

3GPP RAN#84

Newport Beach, 3-6 June, 2019

Rel-17 work scope on uplink coverage enhancements for NR and LTE



Motivation for Uplink Coverage Enhancements

Indoor coverage



- Indoor users suffer from large penetration loss

| Frequency | Glass | Brick | Concrete |
|-----------|---------|----------|----------|
| Sub3G | 7~12dB | 10~15 dB | 20~25 dB |
| C-Band | 10~15dB | 15~23dB | 28~38 dB |
| mmWave | 15~21dB | 35~53dB | 65~79 dB |

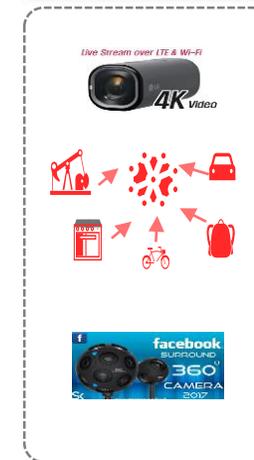
Penetration loss

Remote coverage



- Support basic data speeds and voice services for long range coverage (**up to 100 km**) in low density areas (**up to 2 user/km²**)
- Up to 1 Mbps in the downlink, and 100 kbps in the uplink

Uplink throughput/capacity



1080P: ~4Mbps

2K: 10Mbps

4K: 25Mbps@2D
50Mbps@3D

- Newly emerging video services driven by surveillance cameras have large demanding on the uplink throughput
- Current uplink data rate for both cell average and per link is **lower than the requirements**

Coverage enhancement NR and LTE

Indoor coverage

| Frequency (GHz) | Penetration loss | Path loss difference (dB) |
|-----------------|------------------|---------------------------|
| 0.7 | 10.23 | 0.00 |
| 1.8 | 11.64 | 8.20 |
| 3.5 | 12.69 | 13.98 |
| 4.9 | 13.13 | 16.90 |

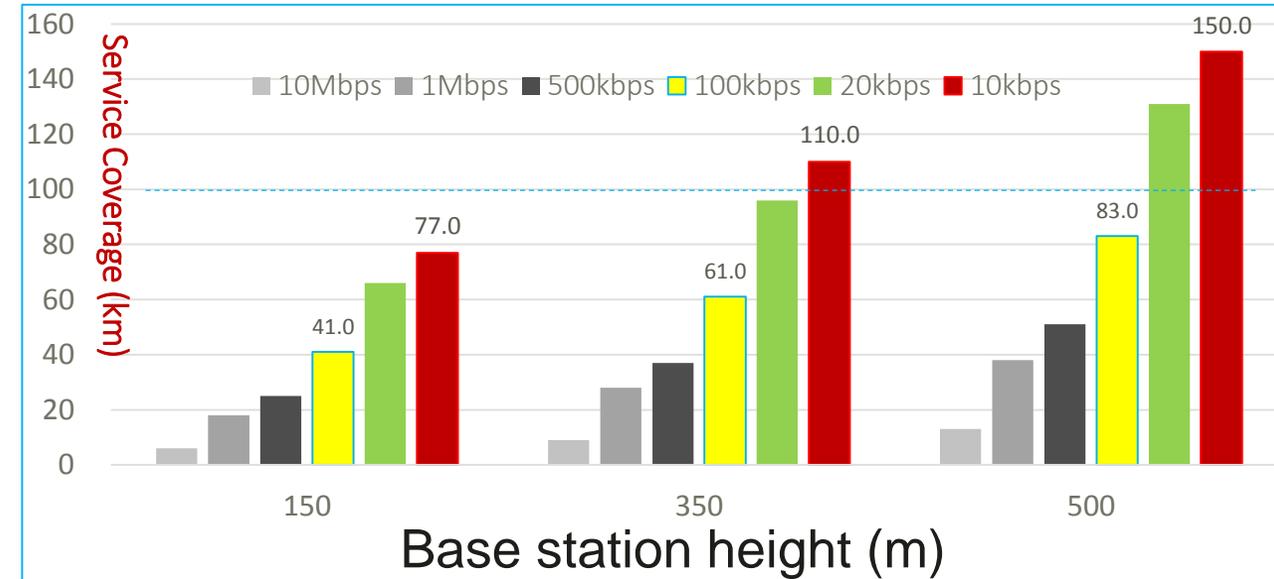


- Uplink coverage is limited in indoor area
 - Higher frequency has higher path loss and penetration loss
 - Small fraction of resource is used for uplink
 - Uplink transmission power is much lower than downlink

• Potential uplink coverage enhancement study

- Identify the requirements of the different scenarios including indoor coverage, remote coverage and uplink video surveillance, and evaluation for coverage GAP identification.
- high power UE, cross slot channel estimation, techniques utilizing frequency diversity, other resource than frequency, time and spatial resources for information transmission, UE cooperation and reusing some of the LTE-M/NB-IOT techniques etc.

Long distance coverage of field testing



- Long distance coverage requirements from TS22.261
 - The 5G system shall support the extreme long range coverage (up to 100 km) in low density areas (up to 2 user/km²).
 - The 5G system shall support a minimum user throughput of 1 Mbps on DL and 100 kbps on UL at the edge of coverage.

Uplink throughput of video surveillance

The link to be improved for UL



CPE



City Surveillance



Traffic monitoring



Home monitoring



Fish farm monitoring



Mining supervising



Factory supervising

- Video surveillance industry with massive connections is an emerging business opportunity for wireless communications.
- In 2016, the number of surveillance cameras in operation reached 200 million, and it is expected to reach 500 million by 2021.

Video surveillance scenario specific

- **slow-varying channels**
 - Measured results indicated the channel is time-invariant within ~100ms (even if there are obstacles e.g. trees between cameras and base station).
- **MU pairing**
 - No “inactive ratio” and fixed users benefit MU pairing.

| scenarios | UL data rate |
|--|--|
| Video surveillance for safe city/village | 60~200 cameras per km ² /cell, 2~4Mbps per camera |
| Factory supervising | 6 video cameras for 1700 m ² , 100Mbps per camera |
| Fish farm monitoring | 24~30 cameras per cell, 25Mbps per camera |

- Uplink throughput improvement possibilities
 - optimized scheduling/HARQ mechanism
 - SU/MU MIMO enhancement.
 - Overhead reduction
 - Interference coordination
 -

Potential Rel-17 work scope

- The objective of this study item is to investigate potential enhancements to improve uplink coverage in Rel-17:
 - Evaluate uplink coverage performance of NR/LTE for different uplink throughput requirements in different scenarios, and identify the coverage gap [RAN1]
 - Identify the requirements of different scenarios including indoor coverage, remote coverage and uplink video surveillance
 - Develop necessary simulation assumptions and performance metrics for the study, including the channel model for the scenarios under study, especially for the remote coverage.
 - Evaluate the performance of Release 16 spec design for control and data channels for the scenarios under study.
 - Identify potential enhancements of control and data channels for NR/LTE for different coverage demanding scenarios [RAN1, RAN2, RAN4]
 - Identify potential coverage enhancement solutions for physical signal, control and data channels for different application scenarios.
 - Evaluate the potential coverage enhancement solutions in different application scenarios, e.g. high power UE, cross slot channel estimation, techniques utilizing frequency diversity, other resource dimension than frequency, time and spatial resources for information transmission, UE cooperation , optimized scheduling/HARQ mechanism, overhead reduction for slow-varying channels, enhanced UL power control and reusing some of the LTE-M/NB-IOT techniques etc.
 - Identify the specification impacts of each potential solutions. [RAN1, RAN2]