3GPP TSG-RAN Meeting #91e
March 16-26, 2021
Agenda Item: 9.7.27

RP-210349

Qualcomm

Views on the Scope of the NR RedCap WI

Qualcomm

Outline

- Overview
  - Enabling design with compact form factor is a generic requirement of R17 RedCap WI
- Design challenges for wearable antennas
- SLS results for capacity impacts of RedCap UE
  - Co-existence of Non-RedCap UE and RedCap UE
  - Performance of 1 RX RedCap UE vs 2 RX RedCap UE
    - antenna correlation between 2 RX antennas: 0 (hypothetical)
    - antenna imbalance between 2 RX antennas: 6 dB
- Proposals
  - RAN1 objectives on UE complexity reduction
  - RAN2 objectives on higher layer support of RedCap

Overview

Generic Requirements

Device complexity	Lower the device cost and complexity as compared to high-end eMBB and URLLC devices of R15/R16, especially for the use case of industrial sensors
Device size	**For most use cases, enables a device design with compact form factor.**
Deployment scenarios	Support all FR1/FR2 bands for FDD and TDD

Use Case Specific Requirements

Use cases	Wearable	Connected Industry	Smart City
Example	smart watches, eHealth related devices, personal protection equipment (PPE), and medical monitoring devices for use in public safety applications	pressure sensors, humidity sensors, thermometers, motion sensors, accelerometers, actuators	Video surveillance
Bitrate	Ref bitrate: 5-50/2-5 Mbps in DL/UL Peak bitrate: Up to 150/50 Mbps in DL/UL	Ref bitrate: < 2 Mbps (UL heavy)	Ref economic bitrate: 2-4 Mbps. 7.5-25 Mbps for high-end video. UL heavy
Latency req	~ eMBB	<100ms. 5-10 ms for safety related sensors	< 500ms
Reliability	~ eMBB	99.99%	99%-99.9%
Battery life	Multiple days (up to 1-2 weeks)	At least few years	

Two Outstanding Issues for R17 RedCap Device

- Reduced Maximum UE BW in FR1
  - ➢Maximum bandwidth of an FR1 RedCap UE during and after initial access of 20 MHz is supported. The possibility of, and any associated conditions for, optional support of a wider bandwidth up to 40MHz after initial access for this case will be further discussed at RAN#91e.
- Reduced Minimum Number of RX Branches in FR1
  - ➢For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE will be decided at RAN#91e; hence no specific work for these frequency bands will be done before RAN#91e.

Design Challenges for Wearable Antennas

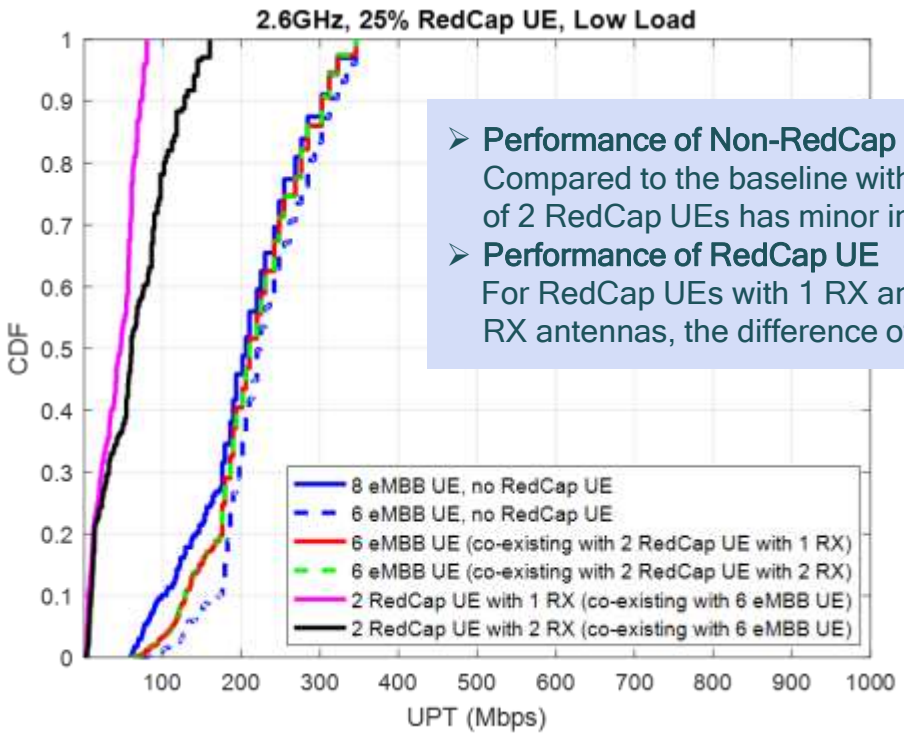
- Multi-connectivity Support
  - Dedicated GPS antenna (total length ~40 mm for L1 support, ~62 mm for L2/L5 support)
  - Dedicated WiFi/Bluetooth antenna (total length ~30 mm)
  - Cellular antenna supporting FR1 FDD/TDD bands (total length desired ~93 mm)
- Small Form Factor and Proximity to Human Body
  - Space is at an extreme premium with advanced/personalized features
    - Bezel-less display
    - Gyroscope/Accelerometer/Sensors (blood oxygen, ECG, ambient light, etc.)
    - Speaker/Microphone/Camera
  - Reduction of antenna efficiency and operating bandwidth
- Insufficient Space for Second Cellular Antenna
  - Cross-polarized antennas are impossible
    - With electrically small antenna (ESA) type typically used in FR1, the ground currents are not controllable; hence, polarization is not controllable.
  - For primary and diversity antennas in close proximity, insufficient separation of these antennas leads to high envelope correlation coefficient (ECC > 0.7) and inability to meet typical Tx-to-Rx antenna isolation requirement of > 10 dB for cellular bands above 2 GHz
  - Impossible to achieve the gain in spatial diversity or multiplexing promised by dual RX antennas on larger smartphone form factor

Dimensions of popular smartwatch

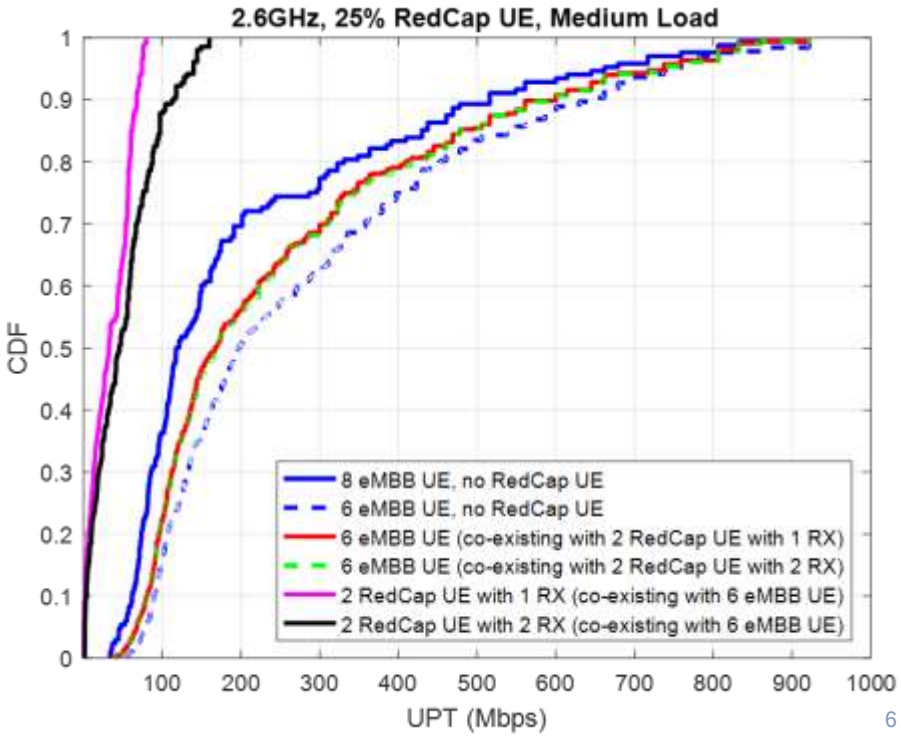
- Length: 40/44 mm
- Width: 34/38 mm
- Depth: 10.7 mm

Co-Existence of RedCap UE and Non-RedCap UE (25%:75%)

UE Type	eMBB	RedCap
Number of UEs per Cell	6	2
Number of RX Antennas	4	1, 2 (antenna imbalance=6 dB, antenna correlation=0)
Max UE BW [MHz]	100	20
Max Modulation Order for DL	256 QAM	64 QAM
Traffic Model	FTP, average inter-arrival time=20 ms Packet size =21.6 KB for low load Packet size =32.4 KB for medium load	FTP, average inter-arrival time =200 ms Packet size =10 KB for low and medium load

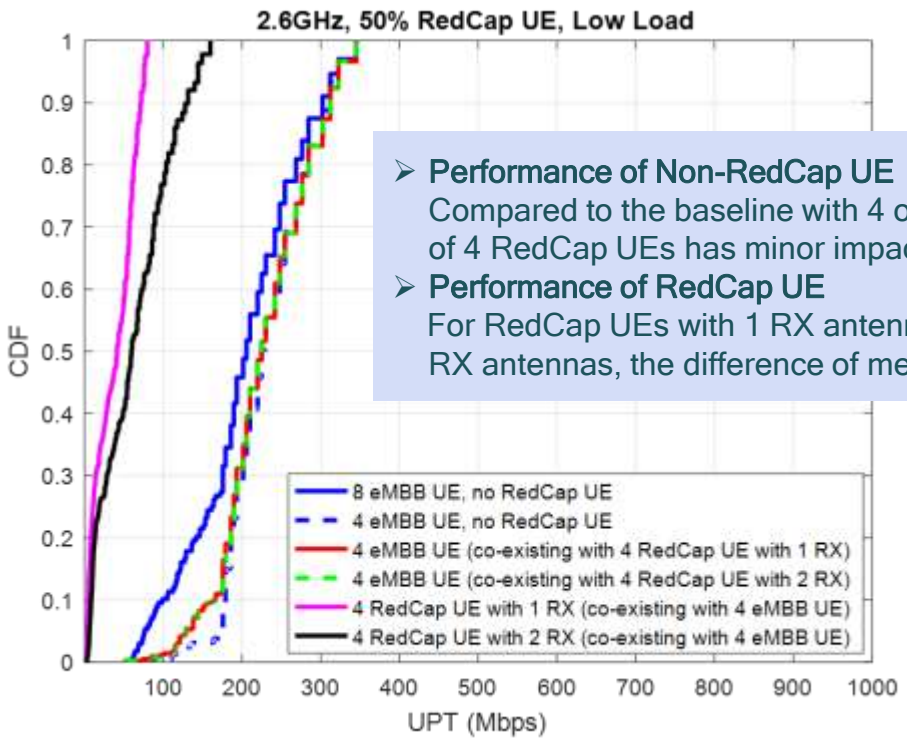


- **Performance of Non-RedCap UE**
  Compared to the baseline with 6 or 8 eMBB UEs only, the introduction of 2 RedCap UEs has minor impacts on the UPT of eMBB UEs.
- **Performance of RedCap UE**
  For RedCap UEs with 1 RX antenna and 2 un-correlated (hypothetical) RX antennas, the difference of median UPT is less than 20 %.

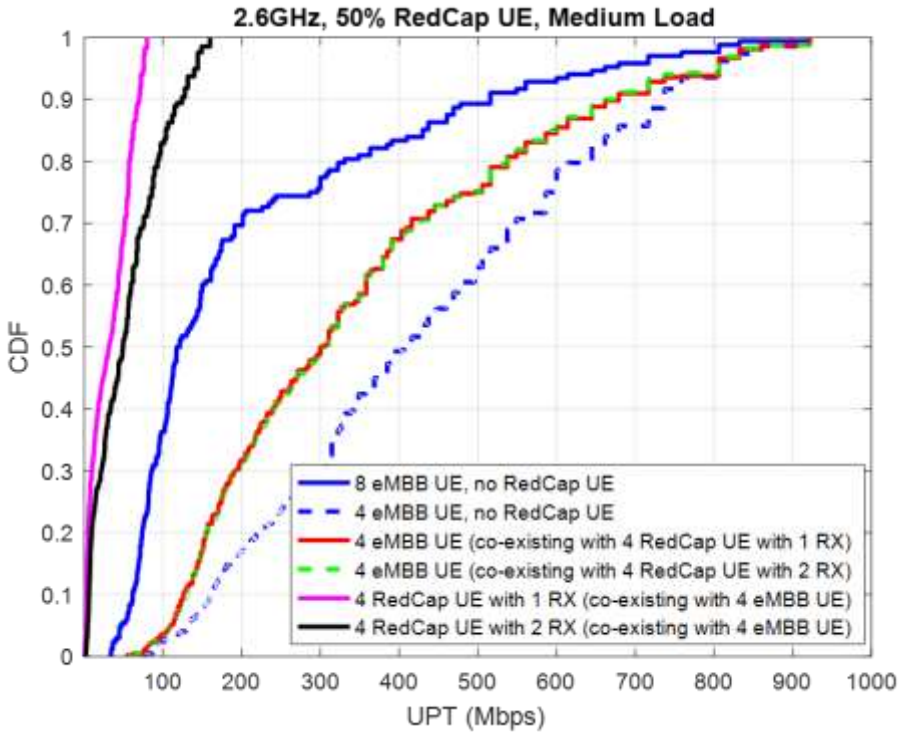


Co-Existence of RedCap UE and Non-RedCap UE (50%:50%)

UE Type	eMBB	RedCap
Number of UEs per Cell	4 (baseline: 8)	4 (baseline: 0)
Number of RX Antennas	4	1, 2 (6 dB antenna imbalance is modeled)
Max UE BW [MHz]	100	20
Max Modulation Order for DL	256 QAM	64 QAM
Traffic Model	FTP, average inter-arrival time= 20 ms Packet size =21.6 KB for low load Packet size =32.4 KB for medium load	FTP, average inter-arrival time =200 ms Packet size =10 KB for low and medium load



- **Performance of Non-RedCap UE**
  Compared to the baseline with 4 or 8 eMBB UEs only, the introduction of 4 RedCap UEs has minor impacts on the UPT of eMBB UEs.
- **Performance of RedCap UE**
  For RedCap UEs with 1 RX antenna and 2 un-correlated (hypothetical) RX antennas, the difference of median UPT is less than 30 %.



Proposals: Objectives on UE Complexity Reduction

- **UE Complexity Reduction Features [RAN1]**
  - For frequency bands where a legacy NR UE is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.
  - Maximum bandwidth of an FR1 RedCap UE during and after initial access of 20 MHz is supported. After initial access, a wider UE bandwidth up to 40MHz can be optionally supported.

Proposals: Objectives on Higher Layer Support of RedCap UE

- **Higher Layer Support for RedCap UE [RAN2, RAN1]**
  - Specify definition of RedCap UE type(s) including set(s) of UE capabilities for RedCap UE identification, preventing RedCap UEs from using unintended capabilities including at least carrier aggregation, dual connectivity and wider bandwidths, and ensuring RedCap UEs are only used for their intended use cases.
  - Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks during initial access and allow operators to restrict their access if desired.
  - Study UE power saving and battery lifetime enhancement for reduced capability UEs in applicable use cases (e.g. delay tolerant)
    - Extended DRX for RRC Inactive and/or Idle
    - RRM relaxation for stationary devices
  - Specify necessary updates of UE capabilities, RRC parameters, and other upper-layer procedures impacted by reduced UE capabilities.