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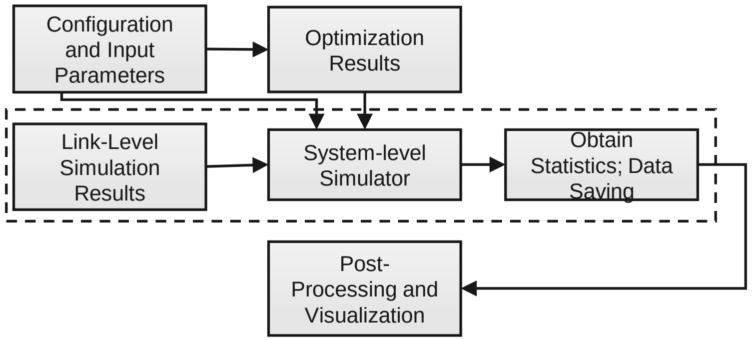
Goals

- **The main goal of TRACK II** is to estimate an impact of MAC scheduling and technological limitations on the optimal solutions



Simulation tool structure

- To achieve this goal, the following steps were accomplished:

  - **Development of packet-level modeler.** The modeling framework that accounts for short- and long-term variations in the channel states, dynamic traffic conditions, and short-term distributed MAC scheduling

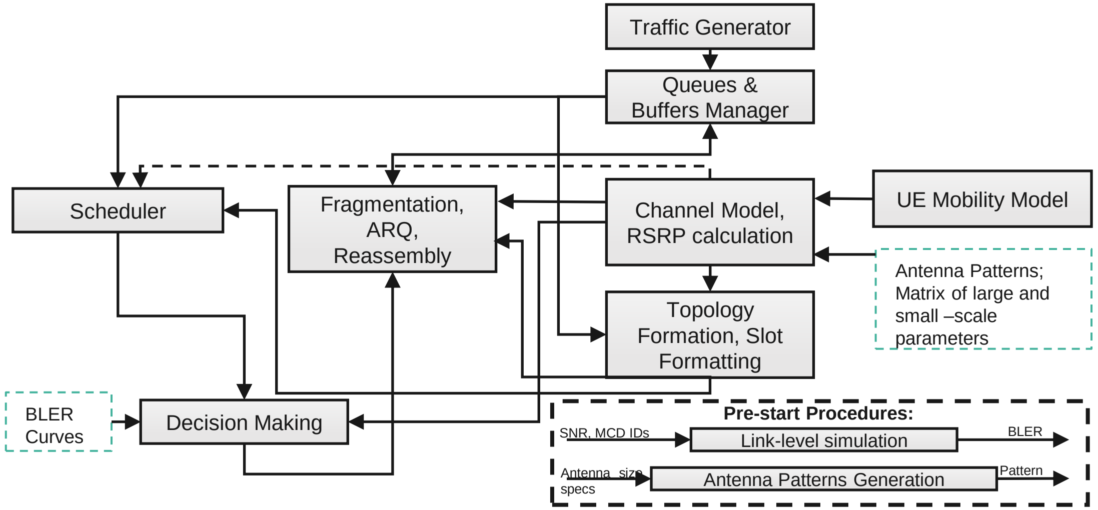
  - **Implementation of MAC scheduling algorithms.** Develop MAC scheduling algorithms, which satisfy or approach the optimal allocations.

  - **Integration of simulation and optimization frameworks**

Packet-Level Simulator

- The blocks of the realized simulator include, e.g., multi-hop ARQ, SINR/SNR-to-BLER mapping, packet fragmentation, FTP traffic model, and MAC scheduling. In addition, the tool accounts for channel variation effects by utilizing antenna, blockage, and cluster channel models

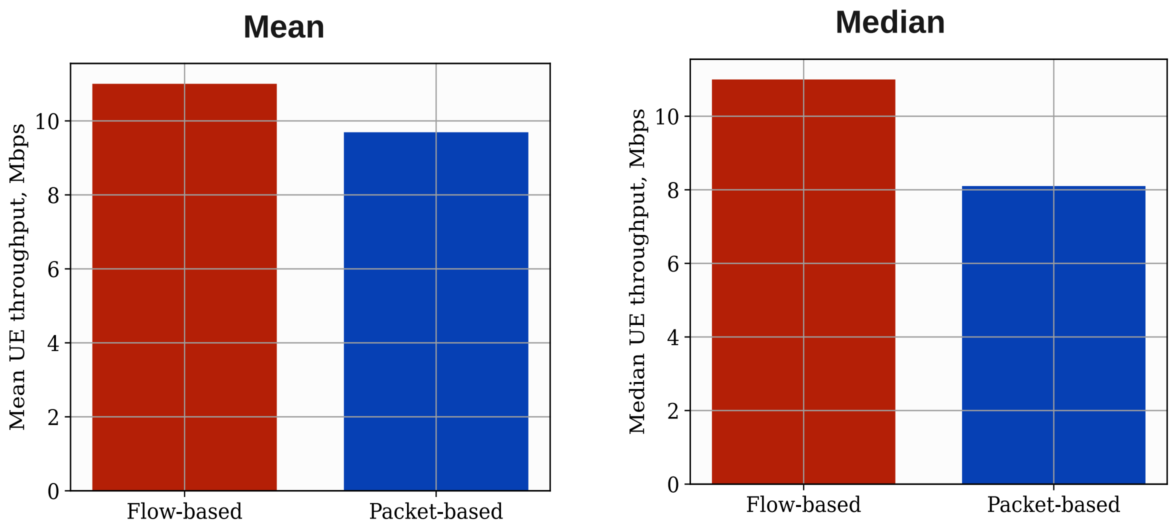
- The tool **allows characterizing throughput and latency** more accurately as compared to the flow-based simulator due to the incorporation of RLC-specific functions



Interconnections between simulator modules

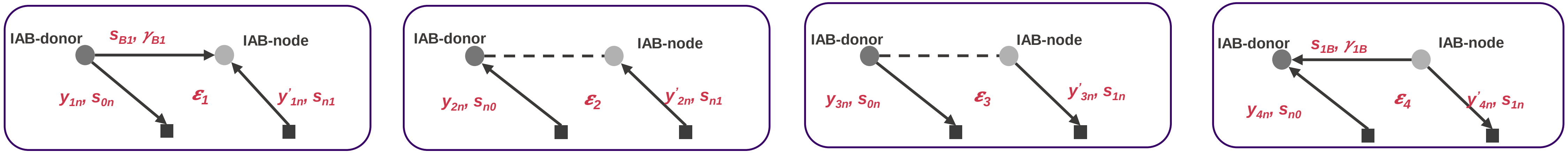
Calibration with Flow-Based Simulator

- To verify the correctness of packet-level simulations, the modeler was calibrated with the **flow-based simulator**, which provides an **upper boundary of throughput**
- **Throughput is lower by 2 – 3 Mbps** due to packet transmission as compared to the flow-based simulator with similar assumptions
- The heuristic resource allocation methods realized in the simulator include 50/50 division and proportional division (for dynamic traffic). Two different MAC scheduling strategies were implemented: round-robin (**RR**) and proportional fair (**PF**) schedulers. Both strategies were calibrated with the flow-based simulator



Calibration of mean and median throughput

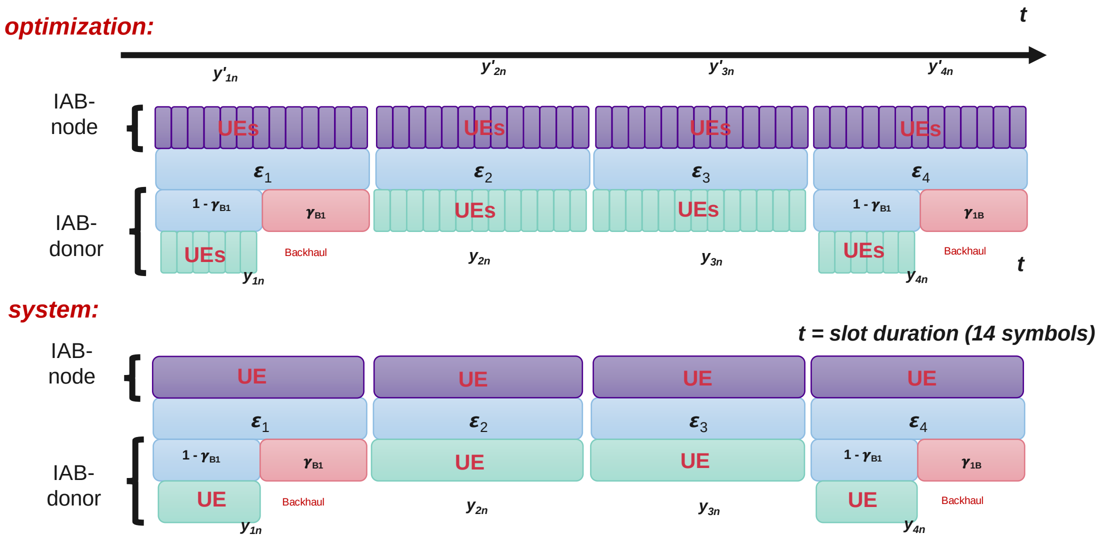
Difference between Optimization and Implementation



- Optimization is not associated with any particular time duration

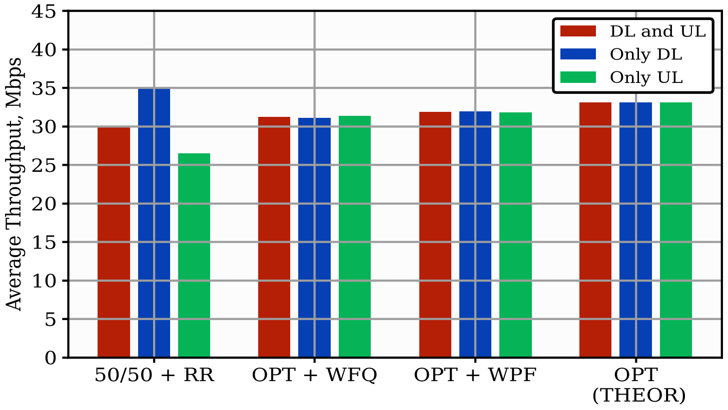
- Simulator is tied with standards limitations; hence, UEs compete for the resource (only one UE can be served within a fraction of time)

- **To achieve optimality, an optimal one should be utilized.** Therefore, for optimization evaluation, the weighted fair queuing (**WFQ**) and weighted PF (**WPF**) schedulers were implemented, which are parametrized with optimal coefficients

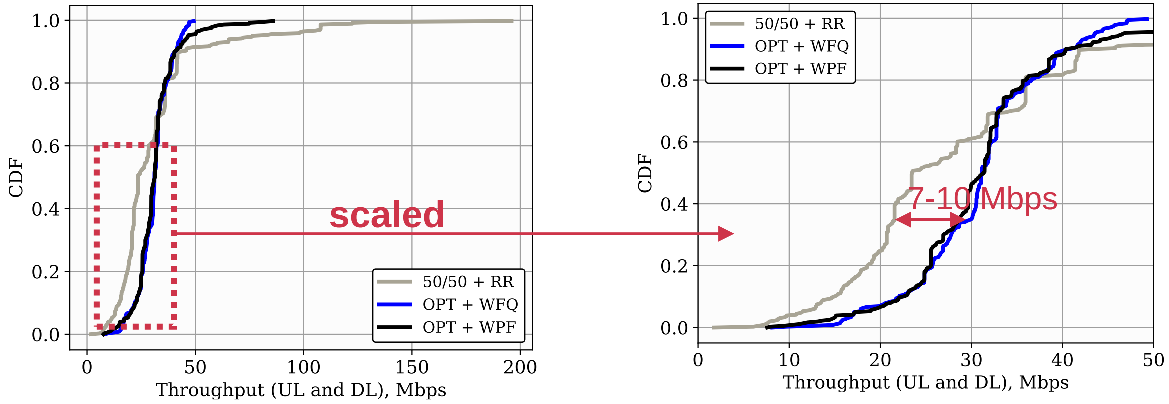


Difference between optimization and implementation

Optimal and Heuristic Resource Allocation and Scheduling



Comparison of mean throughput

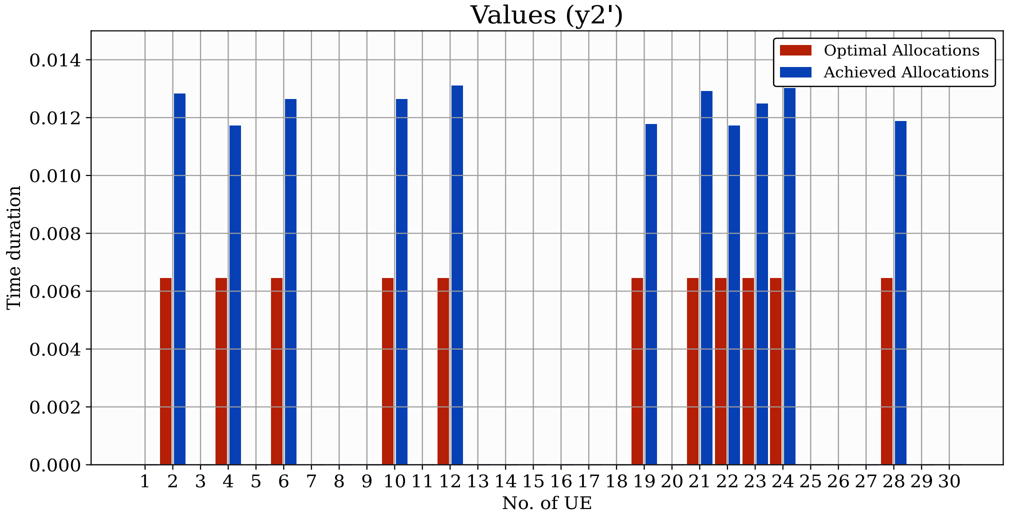


CDF of throughput

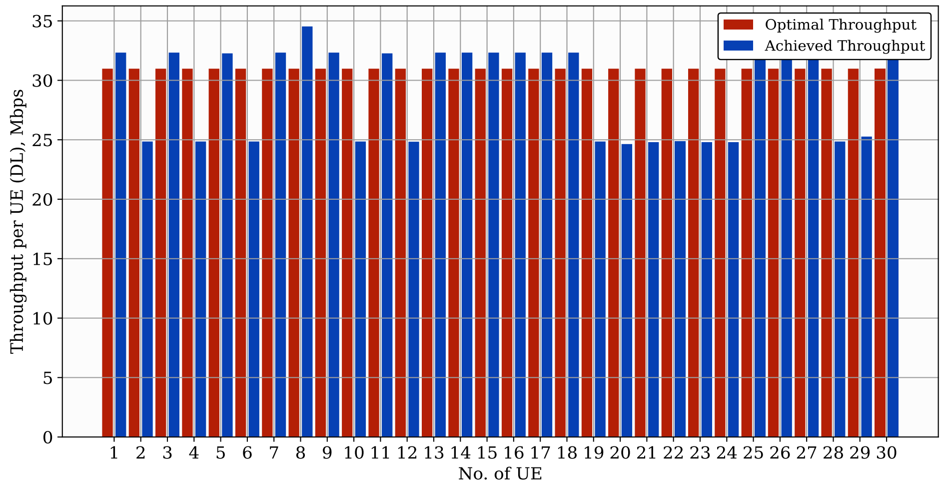
- **To achieve optimality, individual UE allocations should be accounted for**. Therefore, for optimization evaluation, the weighted fair queuing (**WFQ**) and weighted PF (**WPF**) schedulers were implemented, which are parametrized with optimal coefficients

- The **average throughput almost reaches the optimal one** with a slight deviation due to channel variations. However, one should not calculate optimization gain based only on the average values. As the optimization objective is to equalize UL and DL throughput, **the performance gain lies in fairness**

Impact of Systems Limitations



Allocations with integer number of symbols



Throughput with integer number of symbols

- Comparison of the achieved transmission time to optimal allocations demonstrates that most of the time, **achieving optimal allocations precisely is not possible** due to system limitations
- **The reason is the rounding procedure** in the duplexing pattern coefficients, i.e., optimization procedure provide precise coefficients while in reality, 1 slot consists of 14 symbols

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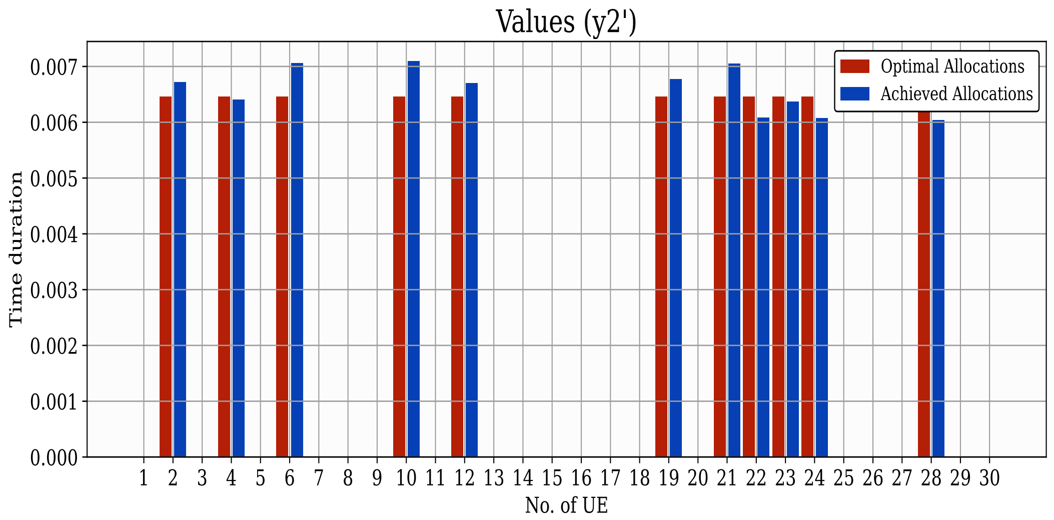
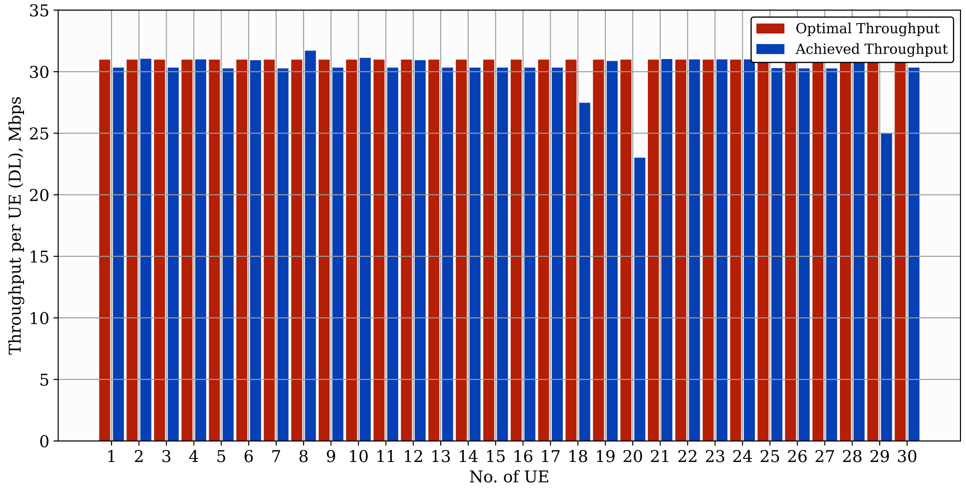
Impact of Systems Limitations



Allocations with non-integer number of symbols



Throughput with non-integer number of symbols

- The **rounding** error **has a major impact on the access-backhaul division**. Depending on the coefficients, either access or backhaul UEs utilize more resources than it was calculated by the optimization
- Considering the same scenario as in the previous example, it can be seen that with non-integer number of symbols it becomes possible to equalize the throughput

Conclusion

- The throughput drops by approx. **2 Mbps (20 %)** due to packet transmission as compared to the flow-based simulator with similar assumptions

- **Optimal allocations** can be achieved by assuming a non-integer number of symbols per transmission. However, it cannot be implemented in real systems. Therefore, achieved allocations **deviate from optimal allocations**

- At the same time, the **average throughput** almost **reaches the optimal one** with slight deviation due to channel variations

- Note that one should not calculate optimization gain based only on the average values for the maxmin optimization. As the optimization objective is to equalize UL and DL throughput, the **gain** should be calculated based on the **fairness**

- PF scheduler together with the optimizer allows achieving higher average throughput due to the fact that it allows accounting for channel variations

Integration of TRACK I and TRACK II

- The outcome of this study is the merged framework, which allows estimating an impact of short-term effects on the optimization. The developed tool will be employed in the following year project, which is aimed at management and adaptation of the IAB system in O-RAN. Specifically, the tool will be employed to

  - Address an impact of **load dynamics** in IAB networks
  - Determine the network **re-optimization time** under the influence of dynamic traffic
  - Evaluate the performance of **ML-aided algorithms**, which may potentially **reduce the complexity** of model-based approaches