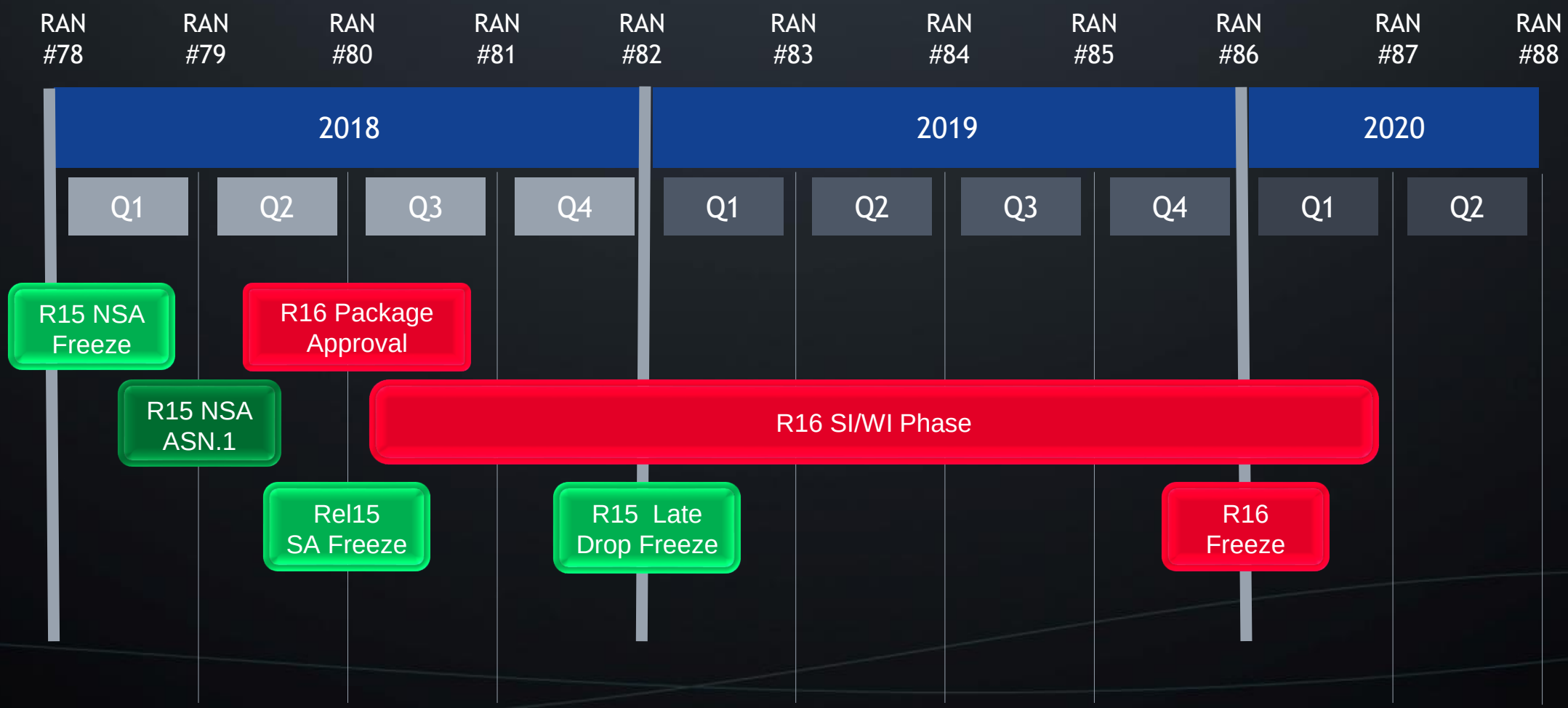
Air Interface for 5G and Beyond

Dec. 9, 2018

Abu Dhabi

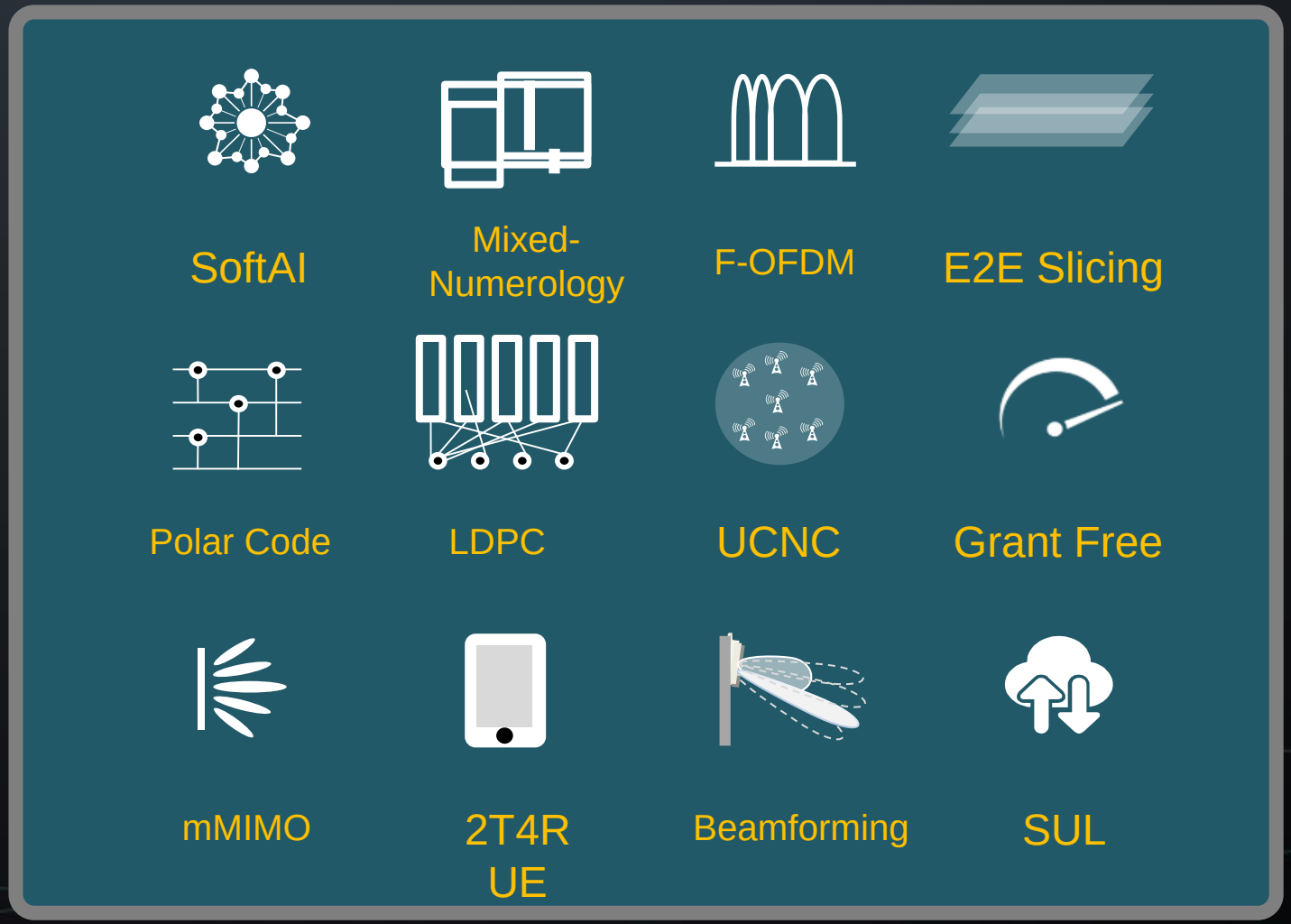
Dr. Jianglei Ma

5G Phase 1/2 (R15/16) Timeline



NR R15 8 Air-Interface Innovations

1. **Soft Air Interface**
   (Hybrid Numerology/Slot/Frame)
2. **New Waveform**
   (F/W-OFDMA)
3. **New Coding**
   (Polar Code, LDPC)
4. **Ultra Low Latency**
   (Special Slot and Transmission Mechanism)
5. **New Transmission Mode**
   (Grant Free)
6. **New Access Scheme**
   (UCNC)
7. **Enhanced MIMO**
   (Massive MIMO)
8. **mmWave Transmission**
   (Beam-Centric UP/CP)



NR R15 8 Air-Interface Innovations - 1

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Unified Air-Interface

- High Frequency/Low Frequency Bands
- NSA/SA
- Licensed/Unlicensed Bands
- Mixed Services

Features (Scalable ,Configurable & Forward Compatible)

1) Scalable and Mixed Numerology
2) Fully Configurable Frame Structure
3) Flexible Numerology & Bandwidth Configuration
4) BWP based Self-contained PHY designs
5) Uplink and Downlink Decoupling

NR R15 8 Air-Interface Innovations - 2

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   (Massive MIMO)
8. mmWave Transmission
   (Beam-Centric UP/CP)

Optimized for Mixed Services

- Low Latency
- Massive Connections
- High Spectral Efficiency
- Forward Compatibility and Slicing

Features

1) Filtered-OFDM
2) Windowed-OFDM
3) Zero-Gourd Band
4) Flexible Waveform OFDM/SC-OFDM

NR R15 8 Air-Interface Innovations - 3

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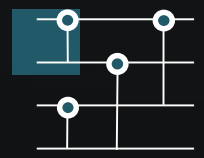

Support High Performance

- High Reliable and Low Latency Control Channel
- Low Complexity Decoding of High Peak Rate

Features

1) Polar Code for Control Channel
   - Parity-Check Polar Code
   - Distributed-CRC Polar Code
   - Polar Sequence and Rate Matching
2) LDPC Code for Data Channel
   - Two Base-Graph Scalable LDPC and associated Re-transmission Redundancy

NR R15 8 Air-Interface Innovations - 4

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   (Massive MIMO)
8. mmWave Transmission
   (Beam-Centric UP/CP)

Support Very Low Latency

- Low Latency eMBB
- URLLC Services
- Co-Exist with other Transmission

Features

1) Mini-Slot
2) Grant-Free Transmission
3) Scalable numerology/frame strucrure Configuration
4) Co-extentence Mechanism for Multiplex of URLLC/eMBB

NR R15 8 Air-Interface Innovations - 5

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   (Massive MIMO)
8. **mmWave Transmission**
   (Beam-Centric UP/CP)

Grant-Free to Support

- Fast Low Latency Access,
- Massive Link Connectivity
- Signaling Overhead Reduction
- Battery Enhancement

Features

1) GF Resource Allocation
2) GF-HARQ Re-transmission Mechanics
3) GF-Slow-loop Link Adaptation
4) Blind Detection of UE
5) UE Collision Handling

NR R15 8 Air-Interface Innovations - 6

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5. New Transmission Mode (Grant Free)
6. **New Access Scheme (UCNC)**
7. Enhanced MIMO (Massive MIMO)
8. mmWave Transmission (Beam-Centric UP/CP)

User-Centric-No-Cell to Support

- UE and Site Decoupling
- Physical Channel and CellID Decoupling
- CP and UP Decoupling
- No HO for intra-NR cell mobility

Features

1) Non Cell-ID based Physical PHY Designs
2) SFN Based SYNC Channel
3) New UE state: Inactive State
4) Intra-Cell Beam Management
5) Inter-Cell Beam Hand-off

NR R15 8 Air-Interface Innovations - 7

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   (Massive MIMO)
8. **mmWave Transmission**
   (Beam-Centric UP/CP)

Large Array Antenna to Support

- Large Number of Data Streams
- Enhanced MU-MIMO
- Enhanced Coverage
- 4-Receive 2-Transmit UE

Features

1) Beam-Based Control Channel
2) Enhanced MIMO feedback mechanism
3) Beam-Based DMRS and CSI-RS Optimization
4) UL precoding
5) UE 4-Receive and Non-Codebook Transmission

NR R15 8 Air-Interface Innovations - 8

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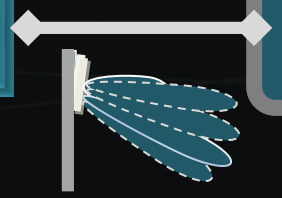


Support mmWave Spectrum

- Beam Based Access and Control
- Dynamic Beam Processing

Features

1) Beam Based Random Access
2) Beam Sweeping Procedure
3) Beam Failure Detection
4) Beam Recovery
5) Phase Noise Tracking

From NR Release 15 to Release 16

2018				2019			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		NR V2X SI					
		NR eURLLC SI					
			Industry IoT				
				NR MIMO WI			
		RIM SI		RIM+CLI WI			
			UE power consumption SI				
			NR Positioning SI				
NOMA (non-orthogonal multiple access) SI							
NR Unlicensed SI							
NR Integrated Access Backhaul SI							
Non Terrestrial Network SI							
				NR mobility enhancements WI			
			UE capabilities SI				
				NR SON/MDT SI			

Potential common for LTE/NR

RIM: Remote Interference Mitigation
CLI: Cross link interference

NR R16 Key Features – URLLC Enhancement

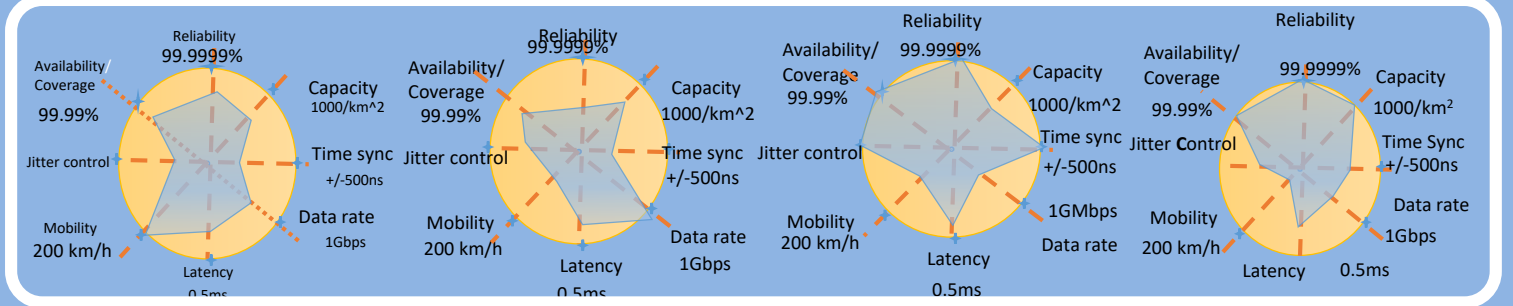
1. URLLC Enhancement
2. V2X
3. MIMO Enhancement
4. IAB
5. NR-U
6. NoMA
7. Positioning
8. UE power consumption
9. NTN

V2X: Auto Driving Remote control

AR/VR Video monitoring

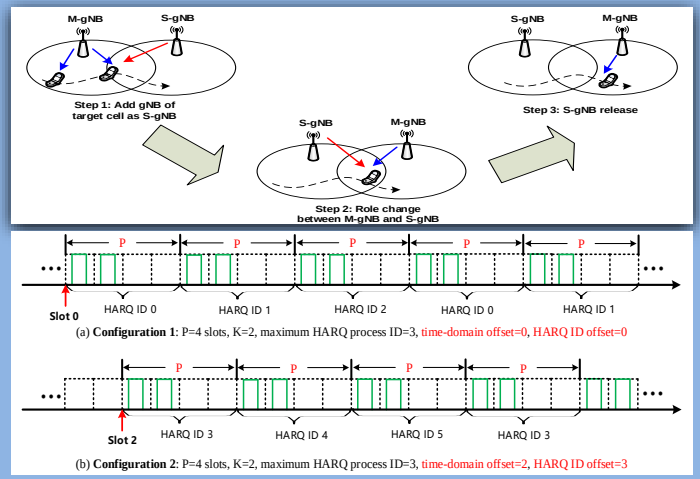
High end Industry control

Electricity distribution



High Reliability and High Availability

- Multi-TRP/panel/beam
- Enhanced UL grant-free transmission
- Reliability enhancement for control & data channel
- UL/DL intra-UE prioritization/multiplexing
- Time Sensitive Networking related enhancements



NR R16 Key Features – V2X

1. URLLC Enhancement
2. V2X
3. MIMO Enhancement
4. IAB
5. NR-U
6. NoMA
7. Positioning
8. UE power consumption
9. NTN

Uses Cases for NR V2X

Vehicle Platooning

Cooperative Operation, Sensor sharing

Advanced Driving

Remote Driving

- Target to reuse Uu link numerology/WF
- BWP based SL and Uu co-existence
- Uu based sidelink resource allocation/configuration
- Autonomous sidelink resource allocation/configuration (GF, sensing)
- SL HARQ process
- LTE Uu control NR SL

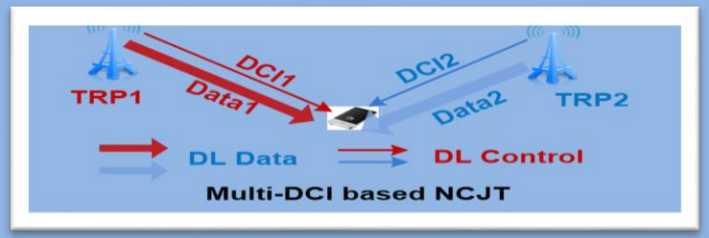
Requirements

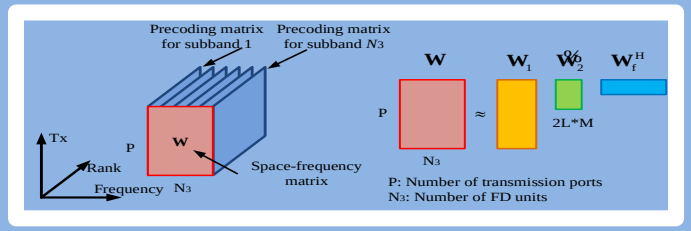
Use Cases	E2E latency (ms)	Reliability (%)	Data rate (Mbps)
Vehicle Platooning	10	99.99	65
Advanced Driving	3	99.999	53
Extended Sensors	3	99.999	1,000
Remote Driving	5	99.999	UL:25 DL:1

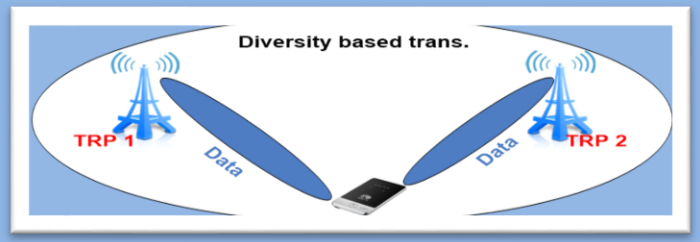
NR R16 Key Features – MIMO Enhancement

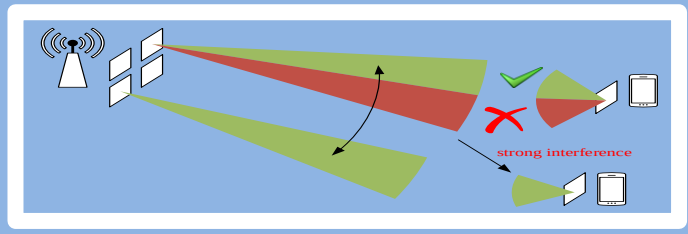
1. URLLC Enhancement
2. V2X
3. **MIMO Enhancement**
4. IAB
5. NR-U
6. NoMA
7. Positioning
8. UE power consumption
9. NTN

MIMO Enhancements







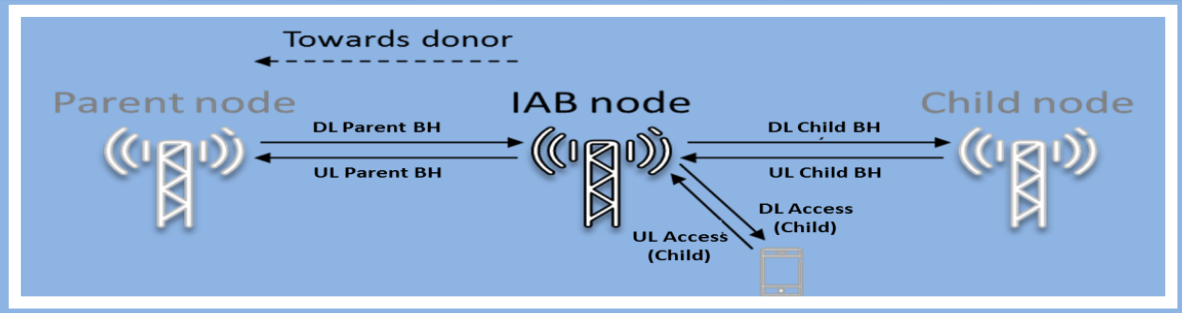


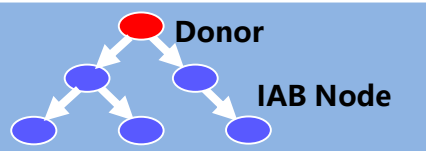
- Multi-TRP/panel transmission for eMBB UE experience enhancement and URLLC reliability/robustness enhancement
- Channel state information acquisition performance enhancement and overhead reduction
- Diversity based transmission for more MIMO robustness enhancement
- Latency/overhead reduction
- Panel-specific beam selection

NR R16 Key Features – IAB

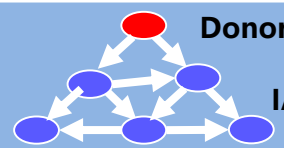
1. URLLC Enhancement
2. V2X
3. MIMO Enhancement
4. IAB
5. NR-U
6. NoMA
7. Positioning
8. UE power consumption
9. NTN

IAB 6 Topology Options





Tree based topology (Multi-hop)



DAG topology (Multi-hop and Multi-connection)

Enable flexible and dense deployment of NR cell without dense transport network

- Dynamic resource sharing (radio & hardware) between access and backhaul
- Multi-hop and Multi-connection topology to enable flexible site deployment
- IAB Node self-discovery and backhaul link self-configuration and recovery

Key Technologies

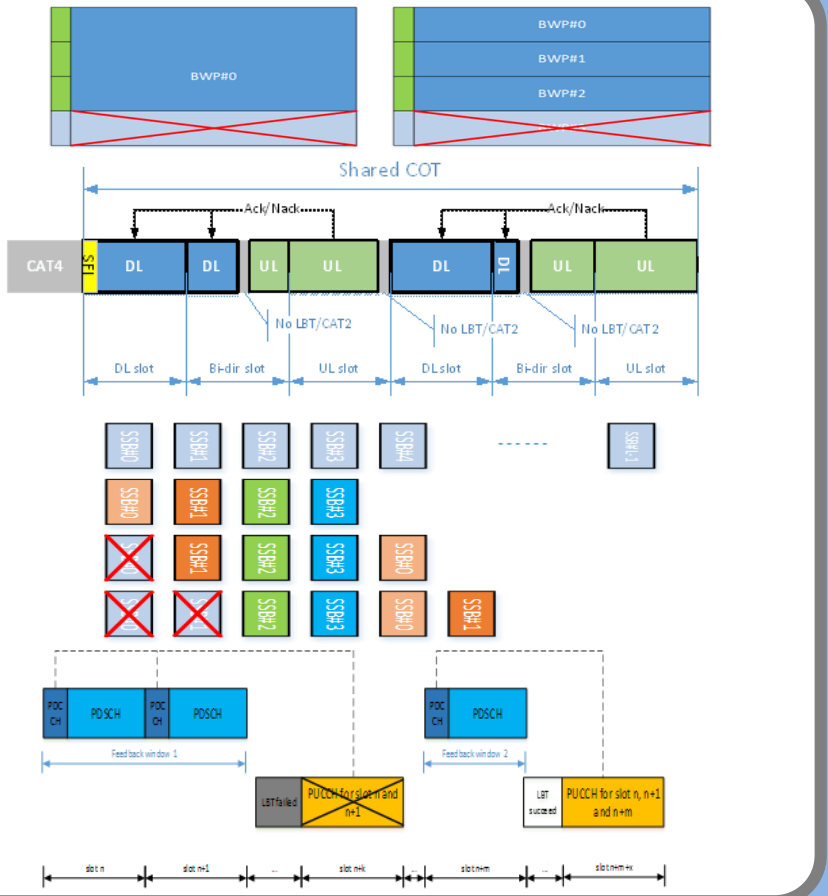
- IAB node discovery initial access
- IAB node discovery and RRM measurement
- Backhaul link management
- OTA synchronization of IAB node
- Resource coordination and dynamic sharing

NR R16 Key Features – NR-U

1. URLLC Enhancement
2. V2X
3. MIMO Enhancement
4. IAB
5. NR-U
6. NoMA
7. Positioning
8. UE power consumption
9. NTN

- Target at sub 7GHz unlicensed band, e.g. 5GHz and potentially 6GHz
- Support deployment scenarios: NR+NRU Licensed Assisted Access, NR/LTE+NRU Dual connectivity, NRU Standalone (including NRU DL+NR UL).

- Single wideband CC with dynamic BW adaption according to LBT
- Non-even PRB based interlace waveform for UL channels
- Self-contained COT with multiple switch point
- Flexible start point and dynamic PDCCH monitoring switching
- DRS based initial access
- Robust/flexible HARQ feedback



NR R16 Key Features – NoMA

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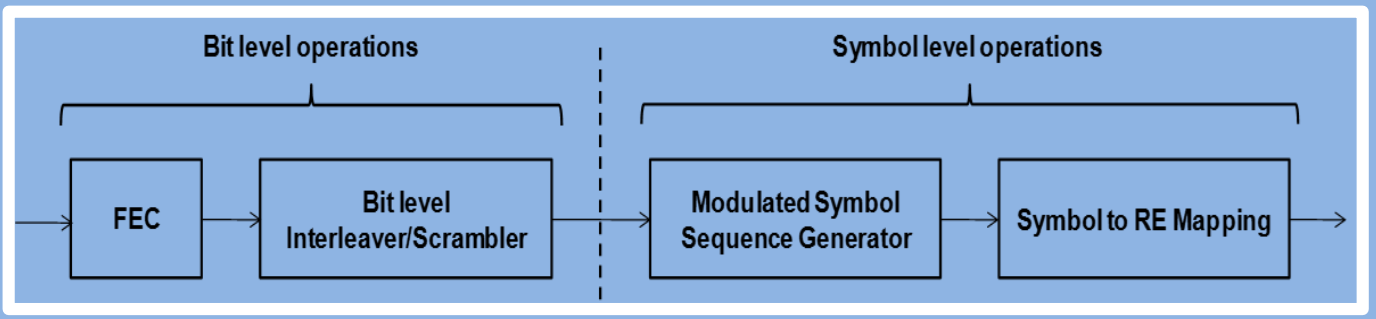

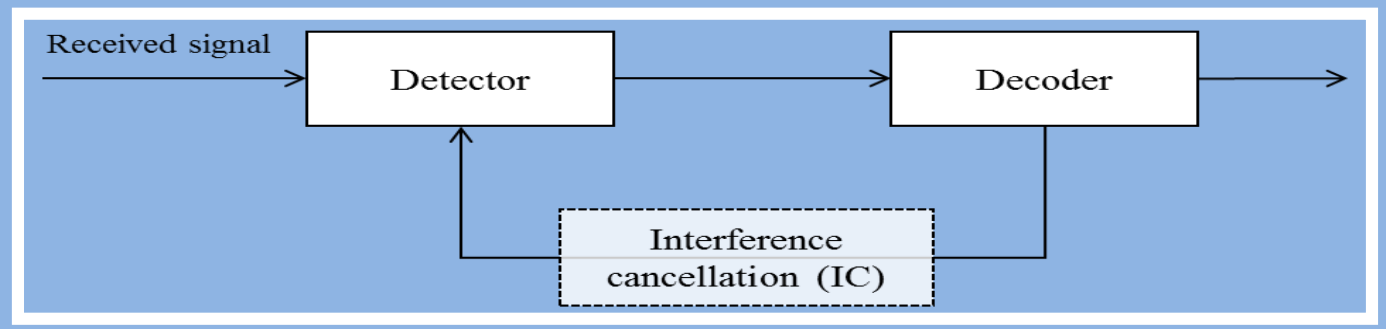

- 15 NOMA schemes were proposed;
- Performance evaluations have been done based on link level simulations and system level simulations under certain application assumptions.
- Complexity of several advanced receivers was analyzed.
- No convergence on NOMA schemes

NR R16 Key Features – Positioning

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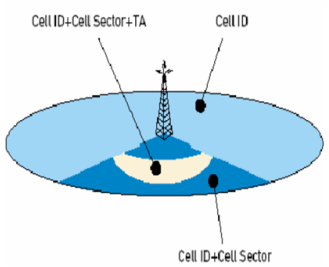
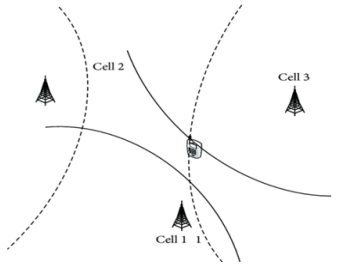
Evolution Positioning

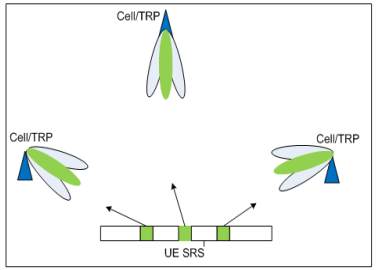
E-CID



OTDOA

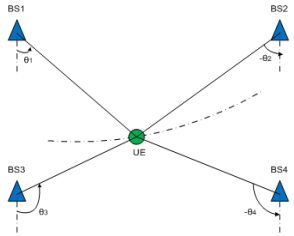


UTDOA

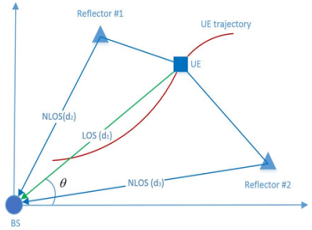


NR-specific Positioning

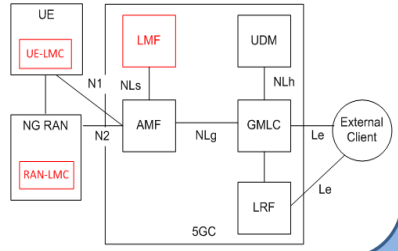
Angle-based positioning



Single-BS positioning



Low-latency architecture



- AoA assisted CID
- DL or UL reference signal enhancement
- Introduce multiple AoA measurements
- Reflection based single-BS positioning
- Low-latency architecture (Move location measurement center to RAN)

NR R16 Key Features – UE Power Consumption

1. URLLC Enhancement
2. V2X
3. MIMO Enhancement
4. IAB
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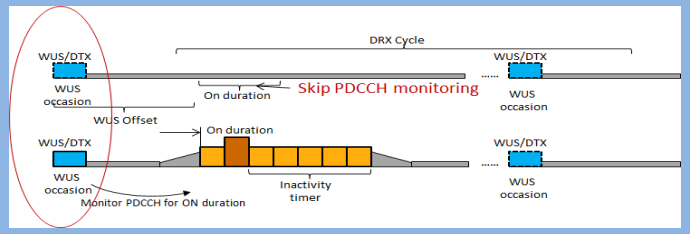
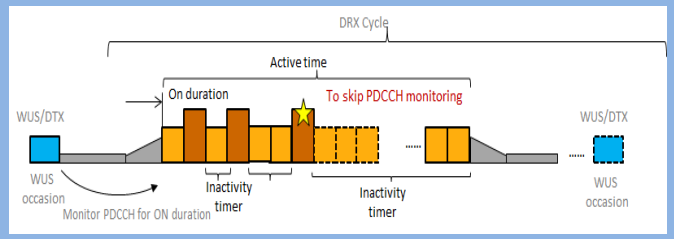
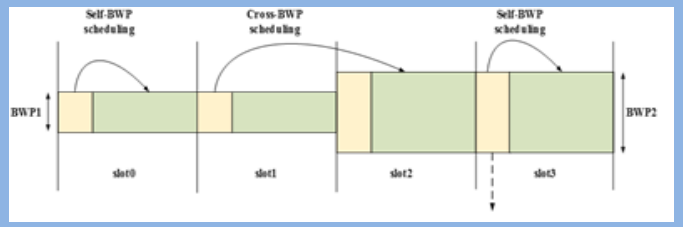
Mechanism of wake up signal



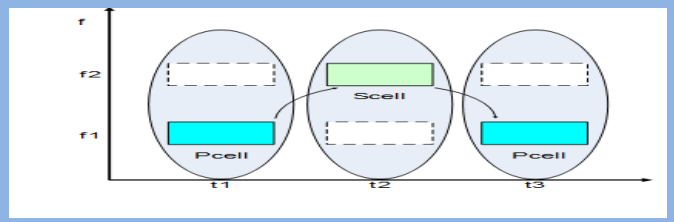
Go-to-sleep for skipping PDCCH monitoring



BWP adaptation



Dynamic Scell (de)activation



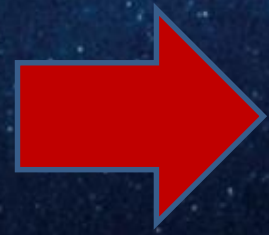
- Wake-up signaling for DRX operation adaptation
- UE operation bandwidth adaptation
- Control signaling monitoring periodicity or timing adaptation
- UE processing adaptation (MIMO configuration, UE processing time, and background processing)
- Intra frequency and/or inter frequency RRM measurement simplification
- UE assistance signaling

Rel-17 and Beyond

Virtual Reality

Autonomous Cars

Factory Automation



- Network Assisted device Collaborations
- Customized Air interface
- mMTC
- MIMO Further Enhancement (FDD, Mobility)
- Continuation of some other Rel-16 topics
- Full Duplex
- On Demand Mobile Base Stations
- Integration of Non-terrestrial Network
- ML Assisted air interface designs
- Even Higher Frequency and Tera Hertz Bands
- Integration of Communication + Sensing

6G

THANK YOU

www.huawei.com