3GPP RAN workshop on 5G
Phoenix, AZ, USA, September 17-18, 2015

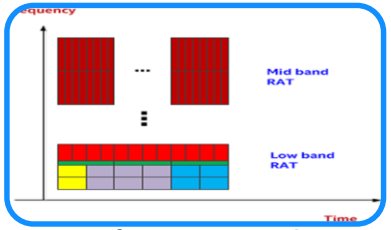
RWS-150023

View on 5G Radio Technology and Standardization

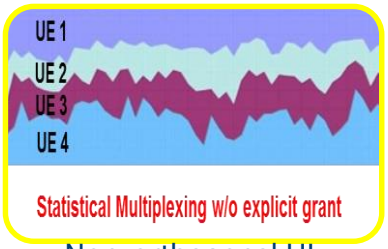
Intel Corporation

September 17-18, 2015

5G requirements, challenges and enablers



Waveform, numerology and frame structure



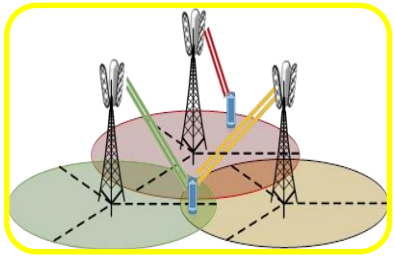
Non-orthogonal UL multiple access

- Uniform user experience
- Higher traffic density
- 2Gbps peak rate

Mobile Broadband

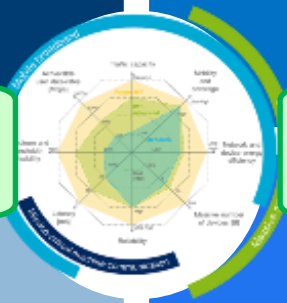
- Long range
- Small data
- Massive # of devices

mMTC



Advanced multi-site MIMO and beamforming

- Low latency
- Energy efficient
- Mobility robustness



- Min. overhead and signaling
- Forward compatible

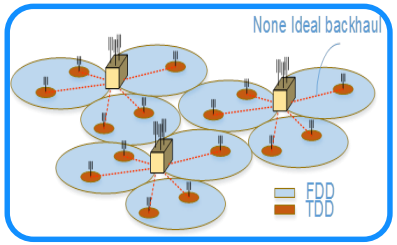
Massive light-weight connections

New spectrum up to 100GHz

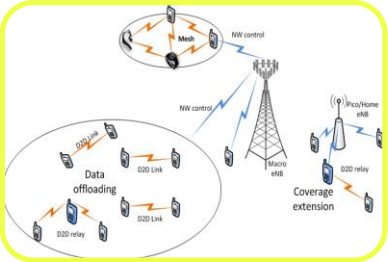
- Higher freq.
- Licensed/ unlicensed
- RF component challenges

uMTC

- Ultra reliable and available
- Ultra responsive

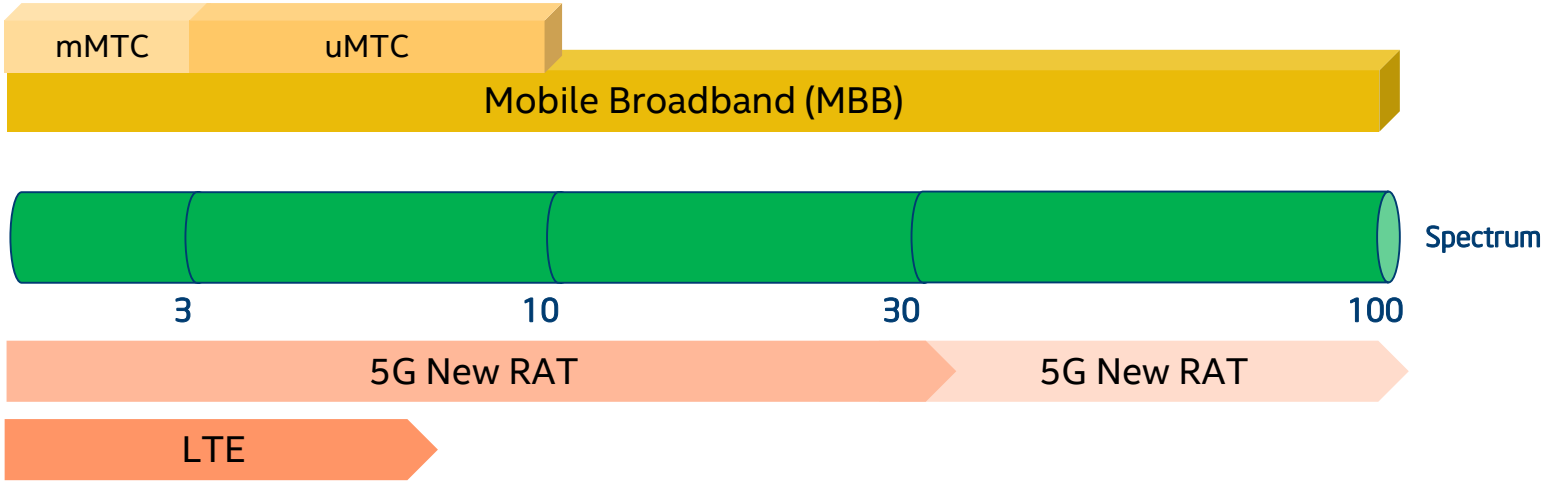


Inter/intra-RAT multi-connectivity



eD2D for 'Best connected' - Ultra dense multi-layer networks

5G spectrum



Sub-6GHz to 100GHz with scalable bandwidth

- FDD and TDD in sub-6GHz
- Dynamic TDD and symmetric UL/DL to enable future unified spectrum utilization

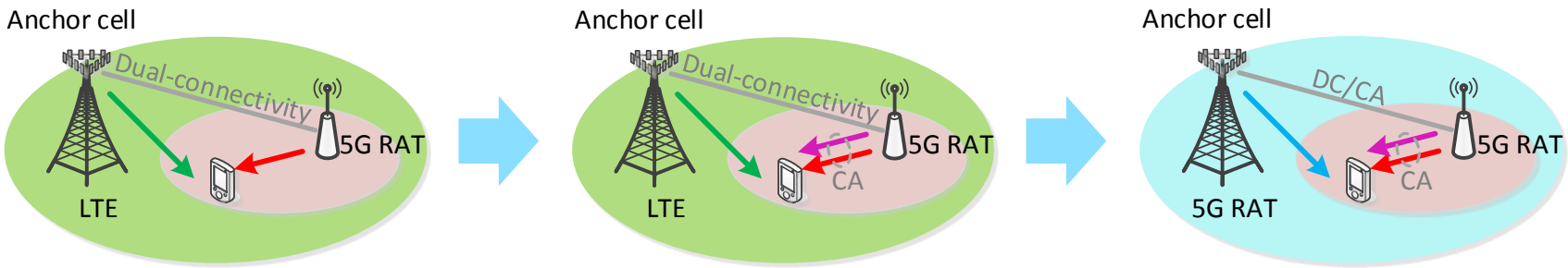
Global harmonized new spectrum allocation is challenging

- Multi-band support on device

Propagation characteristics of the new bands need to be understood

- Critical to align the channel modeling between 3GPP and ITU “spectrum groups”

5G new RAT – multi-connectivity



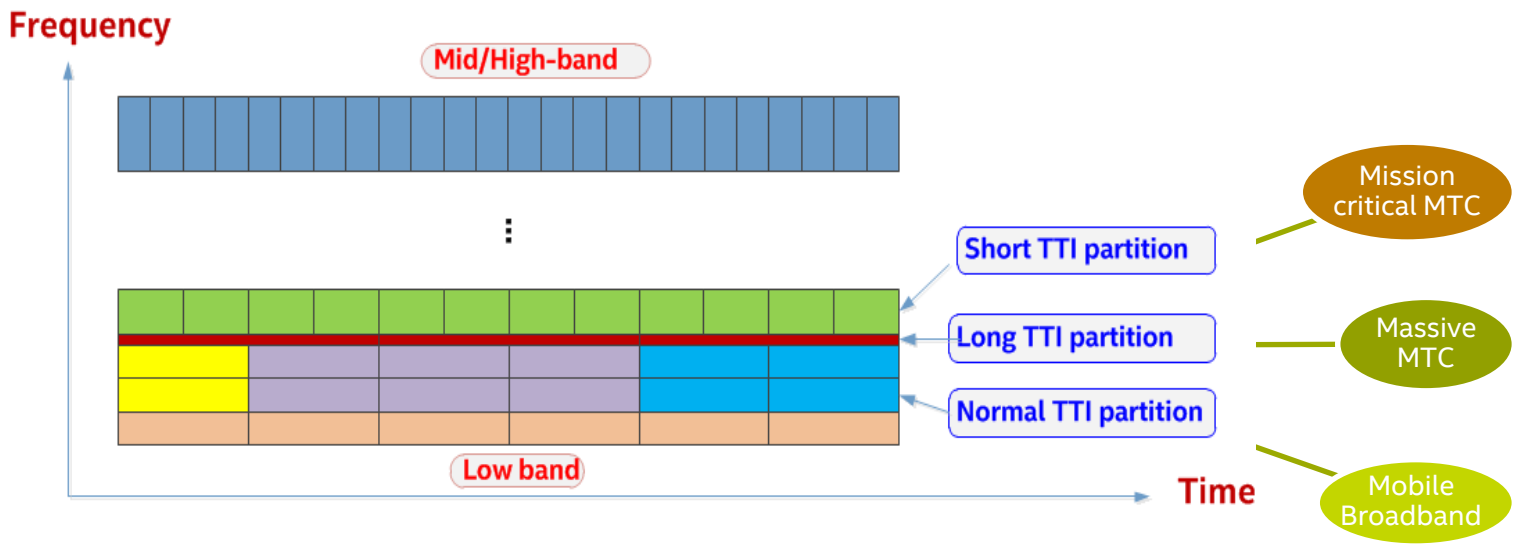
	Co-located / ideal-backhaul			Non co-located (non-ideal backhaul)		
	LTE	5G low band	5G high band	LTE	5G low band	5G high band
LTE	CA	DC [Split][1]	DC [Fallback][2]	DC [Split][1]	DC [Split][1]	DC [Fallback][2]
5G low band		CA[3]	CA[3]		DC [Split][1]	DC [Fallback][2]
5G high band			CA[4]			DC[4]

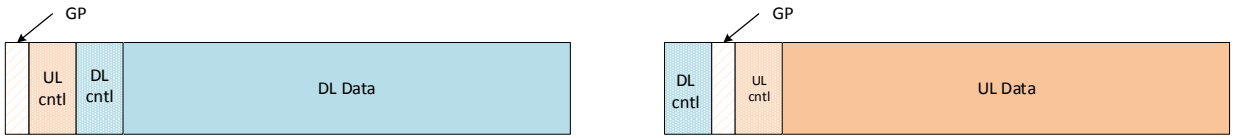
1. Traffic split or aggregation across carriers/RATs is beneficial when data rate from different carriers/RATs are comparable (i.e. bandwidth is similar).
2. Fast fall back to low frequency band (LTE or 5G) is important to address more challenging radio link stability and coverage in high frequency band.
3. When two 5G RAT carriers have different TTI lengths, the support of carrier aggregation (rather than DC) depend on performance evaluation.
4. Needs LTE or 5G low band as anchor

5G new RAT – key technology areas

Framework	Numerology	Waveforms	Multiplexing and access
• Unified flexible RAT • Forward compatible design for phased deployment approach • Minimize always-on control and RS overhead	• Configurable numerology (e.g. subcarrier spacing, TTI) optimized for each use case and spectrum	• MC-OFDM-based waveform for low band • Single carrier waveform can be considered for high band • Further optimization for efficient multiplexing can be considered	• Flexible UL/DL multiplex and dynamic TDD • Non-orthogonal multiple access in UL • Symmetrical UL&DL design, enabling unified directionless transmission in multi-layer network

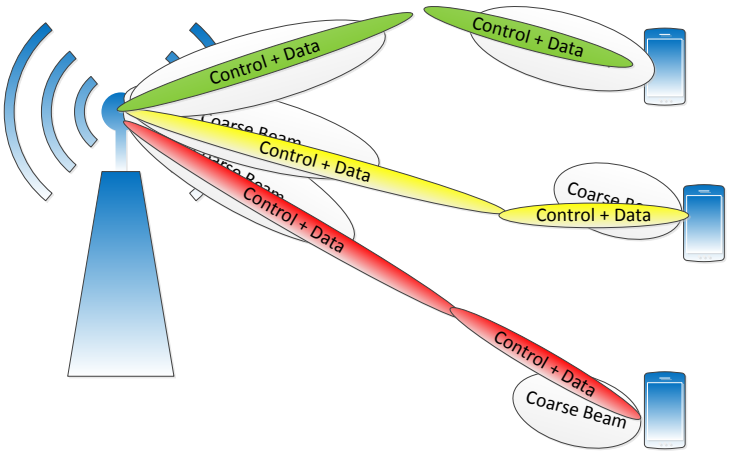
5G new RAT – frame structure

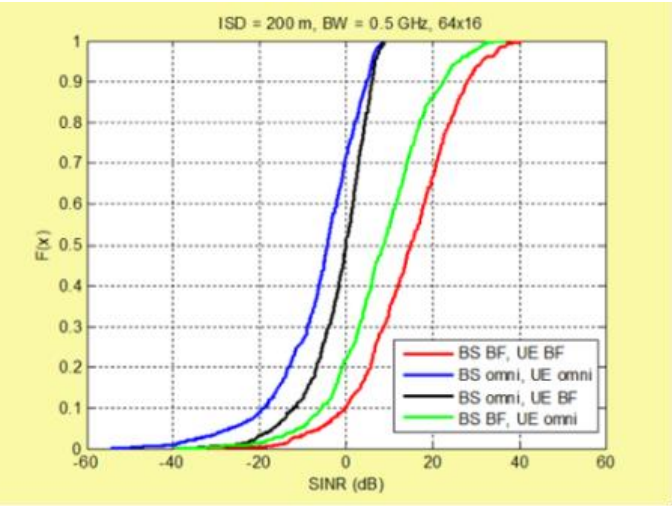




- Allow the UL (or DL) control channels and reference signals (e.g. for beam tracking), even when consecutive DL (or UL) transmissions are needed to accommodate asymmetric traffic patterns
- Minimizing the UL-DL switching to reduce the GP overhead

5G new RAT – mmWave





Beamformed cell

- Beamformed control and data transmission
- Sync channel and RRM RS design need to take into account of coverage, sync/acquisition/cell selection performance
- Beamforming training of digital and analog pre-coder at eNB and UE to support high order MU-MIMO

SE (bps/Hz)	36 sites		96 sites	
	Rx omni	Rx BF	Rx omni	Rx BF
5%-tile	0.04	0.33	0.6	1.73
50%-tile	1.18	2.14	3.23	7.45
95%-tile	7.57	7.57	7.57	7.57

SLS results assuming 1GHz BW @70Ghz, 36/96 cells deployed in a 1sqkm dense urban environment, 100 UEs dropped with full buffer traffic

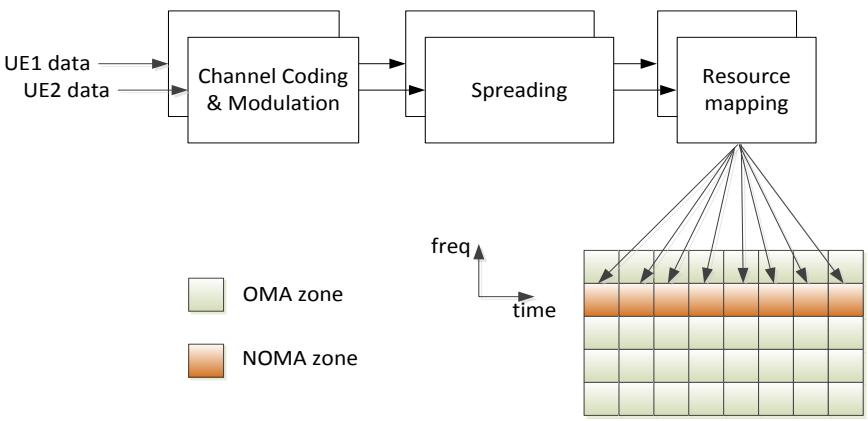
UL multiple access enhancement

Allow non-orthogonal multiple access in UL

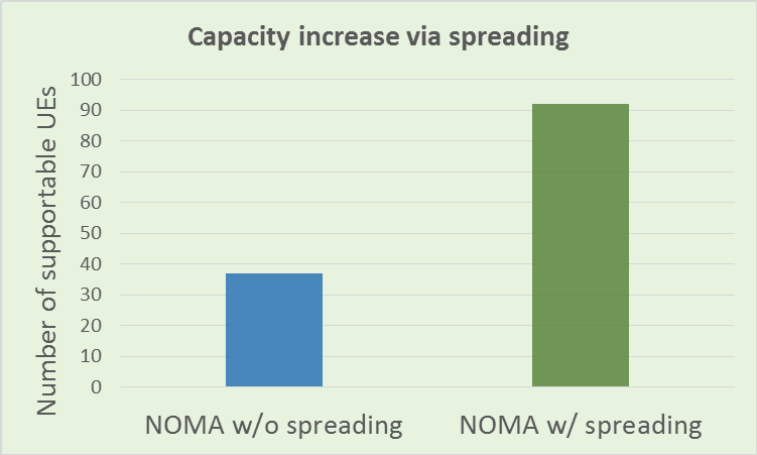
- High capacity (especially with IC receiver)
- Low DL control overhead and low latency
- Specially beneficial for massive connectivity and small packets, e.g., MTC, TCP ACK, VoIP, gaming, etc.

Can be supported in LTE in a backward compatible manner

- FDM/TDM of OMA zone and NOMA zone

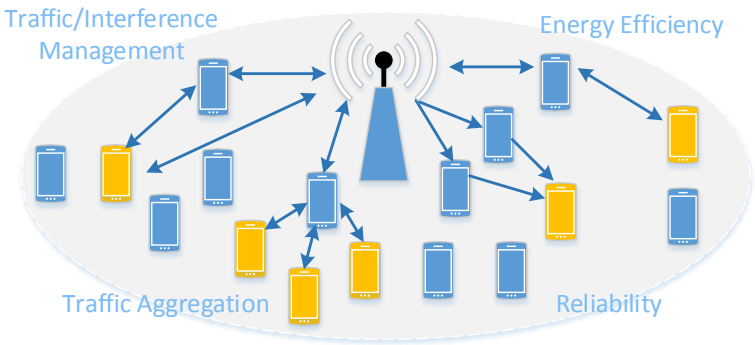


Example of NOMA transmission in the uplink



Simulation assumptions Homogenous 57 macro cells, cell radius 500 m, CF: 2GHz, UE max power 23dBm, traffic model: 288 bits with inter-arrival time 30ms (Poisson dist), fixed MCS: QPSK ½, Ant config: 1x2. Treating other UEs' signals as noise. A UE in outage if 98%-tile delay > 25ms. System in outage if UEs in outage > 3%.

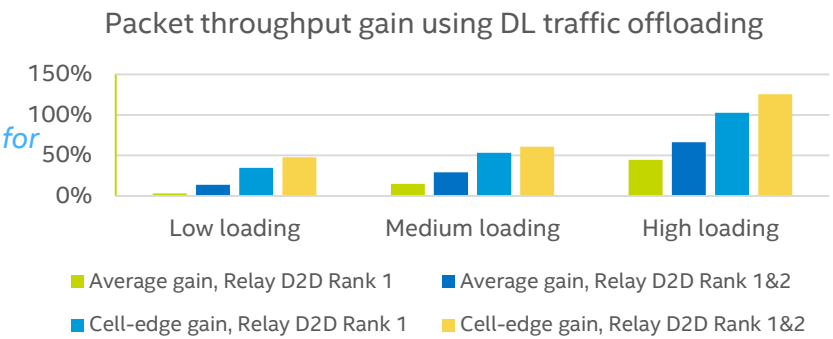
eD2D – enabling ultra dense multi-layer NW



Ultra dense multi-layer NW to support

- Enhanced Mobile Broadband (eMBB)
- D2D-aided MTC/IoT
  - Lightweight power-efficient operation
  - High-rate short range communication
  - Diverse connectivity for ultra-reliability

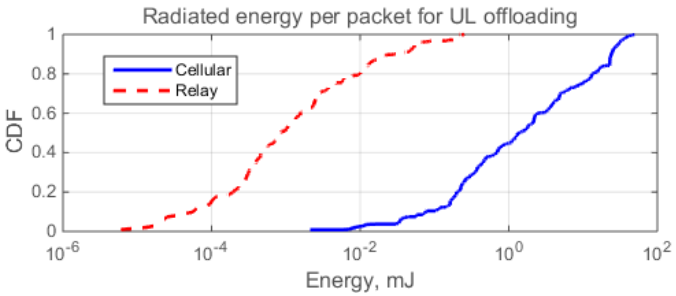
Higher throughput for high-end devices



Multiple design vectors

- Enhanced traffic & interference management
- Lightweight operation with traffic/access aggregation
- Energy efficiency
- Reliability
- User positioning

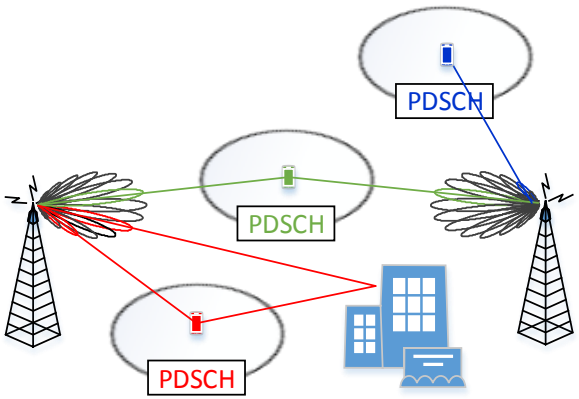
Energy-efficient UL operation for MTC devices



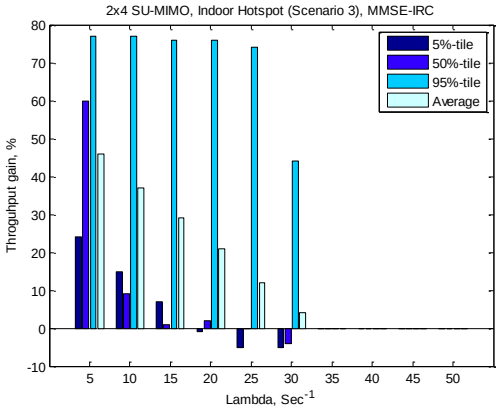
Advanced MIMO/Beamforming

Further enhanced CoMP/MIMO

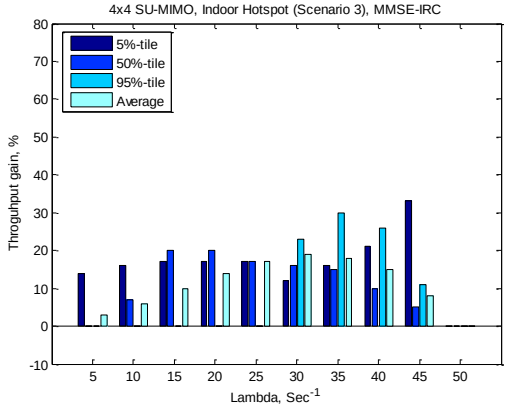
- Multi-point coordination for MIMO layer / beam aggregation and interference avoidance:
  - Increase downlink data rate via aggregation of multiple MIMO layers / beams
  - Beamforming coordination to mitigate interference, e.g. Tx FD-MIMO coordinated beamforming, MIMO layer coordination, Rx interference avoidance at the UE
- FD-MIMO enhancement for DL and UL beyond Rel-13



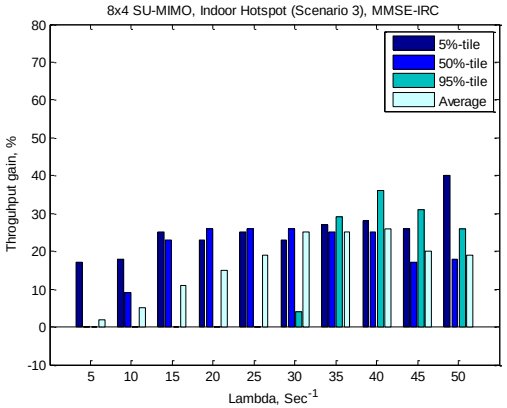
2x4 antenna configuration



4x4 antenna configuration



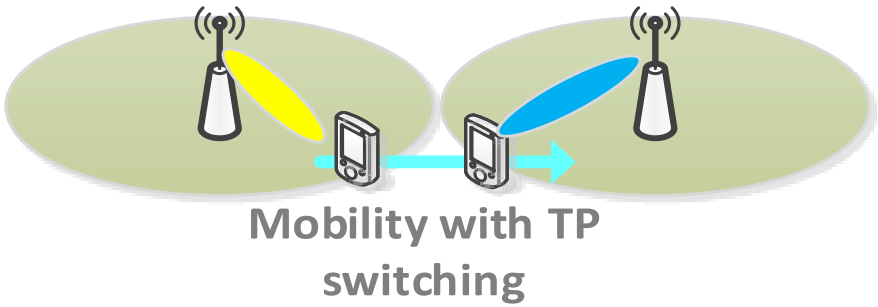
8x4 antenna configuration



Seamless beam/site association and mobility

Beam-cell operation with seamless mobility

- Fast transmission point / beam switching
- Minimized L1/L2 re-configuration



Design consideration

- PHY enhancements
  - Tx/Rx beam acquisition and multi-link time/frequency tracking
  - CSI-RS and CSI-IM resource pooling and CSI measurements restrictions
  - Enhanced UL power control
- L2/3 enhancements
  - Common UE-specific configuration and shared L2/3 context in the network to avoid L2/3 reset/reconfiguration
  - Multi-connectivity to enable seamless mobility in case of non-ideal backhaul

Lightweight connection management

Main requirements

- Signaling storm reduction (radio interface and network signaling)
- Latency reduction
- Energy consumption reduction
- Flexible solutions suitable for different use cases, e.g:
  - Massive MTC
  - MBB

Starting point

- Signaling Reduction WI as proposed for R13
- UE context storage in RAN during idle mode
- Fast, low overhead resumption of RRC connection

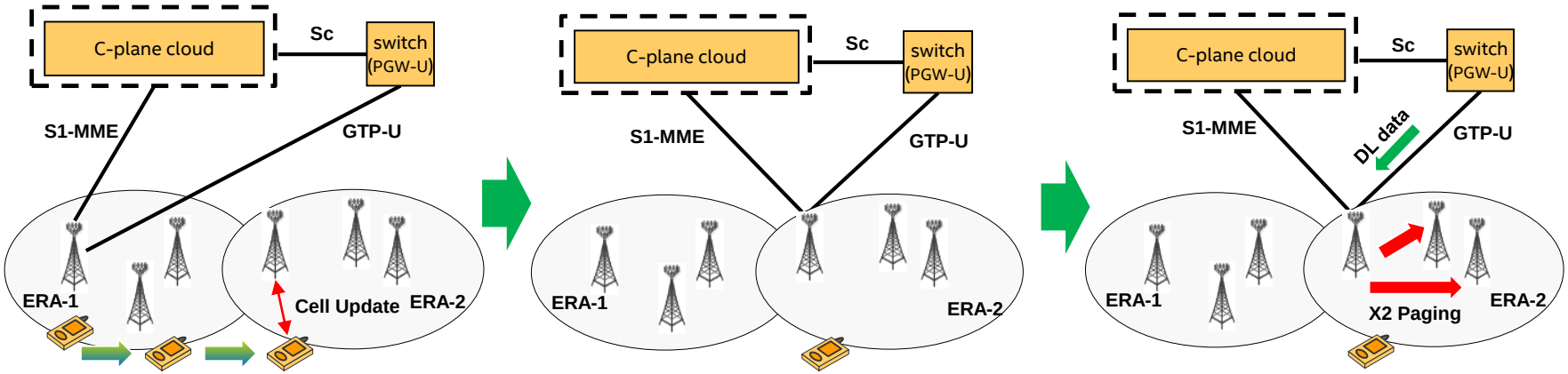
Further enhancements

- New 'lightly connected' UE states:
  - RAN connection maintained during inactivity
  - UE based mobility enabled
  - Cell changes without signaling possible
- Connectionless operation
  - Small data transfer without any RAN connection
- Un-scheduled transmissions

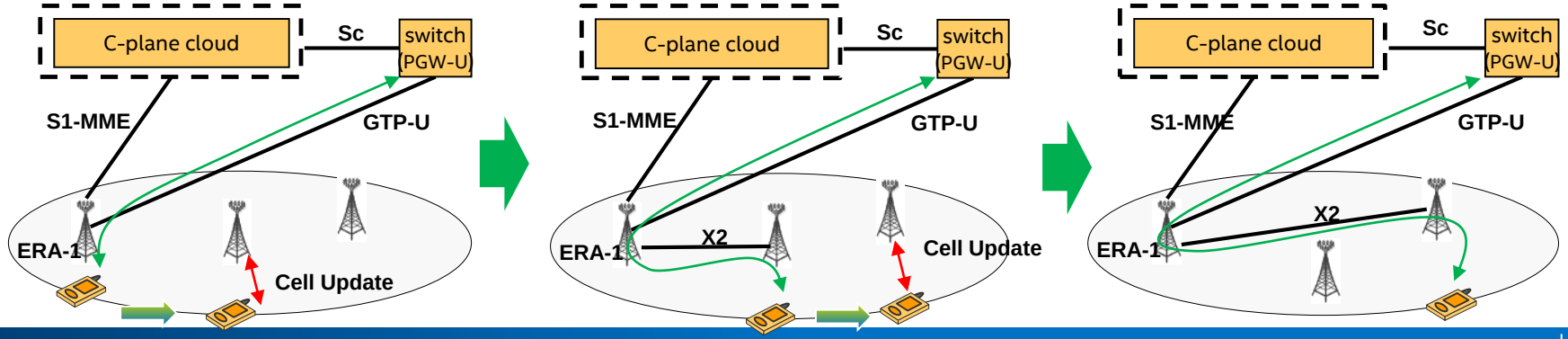
Hierarchical mobility management (1/2)

Introduce **lightly connected states** for user/traffic driven mobility management to allow flexible trade-off of UE power consumption, over-the-air and network signaling overhead and latency

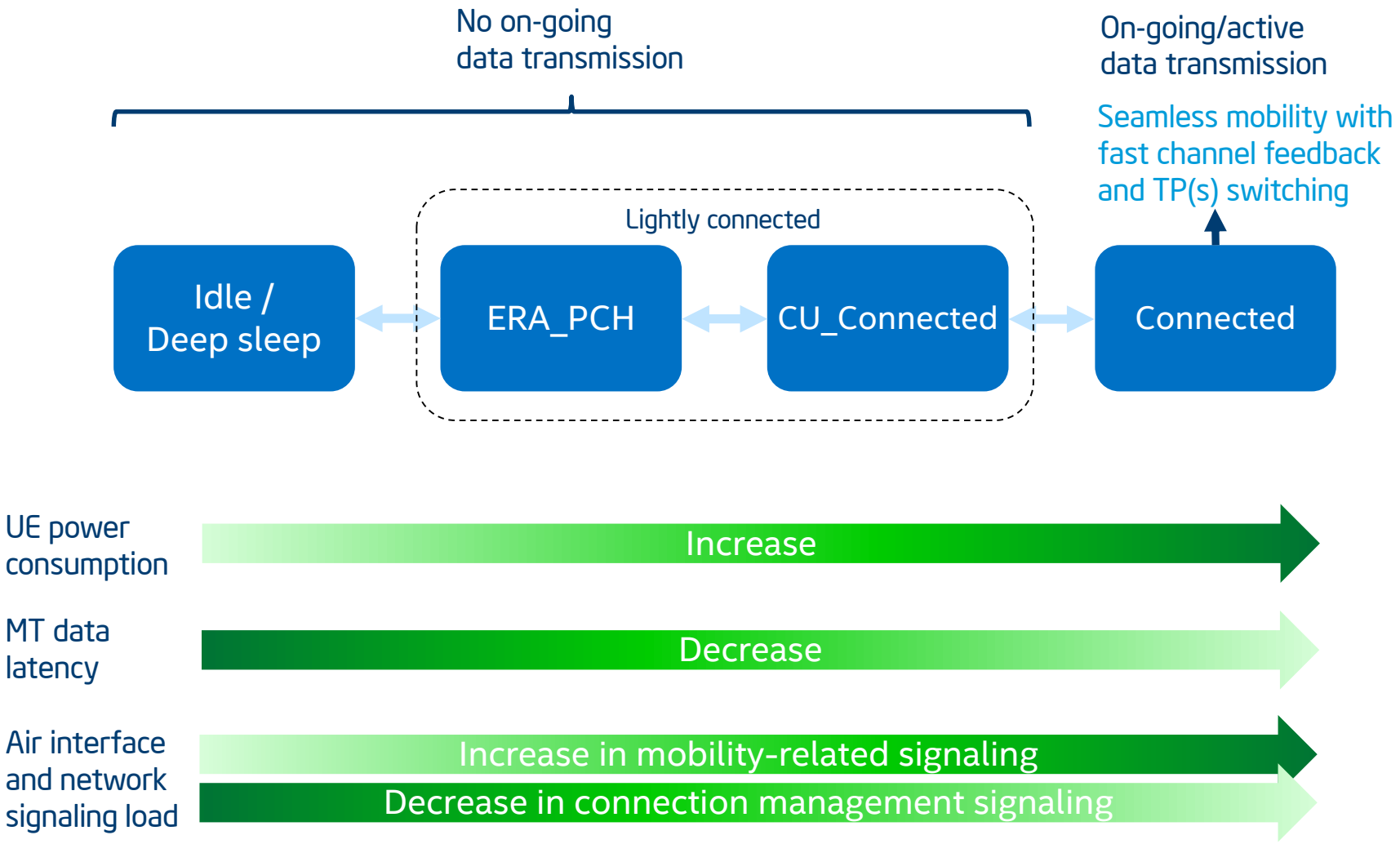
ERA_PCH: network tracks the UE in RAN routing area granularity. 'X2' paging required for MT data.



CU_Connected: network tracks the UE in cell level granularity. No paging required for MT data.



Hierarchical mobility management (2/2)



5G technology phasing

Rel-14/15

New RAT Phase 1 spec (Rel-15)

- FDD and dynamic TDD at sub-6GHz, scalable to support up to ~30GHz
- Baseline design with flexible frame structure, scalable numerology, low-power and minimized control overhead
  - MC-OFDM based symmetric UL and DL
- Prioritize eMBB on non-standalone small cell with tight interworking with LTE
  - Seamless mobility
- Forward compatible design framework
  - mMTC/uMTC
  - D2D enhancement
  - Beamforming operation

LTE evolution

- New UL multiple access to support massive connections
- FeD2D to allow best connections for low-power, long-range and efficient data offloading
- Advanced multi-site MIMO/beamfoming
- Seamless mobility in ultra-dense network
- Light-weight connectionless protocol

Rel-16

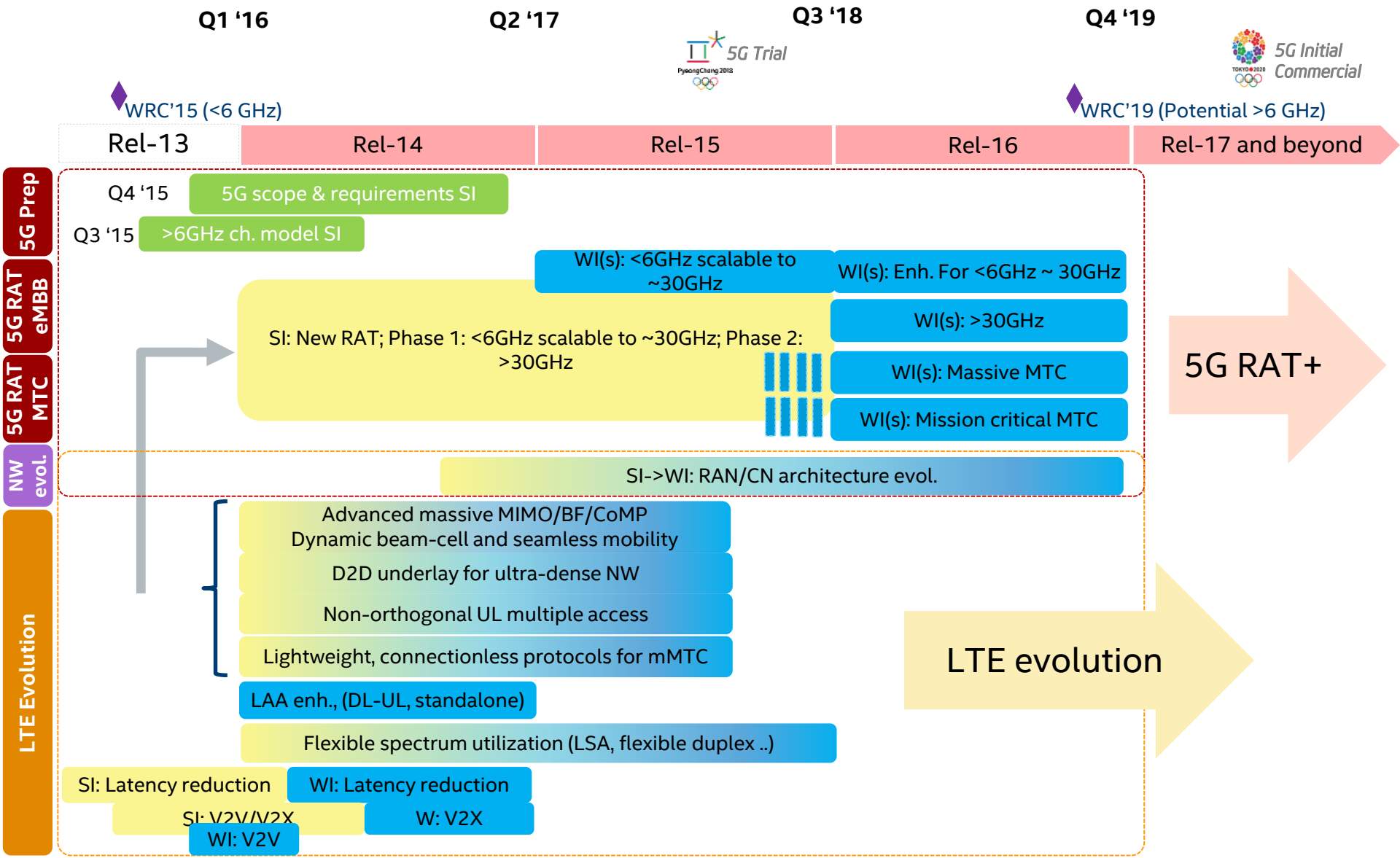
New RAT Phase 2 spec

- Fully compliant to IMT-2020 and 3GPP requirements
- Standalone 5G operation for all deployment scenarios
- Support up to 100GHz spectrum with unified flexible spectrum utilization
  - New waveform, e.g. DFT precoding or alternative single carrier waveform, to be considered in higher spectrum

LTE evolution

- Further enhancements

3GPP release and 5G timeline



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