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Enhancements for support of eMBB+ services for Rel-18

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Outline

- Introduction
- Evolution of scenarios, services, and requirements
- Evolution of technologies and standards
- Conclusions

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Introduction: eMBB+ for Rel-18

Scenarios, services, and requirements	Technologies and standards
• Advanced MBB services • XR • High data rate services w/ high mobility • UL video • Fixed wireless access (FWA) • …	• Cooperative/distributive massive MIMO • MIMO/M-TRP for UL • UL fast carrier switching • Flexible duplex • Carryovers/limitations from R16/17 • …

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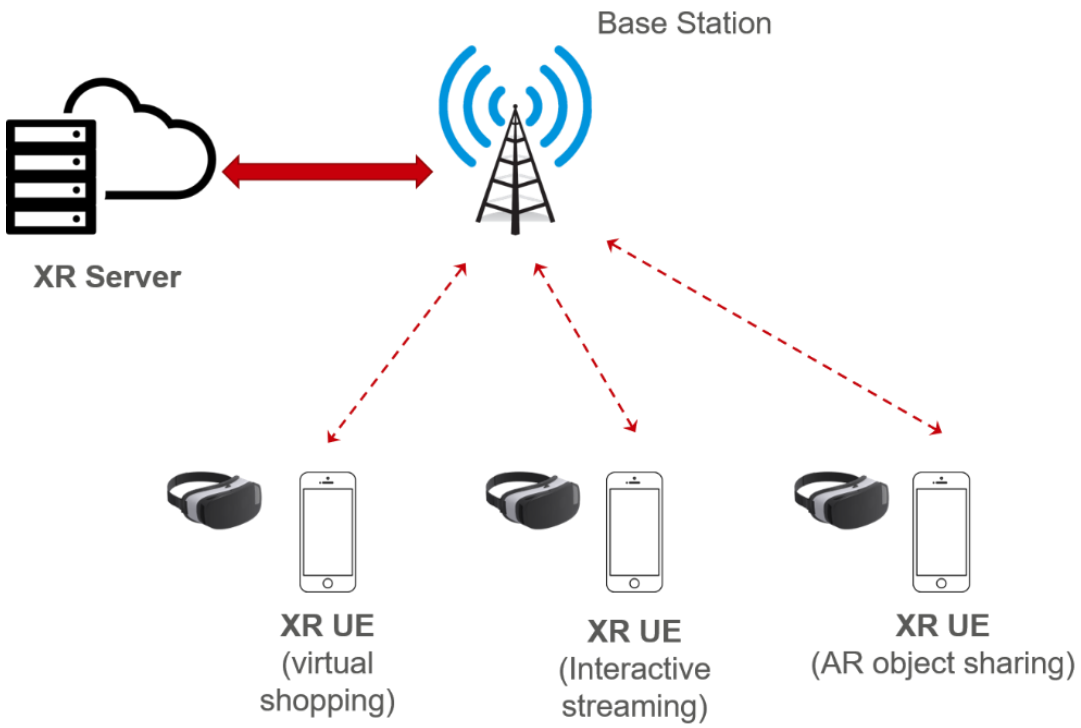
eMBB+: XR

- Challenges to support XR
  - High data rate: 25-250 Mbps
    - 1080p requires 25 Mbps
    - 2k x 2k requires 50 Mbps
    - 4k or 8k may require > 100 Mbps
  - Tight packet delay budget:
    - 10-15 ms air interface delay for DL
  - High reliability: 10^-3 PER
- Limited capacity of XR with existing technologies
  - About 6 users/cell in 100 MHz bandwidth in Dense Urban FR1 with zero-forcing precoding [1]

[1] R1-2104209, “XR initial evaluations”, Futurewei, RAN1#105-e



eMBB+: UL Video

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- Example of use cases for UL HD video
  - HD camera in smart factory
- Challenges to support UL HD video
  - High data rate: 50-100 Mbps/camera
    - 2k x 2k: 50 Mbps/camera
    - 4k UHD: 100 Mbps/camera
  - High cell throughput required: multiple cameras required to cover a factory zone
- Cell edge UE difficult to support with high data rate

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eMBB+: High data rate with high mobility

- Example of use cases for high data rate with high mobility for users in moving vehicles
  - Entertainment with HD video
  - Video conferencing with HD video
- Challenges to support the case
  - High data rate: 50-100 Mbps
    - 2k x 2k: 50 Mbps/camera
    - 4k UHD: 100 Mbps/camera
  - High mobility: up to 120 km/h
- Cell capacity is limited
  - Difficult to support MU-MIMO for high mobility UEs

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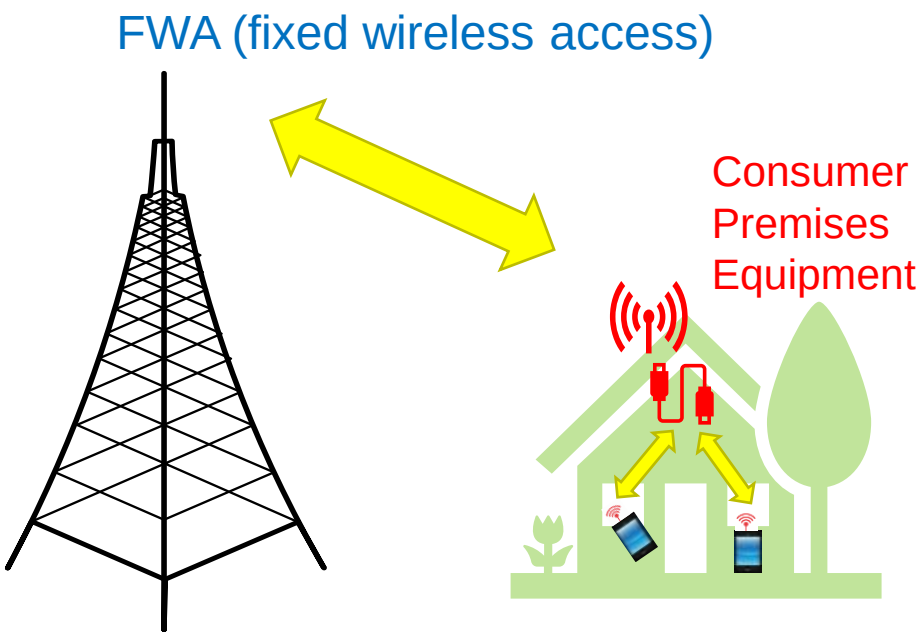
eMBB+: FWA (fixed wireless access)



- Example of use cases for FWA
  - WTTx = Wireless to the {home, office}
  - 5GTTH (5G to the home) targeting hundreds of Mbps to multi-Gbps
- Characteristics and Challenges to support the case
  - A stationary super device with a high-capability transceiver and a very high-capacity demand
  - It is supported in implementation with mostly the same standards/techniques as regular mobiles.
- Traffic demand is very high
  - Very high SE is desirable by exploiting FWA distinctive properties

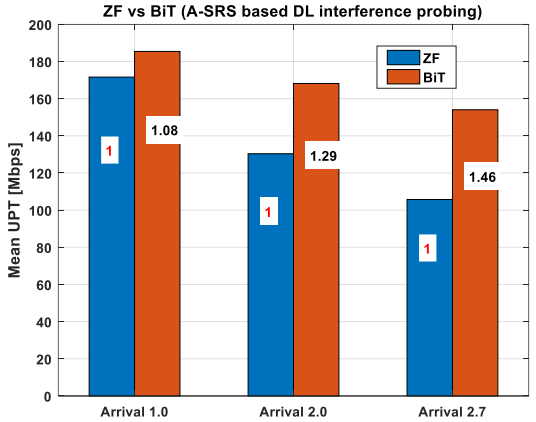
Enhancements: Cooperative Massive MIMO

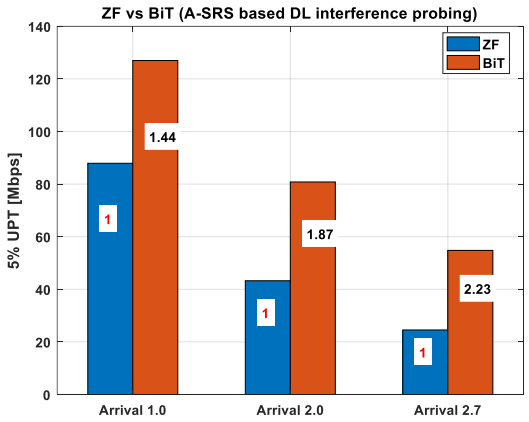
- Cooperative massive MIMO via Bi-directional Training (BiT)
  - Distributed across gNBs w/o central coordination
  - No/little channel information exchange
  - Adapt to inter-/intra-cell interference
  - No estimation of element-wise channel, reducing complexity/overhead
  - Significant SE/UPT gains shown for FTP UPT (~50% gain), and XR capacity (>100% gain) over ZF MU-MIMO
- Standard impact:
  - UL/DL interference probing/avoidance with UL/DL RS associated with pre-scheduled data

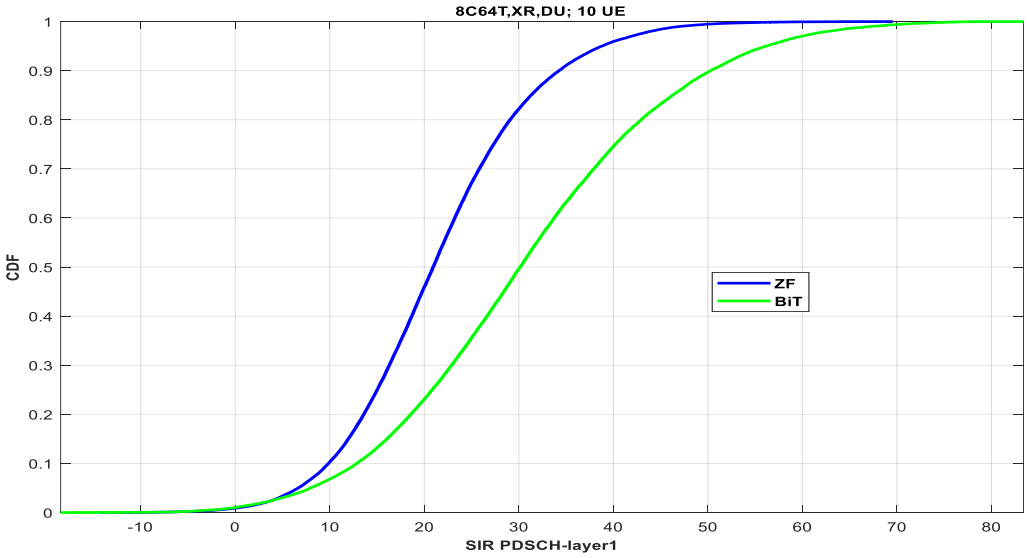
[1] R1-2102765, “Enhancements on SRS flexibility, coverage and capacity”, Futurewei, RAN1#104bis-e

[2] R1-2104209, “XR initial evaluations”, Futurewei, RAN1#105-e

https://github.com/futureweiwirelesslab/bi-directionalTraining/



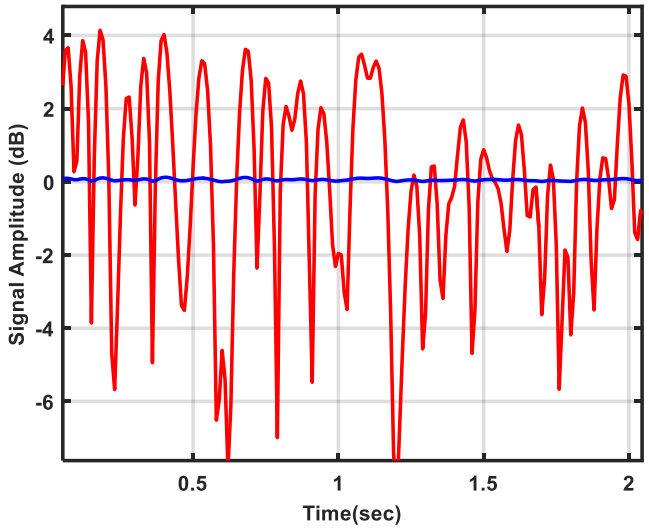




SINR improvement of about 10 dB at 50%ile due to the superb capability of interference mitigation by BiT

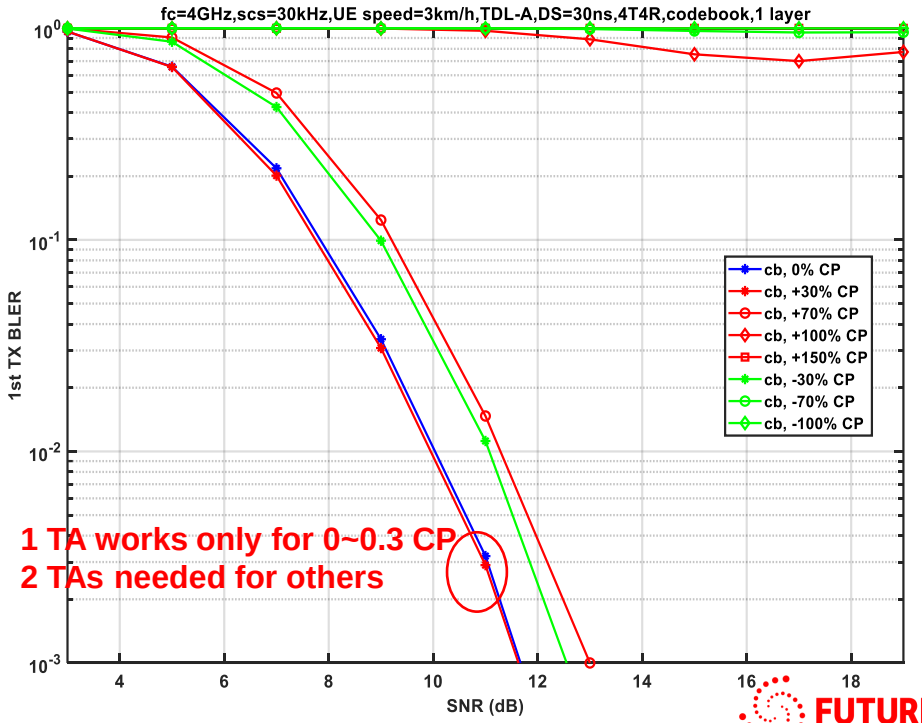
Enhancements: CSI and TA

- Advanced CSI schemes, for high-resolution cooperative MM
  - CSI acquisition and utilization for fixed links
  - CSI-RS flexibility enhancements in frequency/time/spatial domains (e.g., only on the subbands that data will be sent)
  - CSI feedback of UE-selected cooperative transmission schemes
- Carryover from R16/17 M-TRP MIMO
  - R16/17 M-TRP assumes one UL timing (i.e., TA) and one DL timing, generally causing significant degradation
  - Separate (TRP-specific) UL timings and separate DL timings need to be standardized



--- conventional model w/ low speed

--- fixed link



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Enhancements: MU-MIMO for high mobility

- Mobility severely impacts MU-MIMO performance due to outdated CSI
- Enhancements for high mobility channel estimation and prediction
  - Channel estimation/prediction and feedback based on high-dimensional channel characteristics
  - Time-domain filtering-based channel prediction
  - Multidimensional spectral super resolution for high-mobility channel estimation
  - High-mobility channel estimation based on unfolded deep neural network
  - AI (ResNet, CNN) based channel predication

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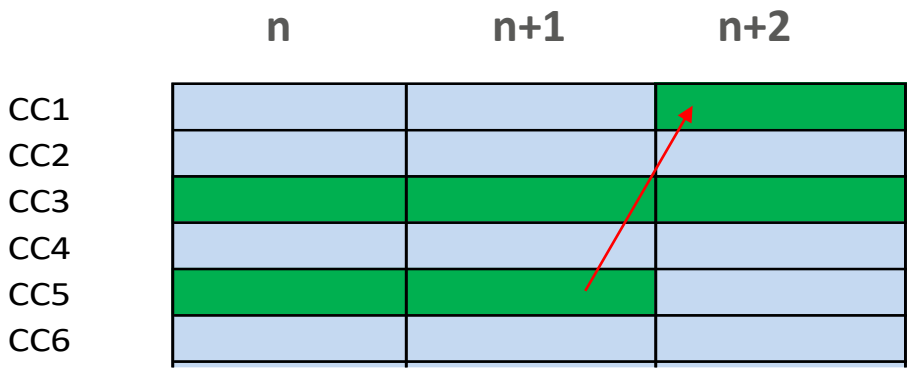
Enhancements: Uplink fast carrier switching

- Motivations
  - UE may have limited UL CA capability
  - UL load steering / balancing and interference coordination rely on semi-static carrier allocation
  - Inefficient for bursty and large UL packets, e.g., event-triggered UL video
- Solution
  - UE with UL CA capability of n CCs may be configured with m CCs, m may be larger than n
  - UE can quickly switch to a different subset of n CCs within the m CCs
  - May be jointly with SRS carrier-based switching for both UL/DL SE enhancements



UE UL CA of 2 CCs

Configured/activated UL CCs: { 1, 2, 3, 4, 5, 6}

CC1 becomes more favorable at n+2

UL Tx CCs: {3,5} ➔ {1,3}

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Enhancements: Flexible Duplex and IM

- Motivations
  - UL video may require significant UL resources
  - Most TDD slots/symbols are assigned as DL
  - Desirable to more flexibly adapt UL-DL slots/symbols
- Solution
  - Flexible duplex; and associated interference coordination, avoidance, and suppression via gNB/UE Tx/Rx beamforming
  - Traditional BiT of joint precoder/combiner optimization between gNBs and UEs → BiT with flex duplex of joint precoder/combiner optimization between all Tx (gNBs/UEs) and all Rx (UEs/gNBs)

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Summary

- Evolution of scenarios and services with very high-capacity requirements:
  - XR
  - UL video
  - High data rate with high mobility
  - FWA
- R18 enhancements needed to increase capacity / SE:
  - Cooperative MM with joint Tx/Rx beamforming optimization: BiT
    - Also suitable for flexible duplex interference control
  - UL fast carrier switching
  - Enhancements for high-mobility channel estimation/prediction and feedback
  - Other enhancements specifically for super devices, fixed links, and M-TRP, etc.

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