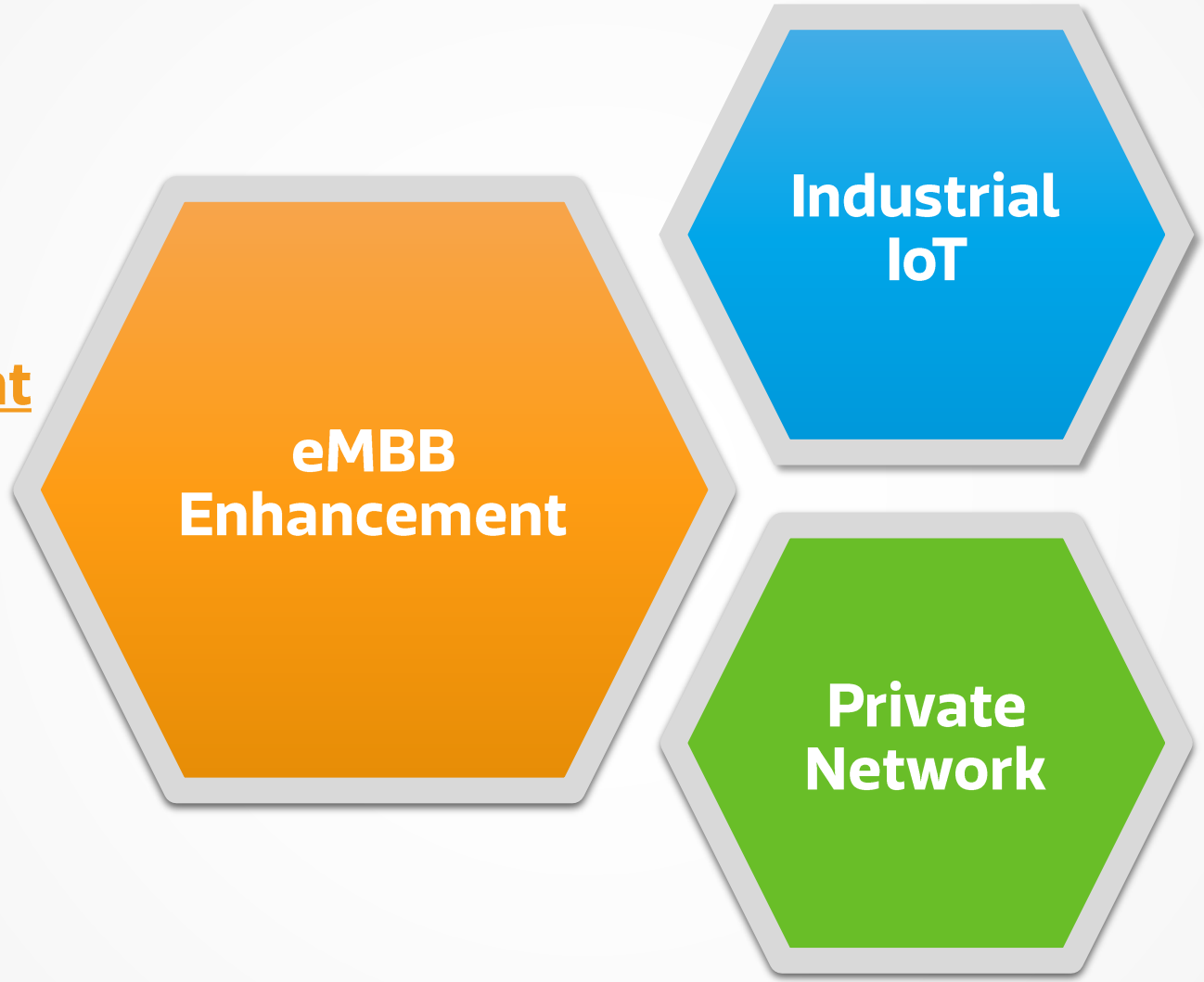
5G Opportunities and Development Challenges

MediaTek, Jun 2019

5G Opportunities

eMBB Enhancement

- Bandwidth
- Coverage
- Power Consumption



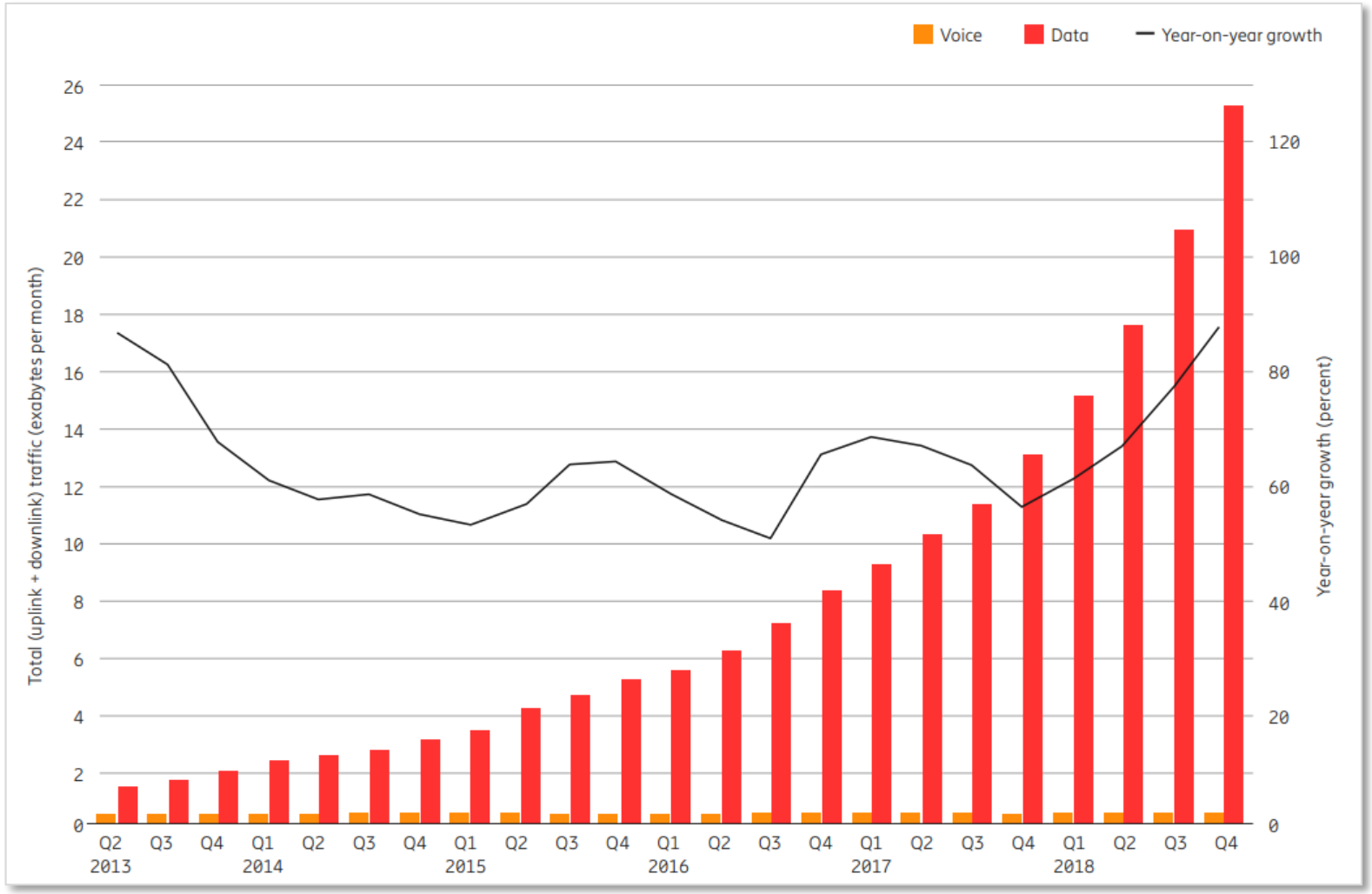
Industrial IoT

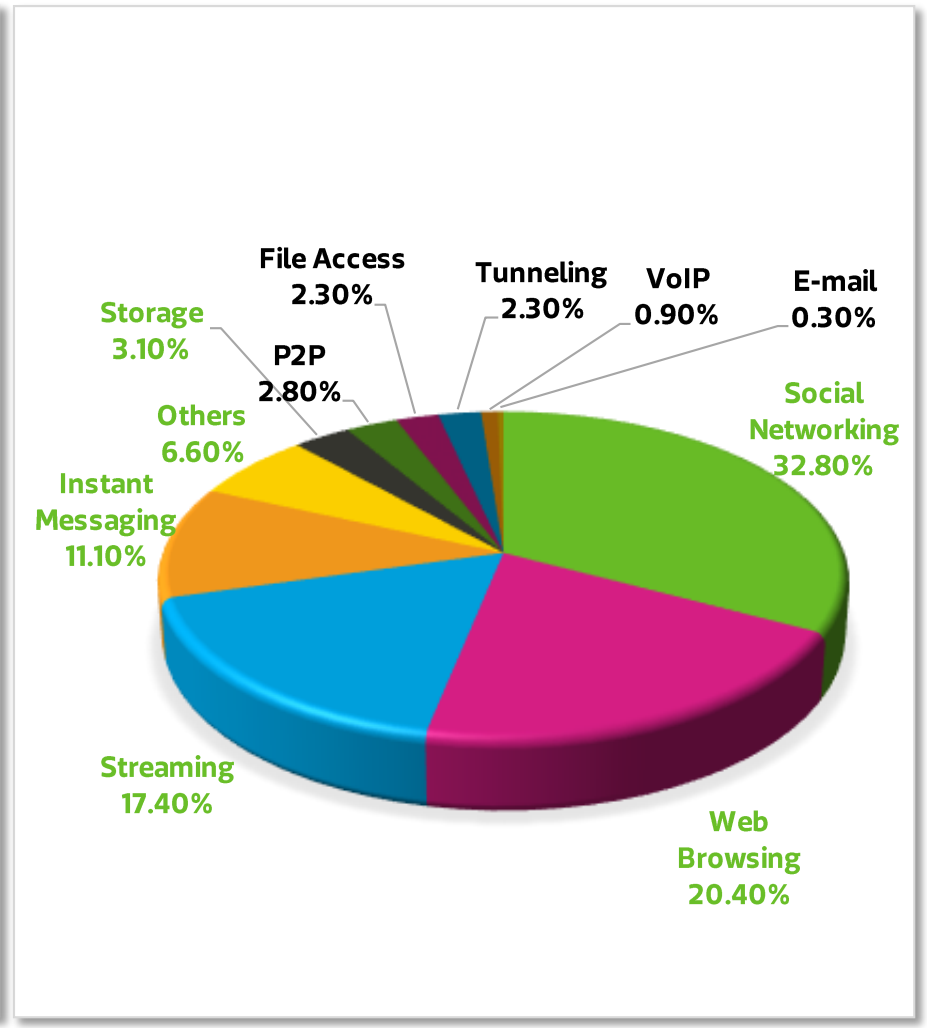
- Mini-Slot
- SA Option 2

Private Network

- NR-Unlicensed
- Indoor mmWave

The Demand of Data Transmission





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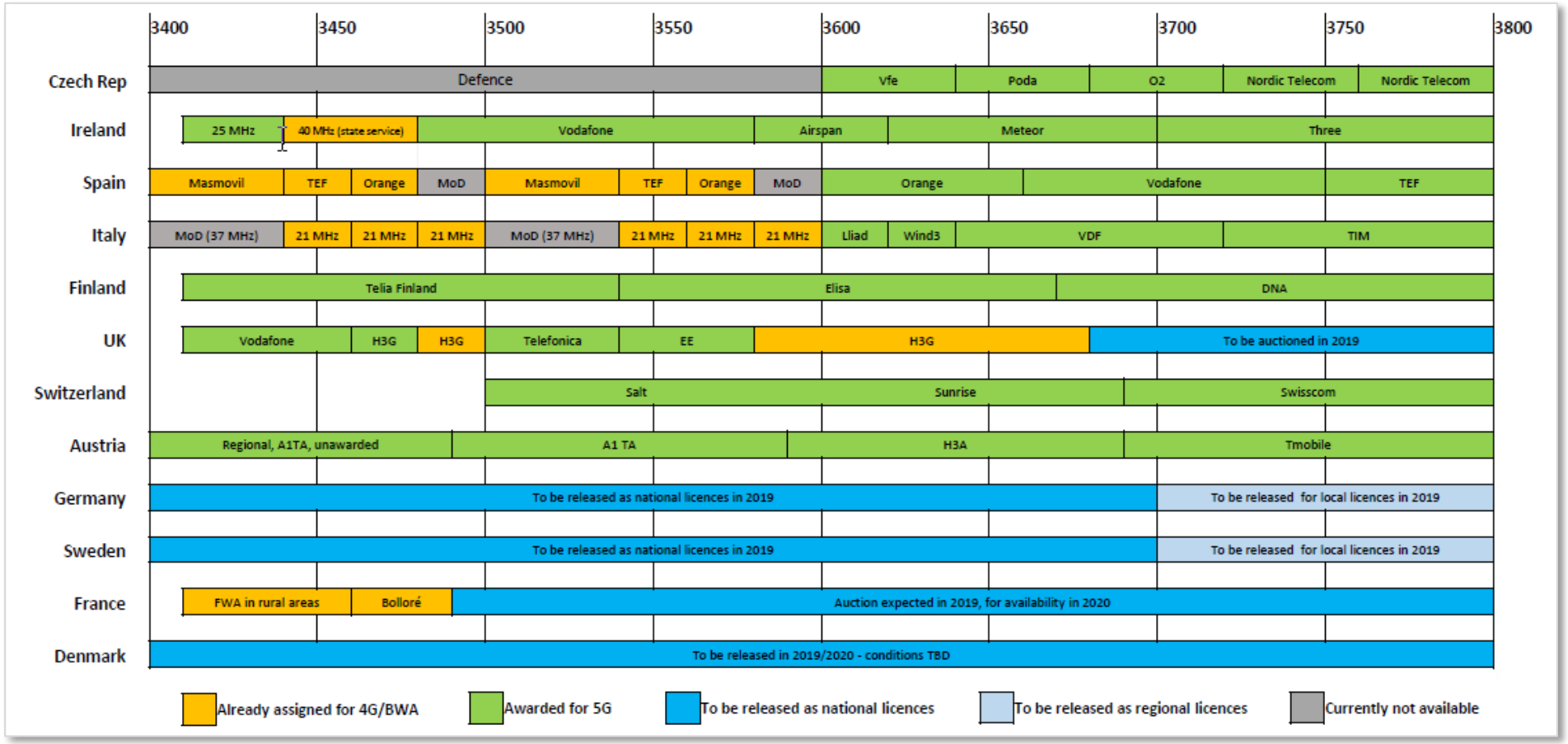
Source: Ericsson traffic measurements (Q4 2018); MediaTek internal observation for data usage

eMBB Enhancement – Bandwidth

Except some countries (China, Korea, Japan, etc.), operators always suffer fragmental and insufficient Sub-6 spectrum issues.



Source: GSA Views On 5g Spectrum Awards In 3400-3800 MHz In Europe, April 2019

eMBB Enhancement – Bandwidth – Solutions

NR Carrier Aggregation

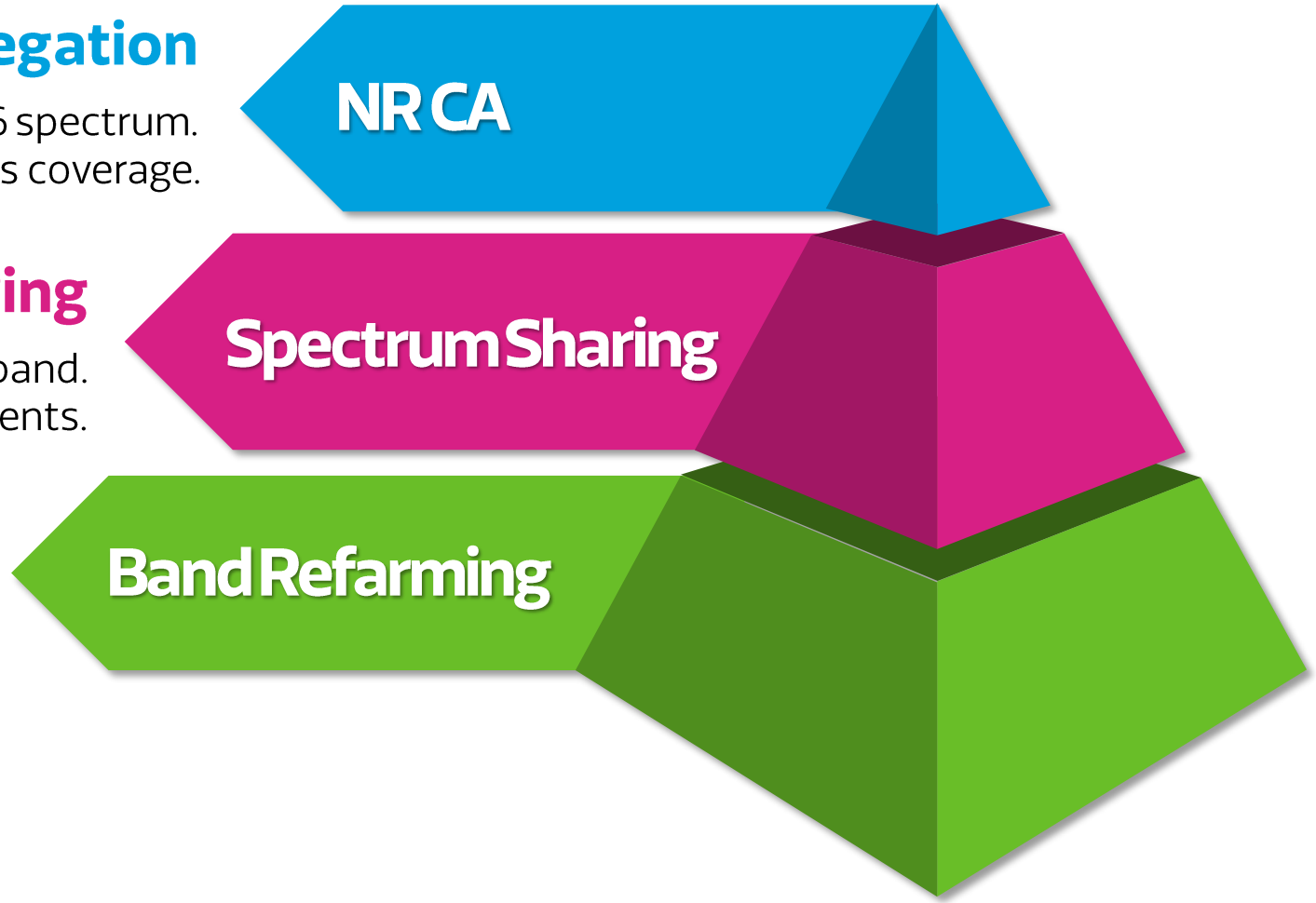
At least 2CC NR CA required for Sub-6 spectrum.
Not just for fragmental allocation, but also helps coverage.

Spectrum Sharing

Transmit NR signals over legacy LTE band.
Different operators may have different requirements.

Band Refarming

Long-term goal to release UMTS/LTE bands.
Regulatory concerns in different regions.



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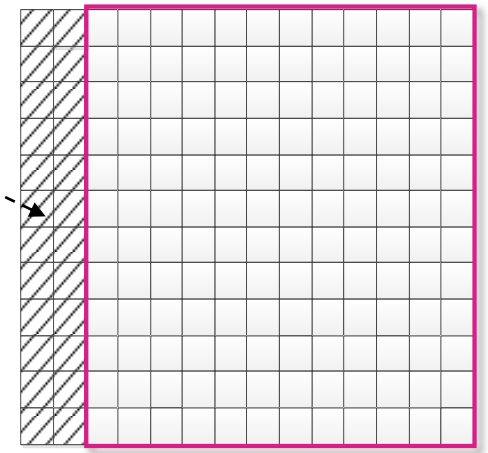
Feature – Spectrum Sharing

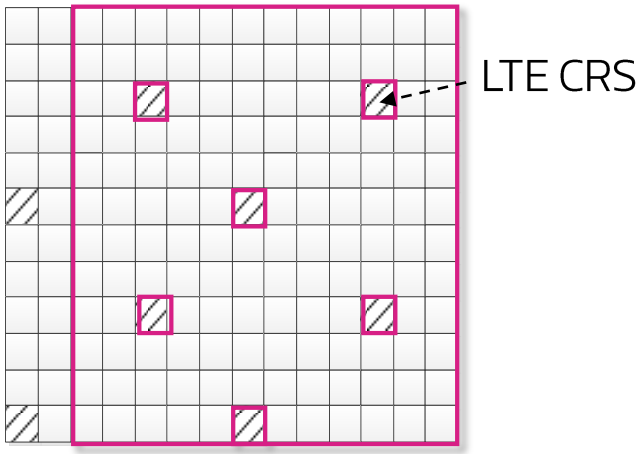
Common Solution

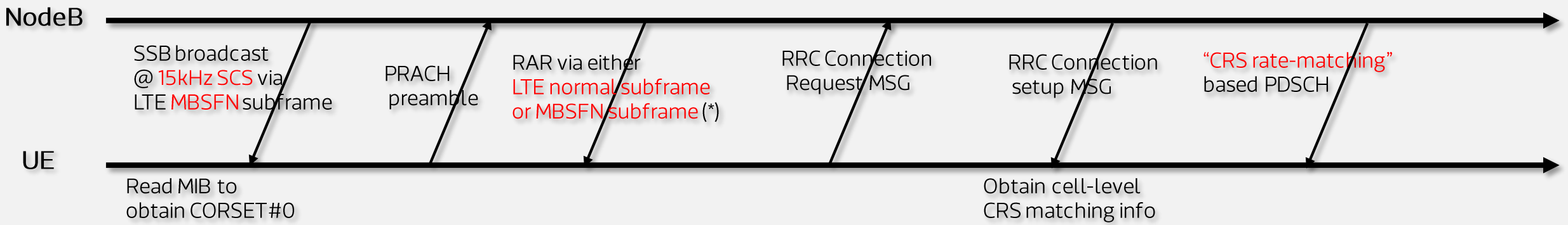
MBSFN-based



Option	Applicability	
	RRC Idle (incl. RACH)	RRC Connected
MBSFN-Based	Yes	Yes - infrequent
Rate-matching-based	No	Yes

Rate-matching-based





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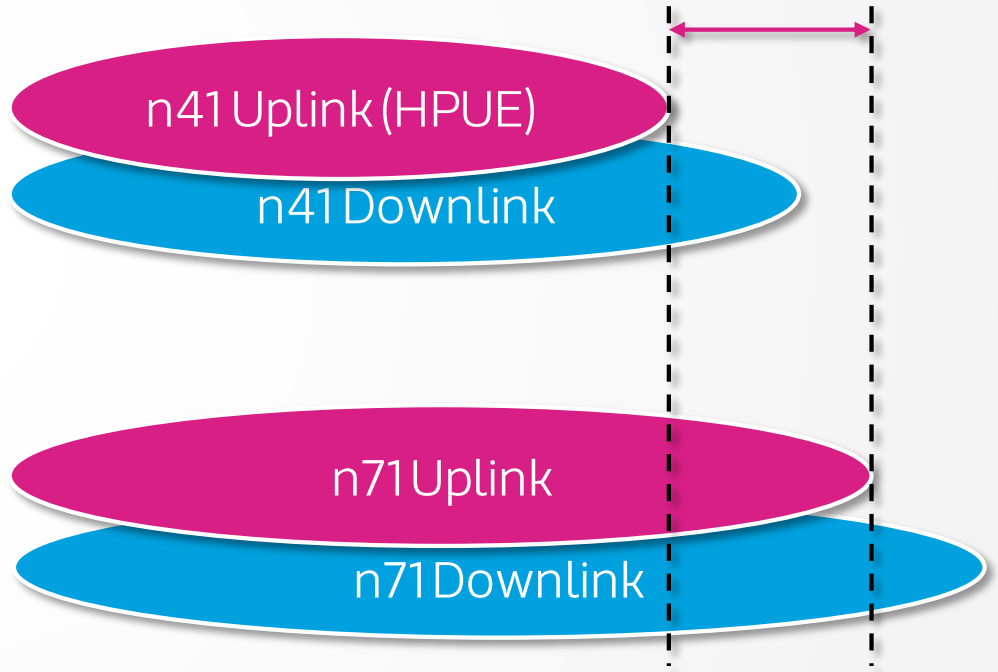
* PDSCH Type A is applied when LTE MBSFN subframe is configured. Otherwise, PDSCH Type B is applied.

eMBB Enhancement – Coverage

Link Budget Comparison		
	Outdoor (dB)	Indoor (dB)
1.9 GHz TD-LTE	0	0
2.6 GHz TD-LTE	-4.0 – -4.5	-6.1 – -6.4
3.5 GHz NR	-6.3 – -7.2	-10.0 – -10.5
4.9 GHz NR	-9.5 – -10.8	-16.3 – -18.3

9 – 11.8 dB gap in UL between n41 and n71
(under UMi model simulation)



eMBB Enhancement – Coverage – Solutions

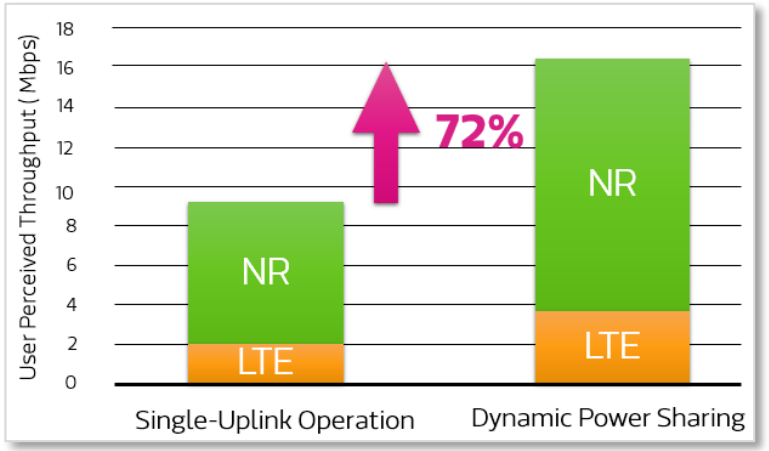
HPUE
Increase Tx Power
Total Tx 26 dBm for NSA and SA

DPS & SUO
Coordinate NSA Tx
DPS (Dynamic Power Sharing)
SOU (Single Uplink Only)

LOW BAND
UL by Lower Frequency
NR CA with Spectrum Sharing
SUL (Supplemental UL)
NR-NR DC (Rel. 15 synced only)

UDC
UL Data Compression
Reduce Over-The-Air Data to
Reduce Tx Power

Feature – DPS vs. SUO under NSA



Cell edge

Fall back to 1 connection (LTE or NR)

SUO

LTE connection

NR connection

P_{LTE}

P_{NR}

Always 2 connections maintained

DPS

LTE connection

NR connection

P_{LTE}

P_{NR}

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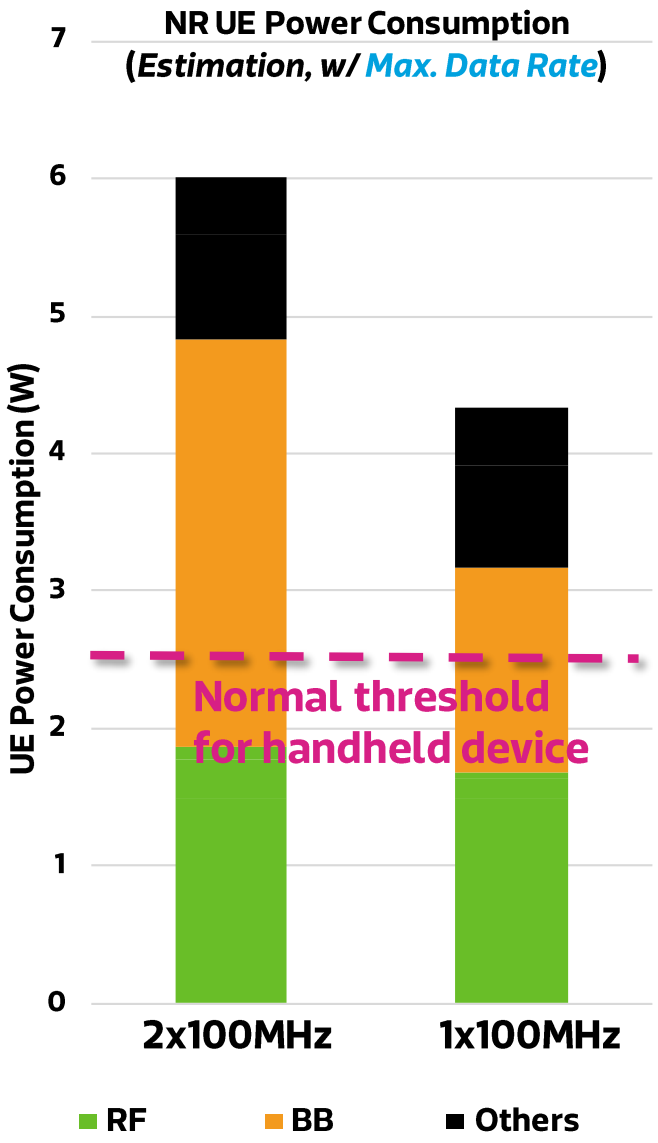
Feature – SUL vs. NR CA + Spectrum Sharing

	SUL	NR CA + Spectrum Sharing
UE configuration	• 1 DL + 2 "configured" UL, wherein only 1 UL is active at one time	• 2 DL + 1UL, wherein the UL freq is related to PCC (note: it is based on CA design principle)
Operation and UL switching	• NW configures 2 UL after initial access • NW commands UL switching by RRC message or DCI	• NW configures SCell after initial access • UE performs PCell/SCell measurements and reports the results to NW • NW sends out RRC message (i.e., handover command) to trigger PCell/SCell switching • And, PCell UL is changed accordingly
Uplink power control @ low band	• Pathloss is measured @ high band and additional "compensation delta" is provided by NW	• Pathloss is measured @ low band
Spec readiness	• Done, in maintenance mode now	• Done, in maintenance mode now
Benefit	• No impact to LTE DL • Scheduling flexibility between SUL and NUL • loose gNB/eNB interaction	• Reuse current LTE CA model • No additional effort on power control
Performance: UL coverage extension	*No difference*	
Performance: UL switching latency	• 1ms by DCI-based control	• <= 20ms by handover operation
Performance: UE power consumption	• Lower (1DL)	• Higher (2DL)
Performance: DL T-put	• Worse (1DL)	• Better (2DL)
Other issues	• Additional NW deployment efforts (e.g., power control)	• Tighter gNB/eNB interaction

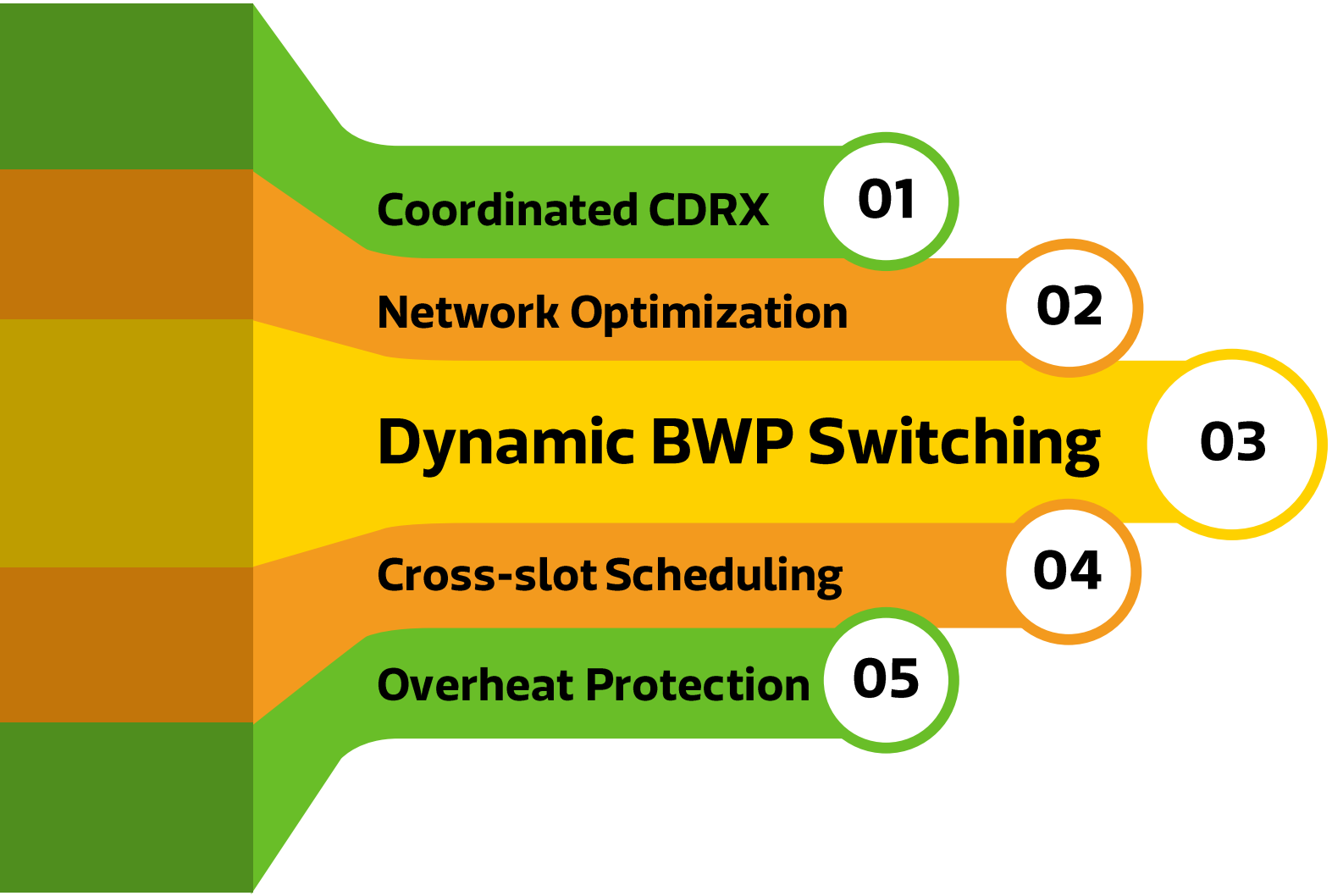
eMBB Enhancement – Power Consumption

USER EXPERIENCE MATTERS!

- The properties of High-Tput & low-latency in NR eMBB would introduce BIG challenge in the 1st Gen 5G's UE.
  - 2x ~ 3x peak power consumption is observed relative to LTE.
  - NSA PDCCH-only power: 3.5x of LTE-only
  - NSA PDCCH-only power: 1.4x of NR SA
- Carefully optimized network configuration are critical to secure 5G UE power consumption that will satisfy users.



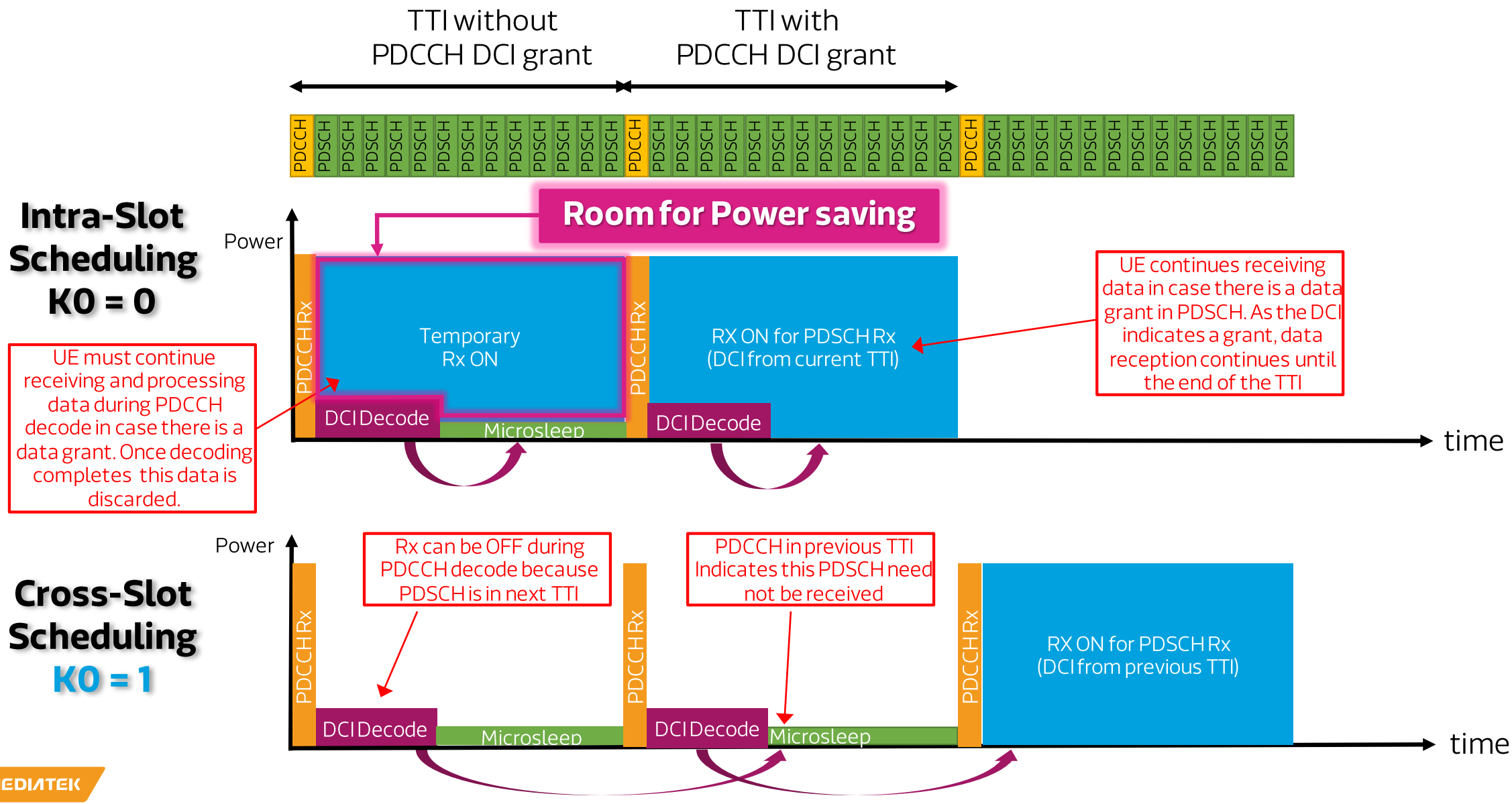
eMBB Enhancement – Power Consumption – Solutions



BOTH UE AND NETWORK'S SUPPORT ARE NEEDED

- Coordinated CDRX to ensure UE can sleep together under EN-DC NSA mode.
- Network Optimization includes:
  - TRS should be tightly coupled with CDRX on-cycle.
  - Avoid in-slot Aperiodic CSI-RS
  - Concentrate monitor occasions in the front of slot
  - Relaxed K1/K2 configuration
- Cross-slot Scheduling is a trade-off between latency and battery life.
- Dynamic BWP switching is relatively simple comparing to above settings.
- Overheat Protection to ensure UE won't have heat crash.

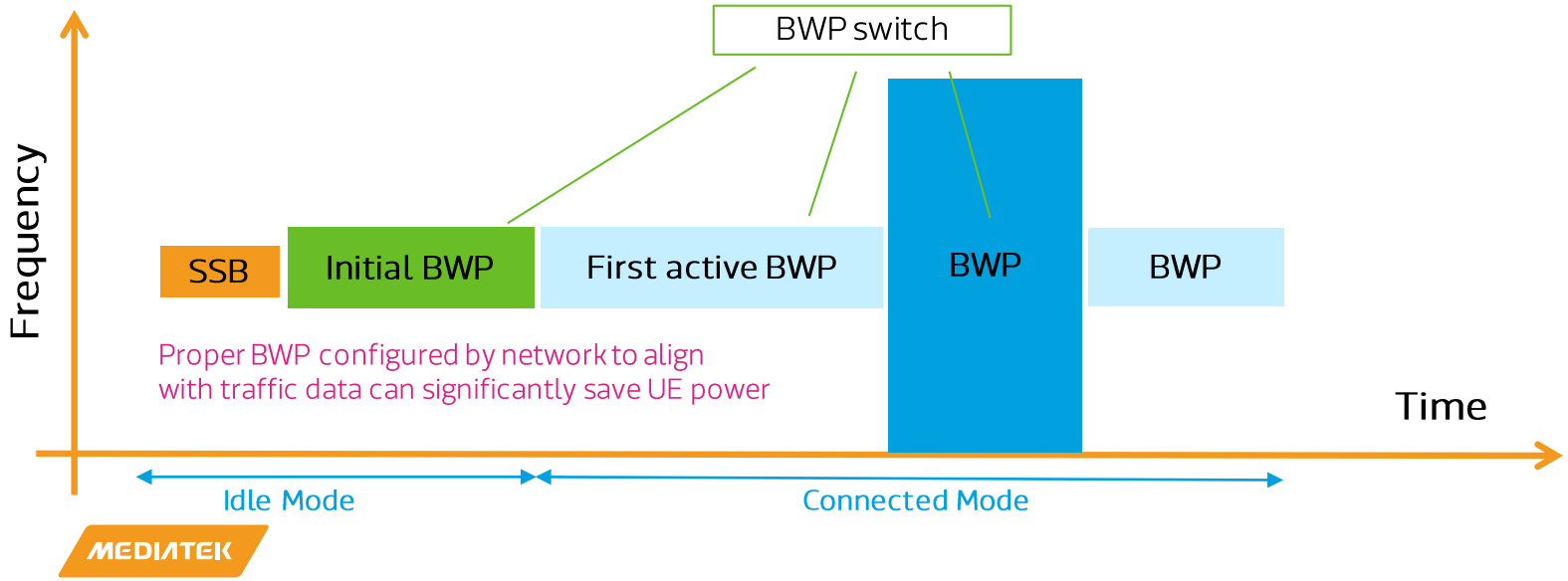
Feature – Cross-Slot Scheduling



Feature – Dynamic BWP Switching

- Flexibly configure UE operation bandwidth for power saving
  - BWP: BandWidth Part
  - For each CC, UE will only process the PRBs within BWP.

BWP Options	Overhead	Switching Latency	Note
RRC-based	One RRC message (~10kB) per switch	**~10ms**	Semi-static adaption
DCI-based	One RRC message; One PDCCH per switch	**~2ms**	Easier to better fit with observed traffic pattern



Power Saving Gain by BWP

Video traffic (example by iQIYI)

- >30% power saving gain by BWP
  - BWP=100MHz when large payload
  - BWP=20MHz when small payload
  - DCI-based BWP applied

Voice traffic (traffic pattern from VoLTE)

- >40% power saving gain by BWP
  - Assume 3 types of voice traffic scenario: Silence/Listen/Talk
  - If no BWP, NR BW = 100MHz. With BWP, NR BW = 20MHz.
  - Power saving from PDCCH and PDSCH processing

Gaming traffic (example by KingOfGlory)

- Up to ~50% power saving gain by BWP
  - BWP bandwidth = 10MHz or 100MHz
  - DCI-based BWP applied

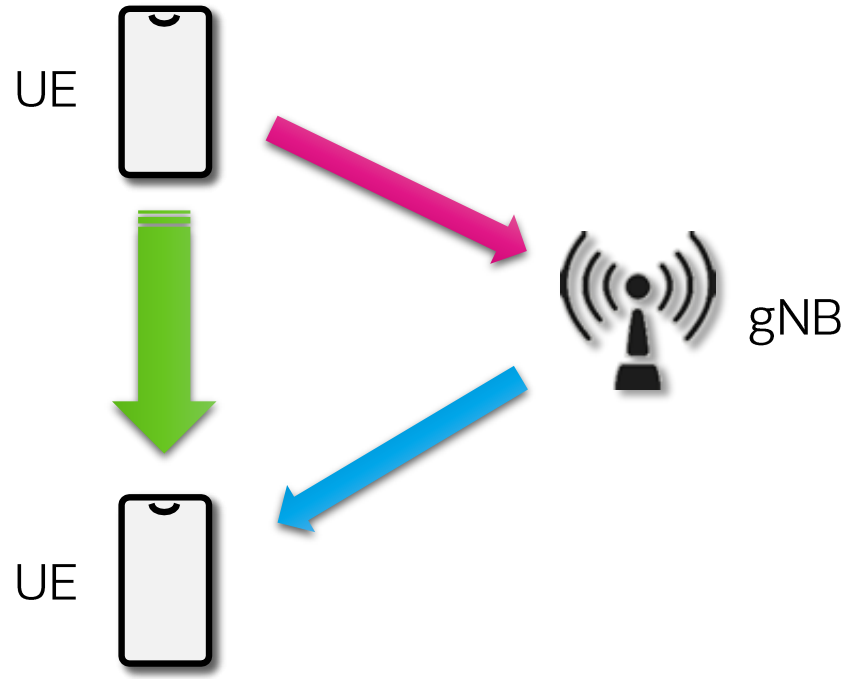
Feature – Overheat Protection

Recommended Ctrl Parameters

- CA#, BWP, MIMO-Layer# → R15 approved
- TX Pwr, Duty-cycles, Modulation-Types… → R16

Opt1:	Opt2:	Opt3:	Opt4:	Opt5:
NR MIMO Reduction 4x4 → 2x2	NR BWP Reduction 100MHz → 20MHz	NR CC reduction LTE+NR → LTE	NR-only DutyCycle Reduction LTE: 100% NR: 100%→40%	NR DutyCycle Reduction LTE: 100→40% NR: 100%→40%
↓14%	**↓29%**	**↓68%**	**↓25%**	**↓60%**

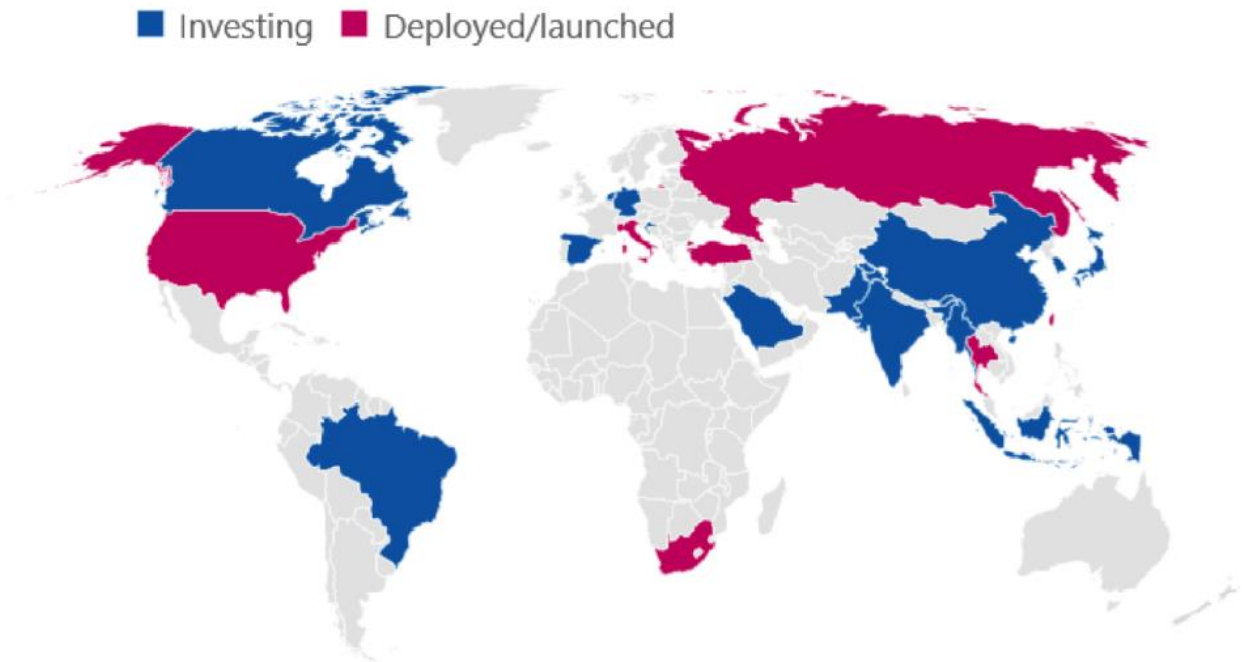
Overheat protection request
- CA/MIMO-Layer/BWP reduction request



Overheat protection response
- Reduced capability to UE

Private Network & IIoT – Spectrum

- **8 LAA deployments/launches:**
  - AT&T (US), T-Mobile (US), AIS (Thailand), MTS (Russia), Smartone (Hong Kong), TIM (Italy), Turkcell, Vodafone Turkey (deployed)
- **28 LAA trials and deployments in progress in 18 countries**

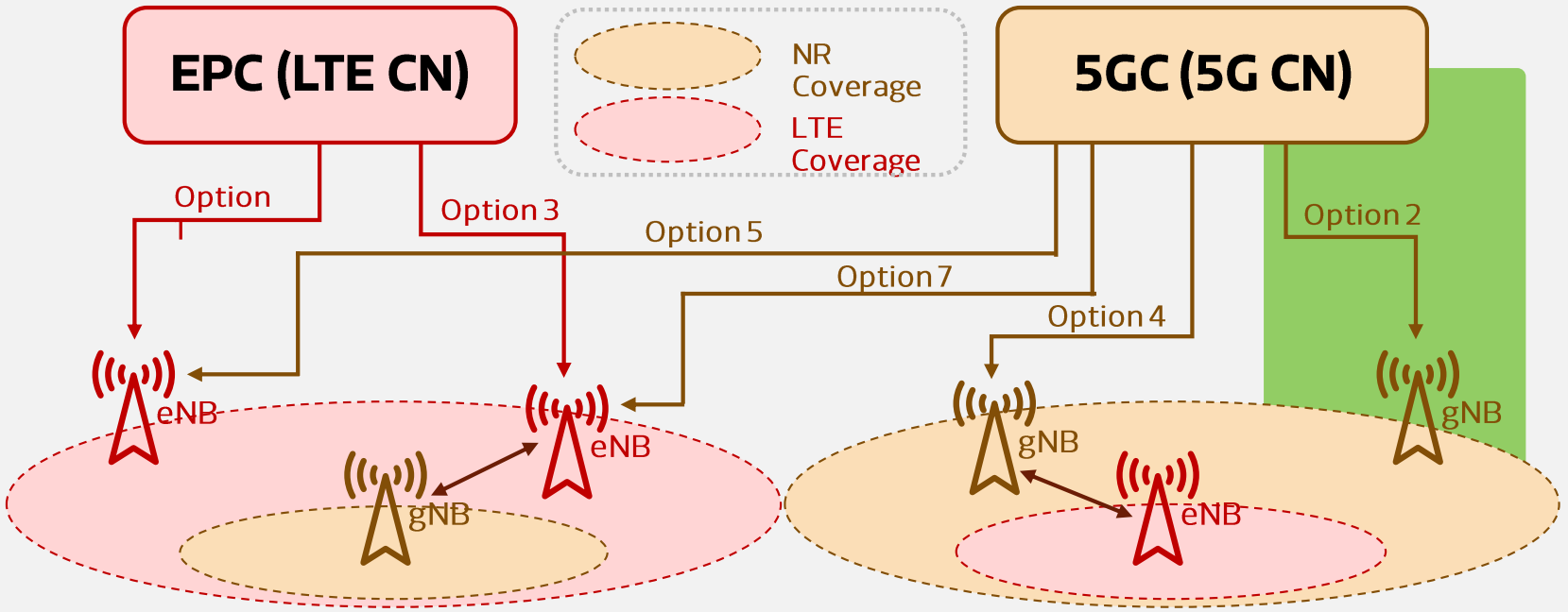


3GPP Rel. 16 NR-U	Licensed-assisted	Enable unlicensed band operation
	Standalone operation	Enable New non-smartphone business opportunity (e.g., IIoT)
	DL data reception	Improve DL system capacity by using unlicensed band
	Uplink data transmission (incl. RACH)	Improve UL system capacity by using unlicensed band
	Sub-7 band support	Enable unlicensed band operation about 6Ghz

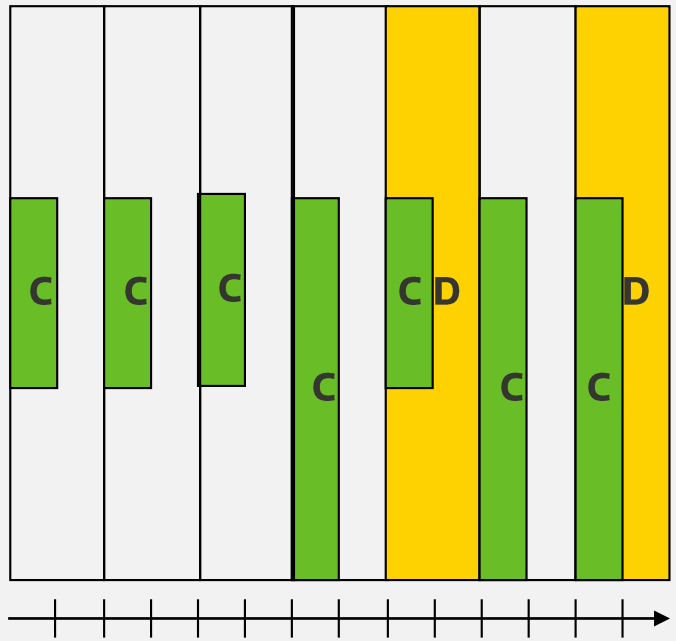
Besides **unlicensed 5GHz**, many customers are considering **CBRS (GAA)** and **indoor mmWave**.

Source: GSA LTE in Unlicensed Spectrum – Snapshot May 2019

Private Network & IIoT – Low Latency

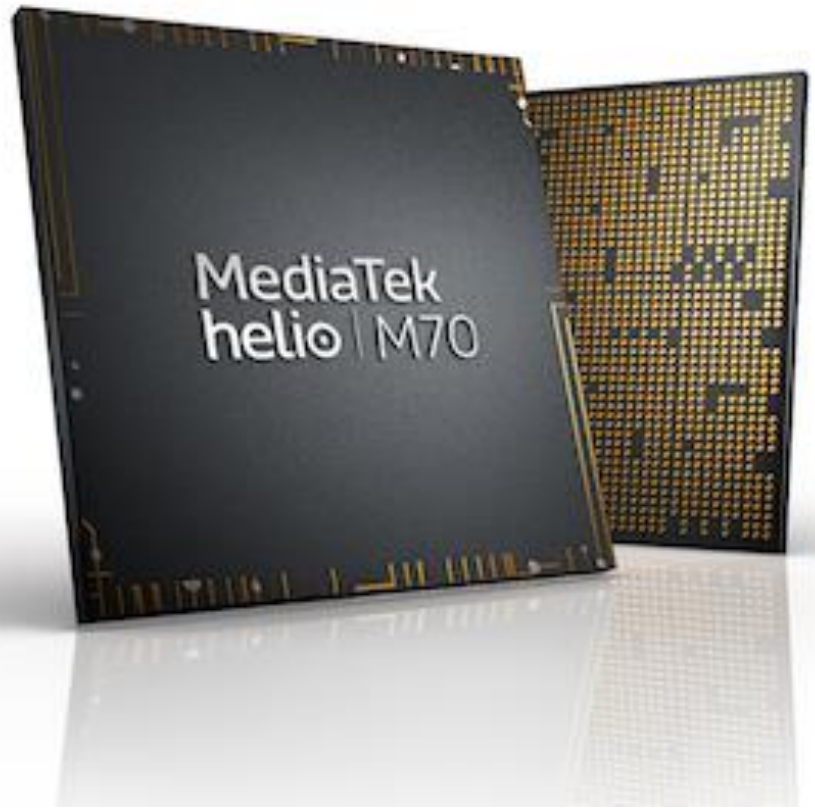


Standalone **Option 2** is a must-be for low-latency private network (**Core NW**)



Mini-Slot is further improvement (RAN)

MediaTek helio | M70



High-Level Capability

LTE Rel-15 Cat.19

1.6Gbps DL 5CC, 4x4 MIMO
316Mbps UL 3CC
DL/UL 256QAM

NR R15 Sep/Dec version

4.67Gbps DL, 200MHz aggregated BW, 4x4 MIMO
2.5Gbps UL, 200MH aggregated BW, 2x2 MIMO
DL/UL 256QAM

NR Carrier Aggregation

DCI-based BWP Adaptation
Dynamic Power Sharing
Spectrum Sharing

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