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Efficient Traffic Aggregation for Dual Connectivity

Carlos Pupiales Ilker Demirkol

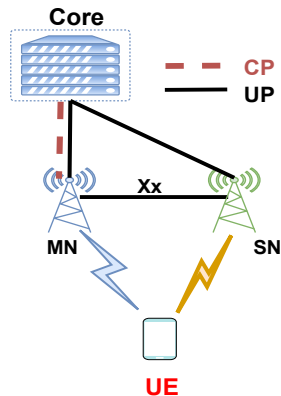
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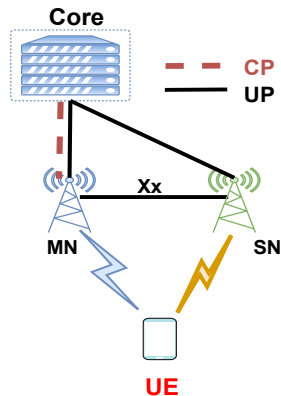


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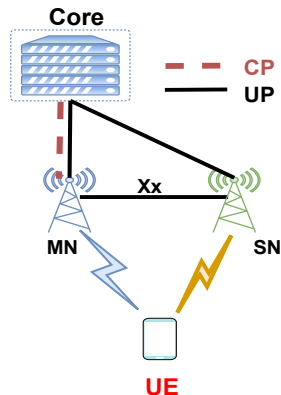
- 1 Dual Connectivity
- 2 Traffic Aggregation
- 3 Challenges
- 4 Capacity and Congestion Aware (CCW) Flow Control
- 5 Results



- The UE is connected with two BSs at the same time
- BSs are connected using a non-ideal BH
- CP and UP managed by one BS
- Use cases:
 - ▶ To increase the data rate

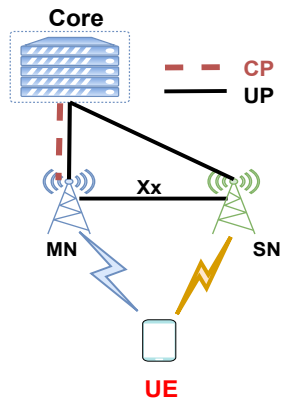


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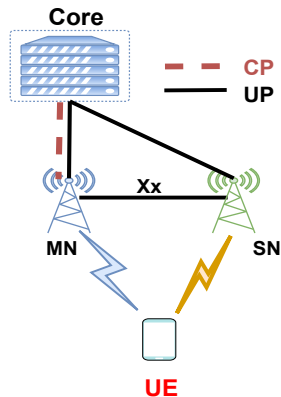
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- Use cases:
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 - ▶ To improve the reliability
 - ▶ To provide mobility robustness

- Ideally, $DC = MN_{SC} + SN_{SC}$



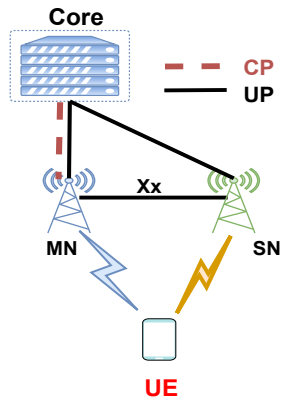
- Split DRB

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 - ▶ Continuous data flow from both BSs



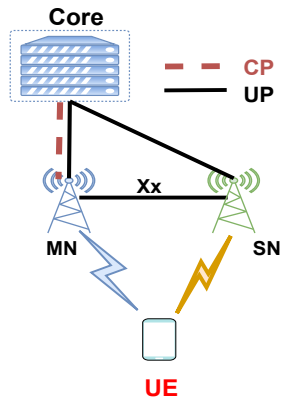
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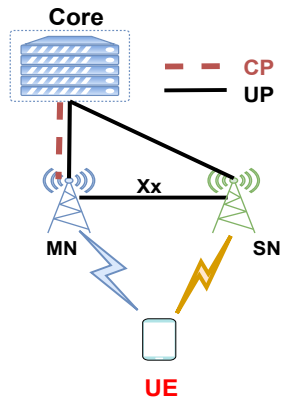
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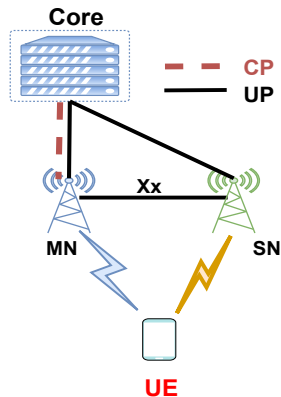
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 - ▶ **Assigned radio resources**



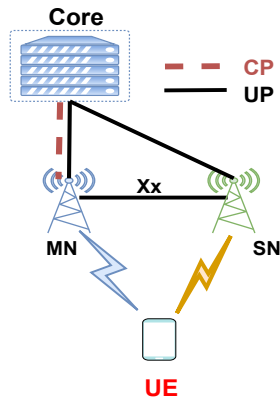
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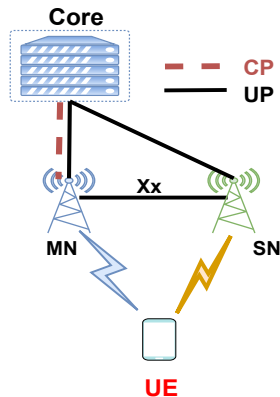
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- Why?



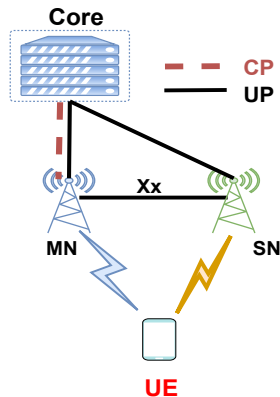
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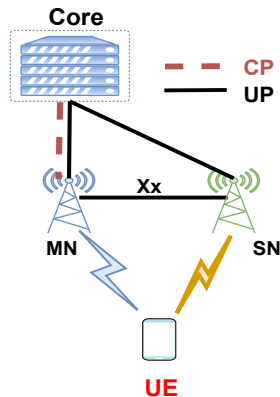
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 - ▶ **Under-utilized links**

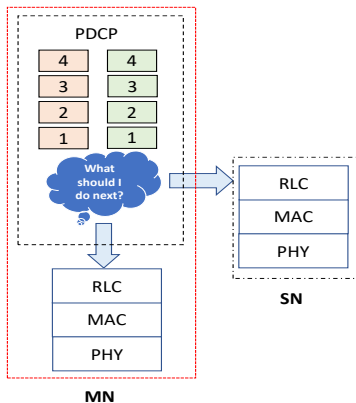


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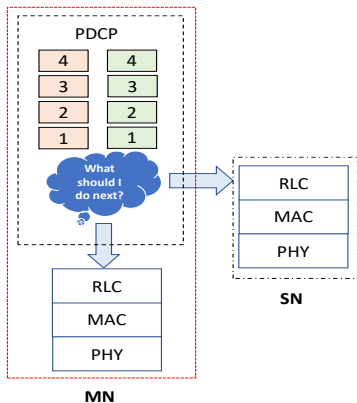
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 - ▶ Continuous data flow from both BSs
- However
 - ▶ Variable radio link conditions
 - ▶ Assigned radio resources
 - ▶ BH latency
- Why?
 - ▶ Out-of-order arrivals
 - ▶ Under-utilized links
 - ▶ High buffering delays



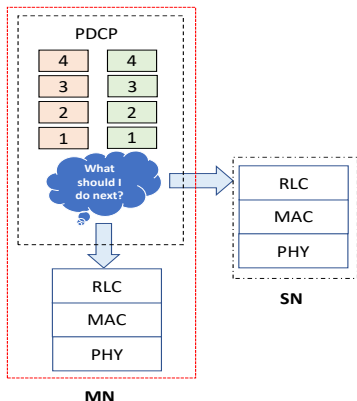
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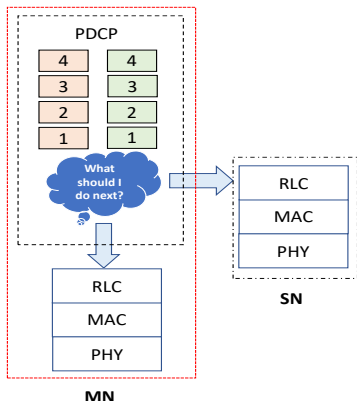
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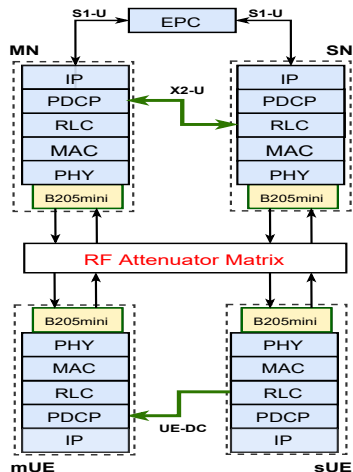


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- **Constant data flow through both BSs**



- Through which BS should the PDUs be sent?
- Available radio resources can change every TTI
- Constant data flow through both BSs
- Capacity and Congestion Aware (CCW) Flow Control

- Maintains a continuous data flow from both BSs towards the UE.
- Fully utilizes the assigned radio resources of both BSs
- Avoids under-utilized links
- PDUs are periodically split according to:
 - ▶ Average **capacity allocated** to the split DRB in each BS
 - ▶ Average **buffering delay** experienced in both RLC buffers
- Agnostic to the RAT setup and MAC scheduler



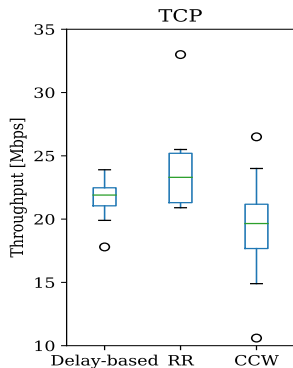
- OAI eNB, UE, EPC
 - ▶ Mosaic5G for EPC
- UE requires two protocol stacks for DC
 - ▶ mUE + sUE
- Real CQI trace from a pedestrian profile
- **ORBIT Testbed** from Rutgers University

Further implementation details can be found at C. Pupiales, et al., "Software-Based Implementation of Dual Connectivity for LTE," in MASSW 2019.

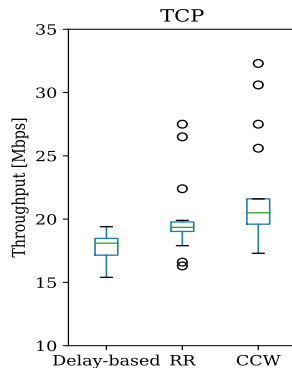
- Algorithms:
 - ▶ Round Robin
 - ▶ Delay-based ¹
- Scenarios:
 - ▶ Scenario A: MN = SN = 10 MHz
 - ▶ Scenario B: MN = 5 MHz, SN = 10 MHz
- TCP traffic using *iperf*
- 3GPP reordering mechanism
- SC throughput is the baseline

²D. Lopez-Perez, et al., "Long Term Evolution-Wireless Local Area Network Aggregation Flow Control," IEEE Access, 2016.

Results: Reordering Disabled

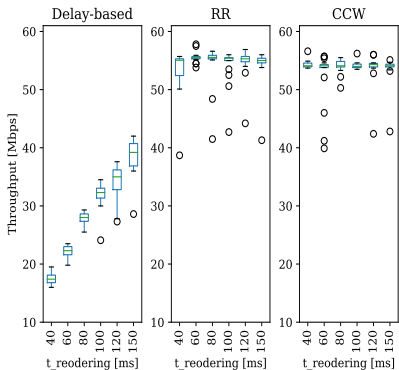


Scenario A → 56 Mbps
MN = 28.5, SN = 27.5 Mbps

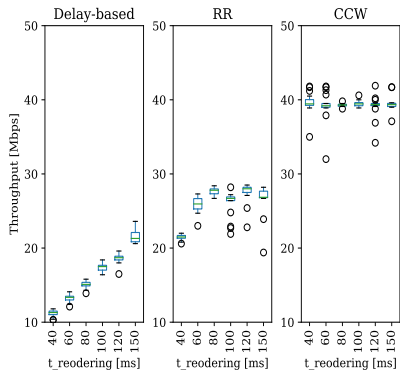


Scenario B → 41.6 Mbps
MN = 14.1, SN = 27.5 Mbps

Results: Reordering Enabled



Scenario A \rightarrow 56 Mbps
MN = 28.5, SN = 27.5 Mbps



Scenario B \rightarrow 41.6 Mbps
MN = 14.1, SN = 27.5 Mbps



THANKS FOR YOUR ATTENTION

ANY QUESTION?