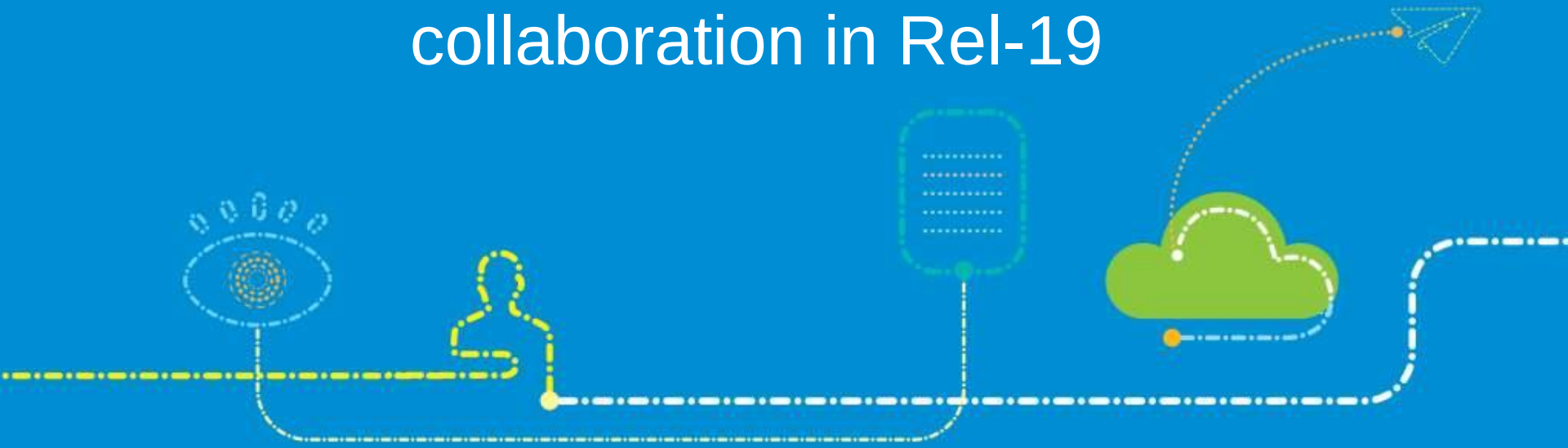
3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023

RWS-230288

Source: ZTE, Sanechips

Agenda: 5

Views on user virtualization and collaboration in Rel-19



Motivations

- The UE aggregation has been studied in R18 where the UE is connected to the network via direct path and via another UE using a non-standardized UE-UE interconnection as shown below [1].

> *This multi-path relay solution can also be utilized to for UE aggregation where a UE is connected to the network via direct path and via another UE using a non-standardized UE-UE interconnection. UE aggregation aims to provide applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Additionally, UE aggregation can improve the reliability, stability and reduce delay of services as well, that is, if the channel condition of a terminal is deteriorating, another terminal can be used to make up for the traffic performance unsteadiness caused by channel condition variation.*

- However, this is far from enough. R18 UE aggregation is based on PDCP layer for intra-gNB scenario. The inter-gNB scenario, the service continuity for mobility scenario, the aggregation with more than two UEs as well as aggregation at lower layer have not been touched.

- In addition, more UE collaboration scenarios are emerging which require multiple devices to form a virtual user and these devices can collaboratively transmit and receive data from the network.

[1] RP-223501 Revised WID on NR sidelink relay enhancements.

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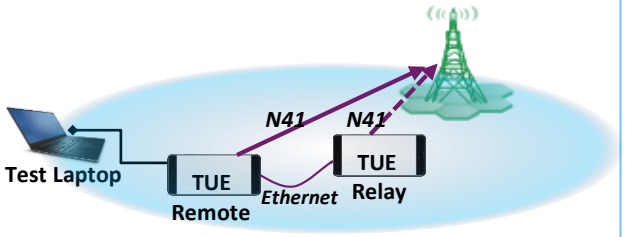
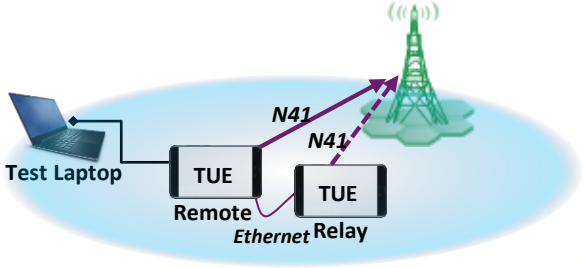
ZTE Prototype of Rel-18 UE aggregation

Test Scenarios

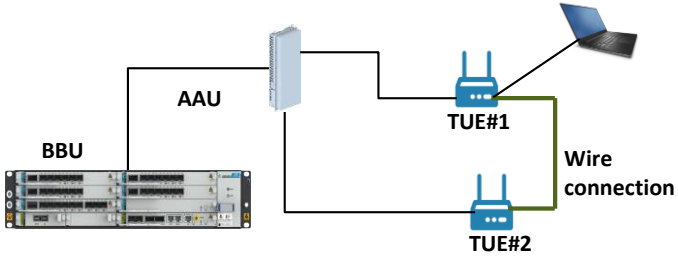
- **Scenario#1:** Remote UE at cell edge and relay UE at cell center



- **Scenario#2:** Both remote UE and relay UE at cell center



Test Architecture and Configuration

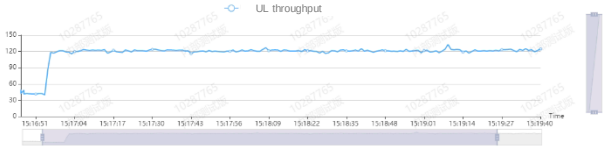


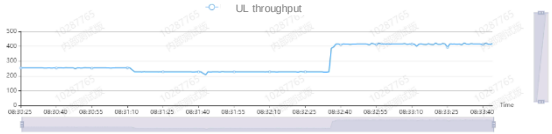
Cell configuration

Band	N41/2.6GHz
BW	100M
Frame structure	5ms (6:4:4)
UL	64TR, 8 Layers

Test results

Scenario	Data rate of remote UE (Before Agg)	Data rate of remote UE (Before Agg)
Scenario#1 (Peak date rate)	36Mbps	150Mbps
Scenario#2 (Normal date rate)	208Mbps	402Mbps
Scenario#2 (Peak date rate)	254Mbps	414Mbps





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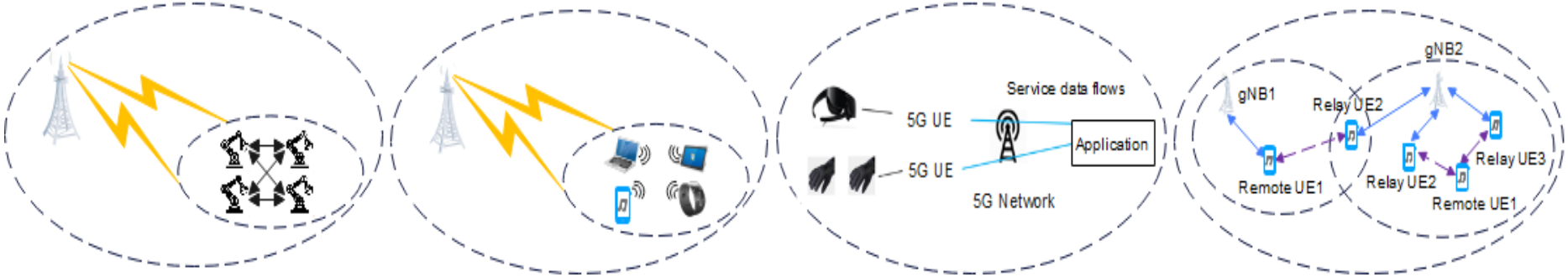
More Scenarios for UE aggregation



- IIoT scenario
  - Multiple coordinative devices (e.g., monitors) are connected together.
  - Collaborative transmission can enable more robust transmission.
- Personal IoT scenario
  - A user has multiple devices with different capabilities, such as mobile phone, laptop, wearable devices.
  - Media (audio/video) can be shared among all the devices belonging to the same PIN.
- Multi-modality scenario
  - A user has multiple devices with multi-modality service.
  - Synchronization and coordination of multi-flow services are required for multiple UEs.
- Extended relay scenario
  - A remote UE is power limited for high data rates at the edge of a cell.
  - Inter-gNB aggregation and aggregation with more than one indirect paths are desirable.

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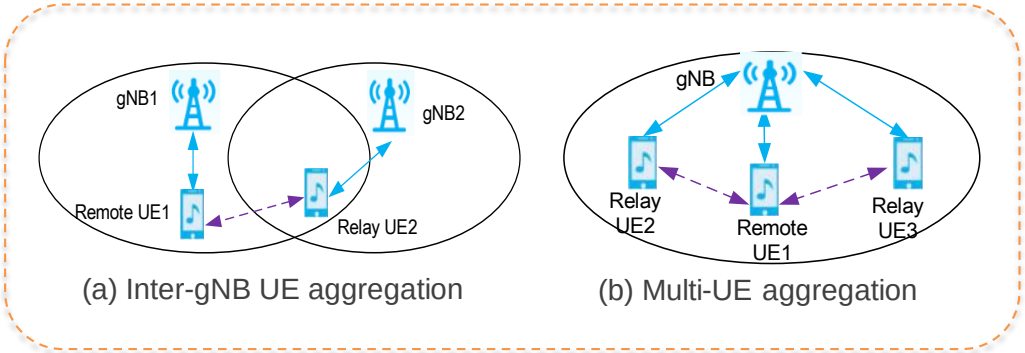
Enhancements for UE aggregation at PDCP layer (1/2)

- In addition to the intra-gNB UE aggregation, it is suggested to extend the following aggregation scenarios on top of R18 UE aggregation:
  - Inter-gNB aggregation
    - Direct path and indirect path are served by different gNBs.
  - Multi-UE aggregation
    - In addition to one direct path, more than one indirect paths may be supported via different relay UEs to jointly improve the data rate, reliability and stability.



(a) Inter-gNB UE aggregation (b) Multi-UE aggregation

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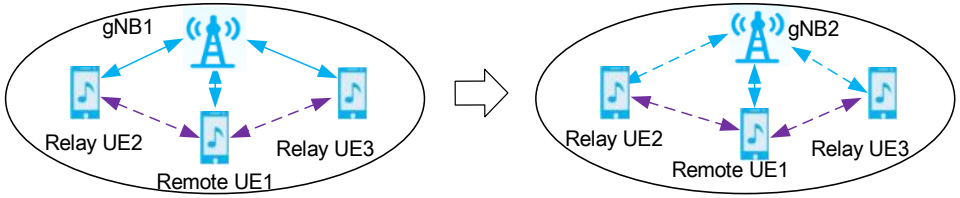
Enhancements for UE aggregation at PDCP layer (2/2)

- Moreover, the following aspects may be considered for the UE aggregation at PDCP layer:
  - Group mobility
    - The remote UE and relay UE move and perform HO together to neighboring gNB
  - Service continuity for inter-gNB HO and path switch
    - The lossless delivery of data packet during inter-gNB HO and path switch
  - Network controlled UE aggregation association
    - Network authorization for the UE association
  - UE interoperability
    - Multi-vendor support for relay UE and remote UE



(c) Group mobility

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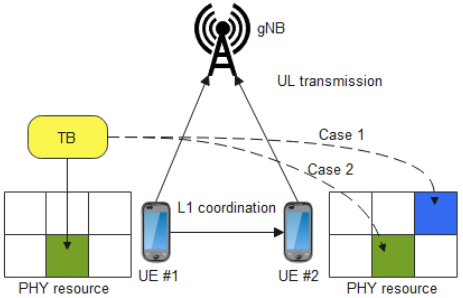
Support UE aggregation at lower layer: Data duplication (1/2)

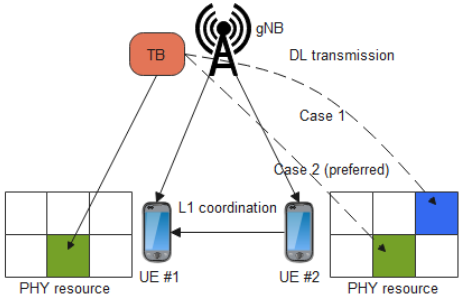
Mechanism

- UL transmission
  - gNB schedules the anchor UE and assistant UE to transmit the same TB.
    - The same resources can be used to reduce half of the resource utilization in PHY.
    - Different resources can be considered for better diversity.



Case 1: UE#1 and UE #2 transmit TB 1 on the different resources
Case 2: UE#1 and UE #2 transmit TB 1 on the same resource

- DL transmission
  - The gNB transmits the same TB to both the anchor UE and the assistant UE.
    - Similar as multicast transmission, the same resources can be scheduled to reduce half of resource utilization in PHY (preferred).
    - Different resources can be considered for scheduling flexibility.



Case 1: UE#1 and UE #2 transmit TB 1 on the different resources
Case 2: UE#1 and UE #2 transmit TB 1 on the same resource

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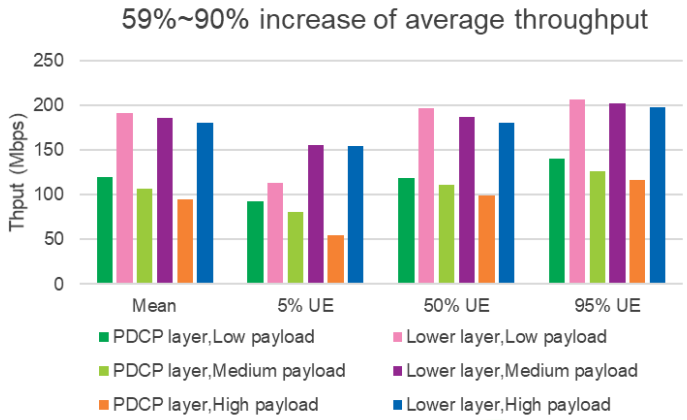
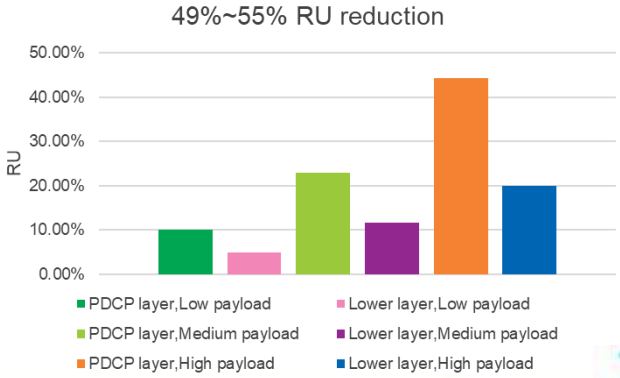
Support UE aggregation at lower layer: Data duplication (2/2)

- **Benefits over PDCP aggregation: Lower resource consumption, higher throughput, higher reliability and lower latency.**

- PDCP aggregation
  - The data is always transmitted on more than one legs since the anchor UE cannot know the transmission status at the assistant UE.
  - PDSCH/PUSCH would be transmitted on the different resources.
  - No combining gain at lower layer.
  - HARQ re-transmission is always needed if the initial transmission fails in PHY.

- Lower layer aggregation
  - The gNB knows the transmission status of the transport blocks for the anchor UE and assistant UE.
  - PDSCH/PUSCH can be transmitted on the same resources to reduce resource overhead and enhance UE antenna capability.
  - Decoding performance can be improved due to combining gain at lower layer.
  - HARQ re-transmission is not needed as long as transmission on one UE succeeds, which can reduce the latency and avoid unnecessary re-transmission.





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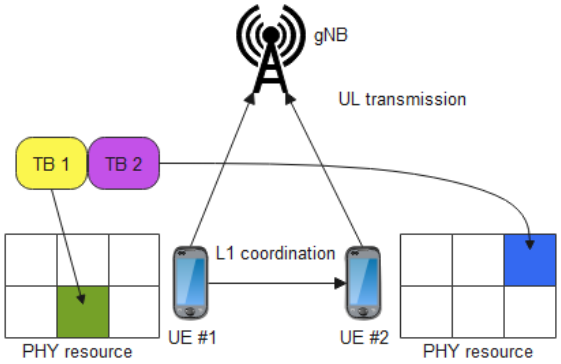
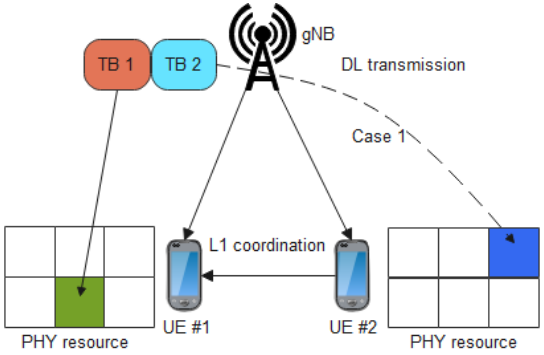
Support UE aggregation at lower layer: Data split (1/2)

Mechanism

- UL transmission
  - gNB decides how to split the data from anchor UE via separate UL grants to anchor UE and assistant UE respectively.
  - The anchor UE and assistant UE transmit the different TBs to the gNB.



- DL transmission
  - The gNB transmits different TBs for the anchor UE via two DL grants to the remote UE and the assistant UE respectively.
  - The assistant UE forwards the received TB to the anchor UE.



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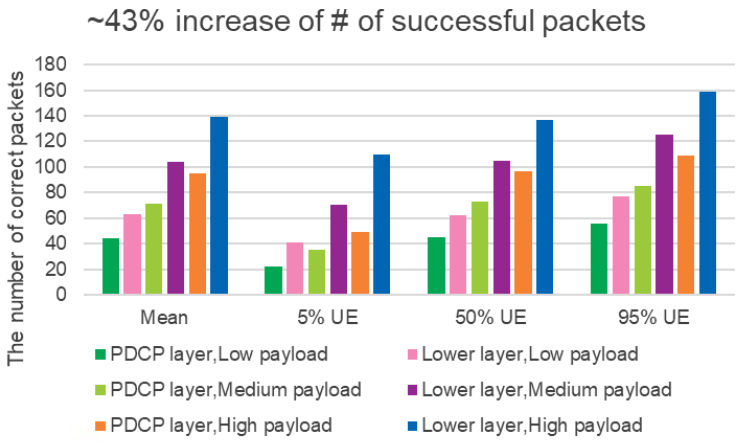
Support UE aggregation at lower layer: Data split (2/2)

Benefits over PDCP aggregation: Higher throughput and lower latency

- PDCP aggregation
  - UE decides how to split, and the PDCP packet split cannot fully take into account the physical layer capabilities and physical link conditions.

- Lower layer aggregation
  - gNB decides how to split, and the data can be split dynamically and efficiently according to instant channel conditions and available physical resources (e.g., time/ frequency resources or rank or power).



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Work Scope

Objectives

- Enhancements for UE aggregation at PDCP layer
  - UE aggregation with more than one indirect paths and inter-gNB UE aggregation
  - Mobility support for aggregated UEs and service continuity
  - Network controlled UE association for aggregation
  - UE interoperability support
- Support of UE aggregation at lower layer
  - Identification of UE aggregation at lower layer for both data split and data duplication
  - Scheduling enhancements
    - Scheduling via separate DCIs or one DCI (e.g., similar as multicast transmission or singe DCI based M-TRP transmission)

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Thanks

Tomorrow never waits