5G Evolution:

Progressive Enhancement & New Features for New Markets

Matthew Baker, Head of Radio Physical Layer & Coexistence Standardisation Cambridge Wireless 26th September 2019



NR Release 15 – Overview

Scope:

Timeline



- Basic URLLC
- Up to 52.6 GHz



5G NR Enabling Technologies

| Scalable Numerology | Flexible Frame Structure | Advanced Channel Coding | Enhanced MIMO | Beamforming |
|--|--|--|--|-------------------------------------|
| Single framework for <1 GHz – 50+ GHz Low latency: one-way latency ~1ms | Flexible TDD Forward-compatible design | Low-Density Parity- Check (LDPC) for high throughput low latency data channels. | Higher spectral efficiency MU-MIMO support | mmWave support Enhanced coverage |

New radio interface to set the foundation to meet IMT2020 requirements & beyond









Release 16 - Overview

- Focus
 - Capacity enhancement
 - Operational efficiency
 - Expansion to vertical markets

Timeline

| [| 2018 | | | | | 20 | 2020 | | | |
|---|------|----|----|----|----|----|------|----|----|----|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 |



Main features

Capacity and Operational efficiency

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- MIMO enhancements
- UE power saving
- Cross Link Interference / Remote interference Management (CLI/RIM)
- Integrated Access & Backhaul (IAB)

- MR-DC (Multi-RAT Dual Connectivity)
- Mobility enhancements
- Direct data forwarding for inter-system mobility
- SON & MDT
- Wireless-Wireline convergence

Vertical expansion

- URLLC (Ultra Reliable Low Latency Communications)
- IIoT (Industrial IoT)
- 2-step RACH

- NR unlicensed
- Private network support
- NR Positioning
- V2X (Vehicle to Everything)

MIMO Enhancements

Including:

1. Improved channel state feedback for Multi-User MIMO



2. Enhancements for multi-beam operation and multi-transmission-point operation



Ultra-Reliable Low Latency Communications (URLLC) and the Industrial Internet of Things (IIoT)

- Release 15 provided basic URLLC functionality, targeting at 1ms latency and 10⁻⁵ reliability
- Release 16 motivation to further enhance URLLC
 - Latency in the range of 0.5 1 ms, reliability in the range of 10^{-6}
 - Support new use cases, e.g. factory automation, transport industry
 - Further enhance release 15 use cases, e.g. AR/VR, gaming.





UE Power Saving

• Targeting better power efficiency than LTE.



Time

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Fibreless Backhaul – Integrated Access & Backhaul (IAB)

Motivation:

- Support wireless backhaul
- Improve capacity
- Improve coverage







NR Unlicensed – NR-U

- Licensed spectrum is the cornerstone of wireless-mobile service (coverage/efficiency /reliability).
- Unlicensed spectrum complements licensed, • boosting capacity and improving data connectivity.

Exclusive use

Shared use

Spectrum priorities in Rel-16:



NR Positioning

- Rel-15 provides support for RAT-independent positioning techniques, and OTDOA on an LTE carrier
- Rel-16 introduces native NR support for UE positioning to support regulatory and commercial use cases:
 - Regulatory requirement: horizontal error <50 m with 80% confidence
 - Commercial target performance:
 - Outdoor horizontal error < 10 m with 80% confidence.
 - Indoor horizontal error < 3 m with 80% confidence.
 - Utilize NR capabilities e.g. operation in FR1 and FR2, higher BW and massive antenna arrays with beamforming.
- RAT-dependent positioning schemes:
 - DL-Time Difference Of Arrival (TDOA)
 - UL-TDOA
 - DL-Angle of Departure (AoD)
 - UL-Angle of Arrival (AoA)
 - Multi-cell Round trip time (RTT)
 - E-CID



Vehicle-to-Everything (V2X)

- Takes Cellular V2X to a new level
 - LTE V2X provides basic road safety support, with some enhancements in Rel-15 to increase data rates and reduce latency.
 - NR V2X additionally provides support for advanced use cases, with much lower latency, higher data rates and improved spectral efficiency



- Advanced use cases for NR V2X
 - Platooning
 - Extended sensors
 - Advanced driving
 - Tele-operated driving



Release 17 – Further evolution





| | | 2019 | | | 2020 | | | 2021 | | | | |
|--------------------------------|---------------------------|------------------------|-------|-------------------------------|----------|---------------------------------|-------------|----------------|-------------------|----------|----------|--------|
| Kelease 1/ | | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | | 23 |
| | | | | | | | | | | | | |
| | | Release 17 Planning | | Release 17 Specification Work | | | | | | | | |
| | | | | , | | ∢ —_15 n | onths relea | ase-to-relea | ase freeze o | date 🔸 | <u>\</u> | |
| | | Rel-17 | , | Re | l-17 Rel | I-16 | | | | Re | l-17 | Rel-17 |
| Topics under consideration: | | | | | | | | | | | | |
| NR Light Multi-SIM | | | | IIoT/URLLC | | NR-U Enhancements | | | | | | |
| | | | | ennancements | | | | | | | | |
| Small data Enhancements | NR Multicast/ | / Broad | lcast | MIMO | Enhar | ncemei | nts | Powe Enhai | r savin ncemei | g nts | | |
| Sidelink Enhancements Coverage | | | | NTN Enhancements | | Data collection Enhancements | | | | | | |
| | Enhancements | | | | | | | | | | | |
| Above 52.6 GHz | NB-IoT Enhar | ncemer | nts | IAB Er | hance | ements | | Posit Enhai | ioning hceme | nts | | |
| | RAN Slicing Enhancemen | ts | | UAV E | nhanc | ement | S | | | | | |



NR-Light in Rel-17

- NR-Light should address new use cases with IoT-type of requirements that cannot be met by the Low-Power Wide Area technologies of LTE
 - Higher data rate & reliability and lower latency than eMTC & NB-IoT

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- Lower cost/complexity and longer battery life than NR eMBB
- Wider coverage than URLLC



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Industrial Use Cases





Enhanced Industrial IoT

• Enhanced Time Sensitive Communications (TSC) for private WANs



Non-Terrestrial Networks

• Bringing truly ubiquitous coverage







Unmanned Aerial Vehicles

NR beyond 52.6 GHz

Larger carrier bandwidth Component carriers > 400 MHz

Waveform design Power efficient, low demodulation complexity

Enhanced beam management Managing narrower beams and more beams

Enhanced path diversity Methods for improving path diversity and increasing the probability of LoS













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