Multi-Connectivity based adaptive Data Traffic Steering for Cooperative Corridor Management

Webinar "The German LL in the PoDIUM Project: Preliminary Results from the Use Case "Cooperative Corridor Management in the City of Ulm involving Multi-connectivity"'

Prof. Dr.-Ing. Amr Rizk
University of Duisburg-Essen
Leibniz University Hannover

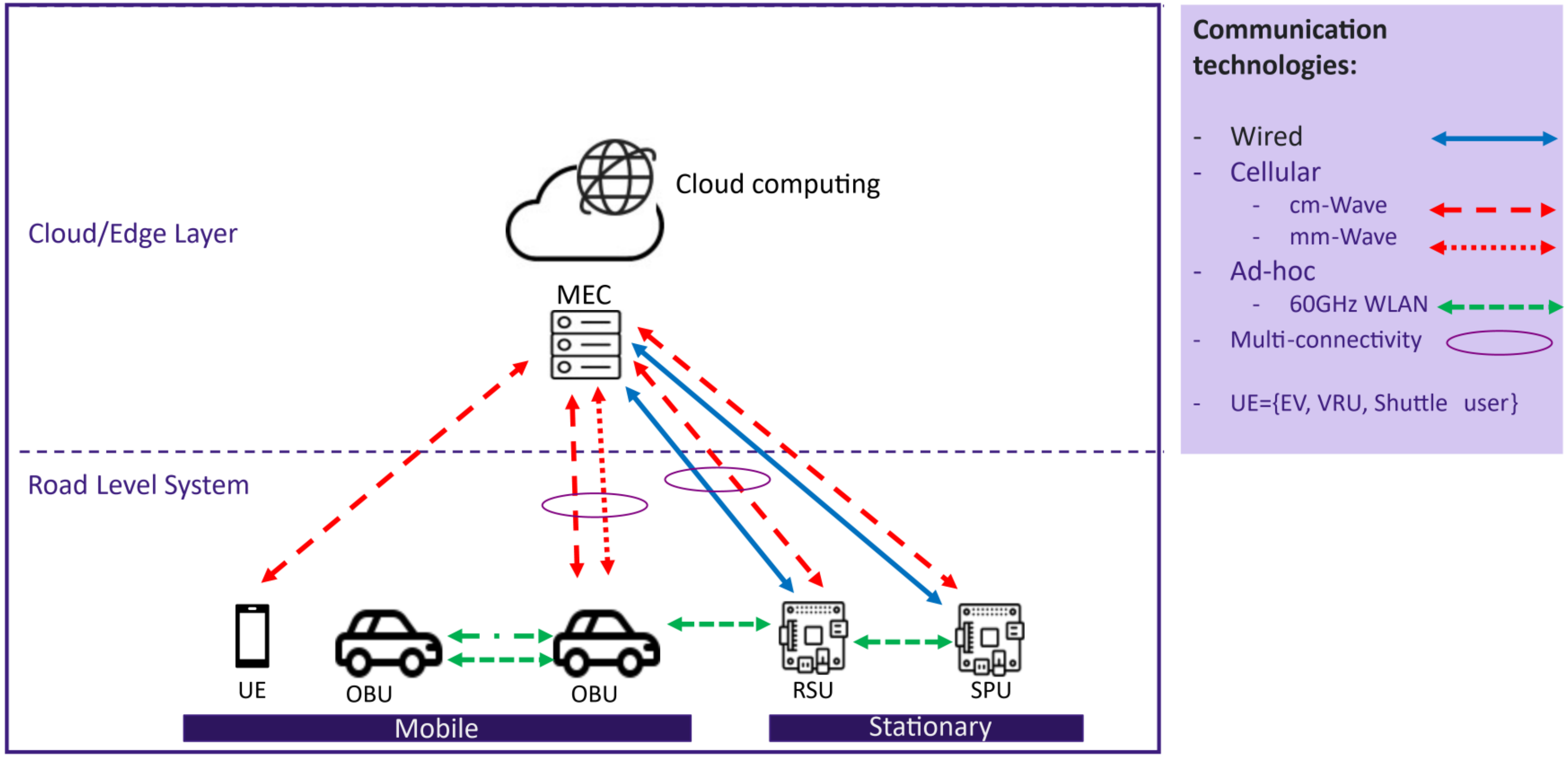
December 3rd, 2024

Co-funded by the European Union

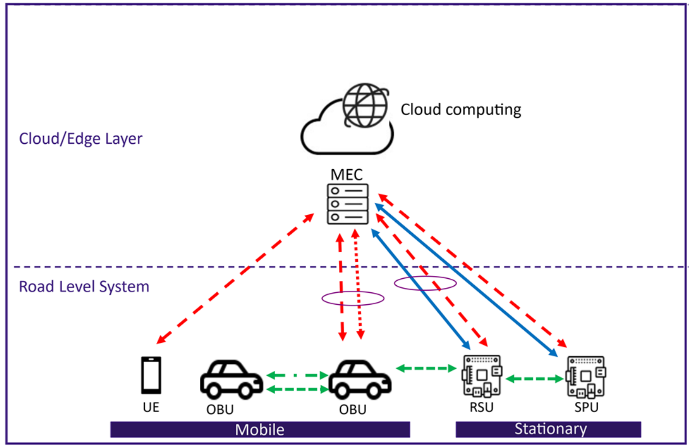
PoDIUM

Communication Architecture Overview

- Integration of mobile road-users and stationary road-side equipment via:
  - Cellular mobile networks (5G) with cm-wave and mm-wave cells
  - 60-GHz-WiFi
  - Wired connections
- Redundancy of multi-connectivity for
  - enhanced bandwidth
  - enhanced reliability



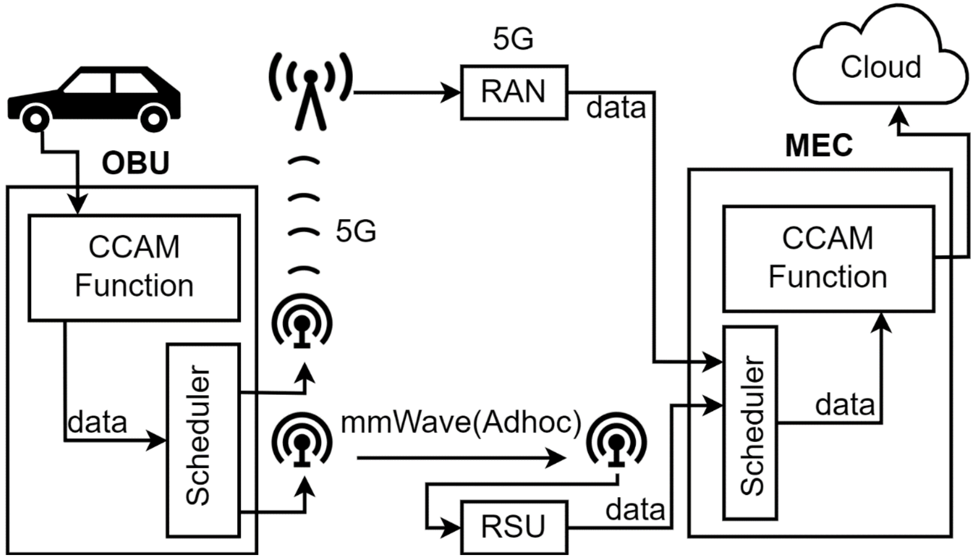
Types of Communication



- Single-Connectivity
  - using only a single technology btw. end-points
- Multi-Connectivity
  - between devices that can use multiple technologies simultaneously
  - includes the ability to schedule messages and data packets over the available communication technologies
  - for reliability, availability and redundancy in addition to latency reduction
- Hybrid Communication
  - messages are simultaneously transmitted over all available communication technologies (always duplicated)
  - redundancy decoupled from message-specific criticality

Technical Setup

- ComPC
- Interfaces
- Scheduler Software
  - maps packets to paths
  - possibly duplicates packets
  - drops duplicated packets on arrival

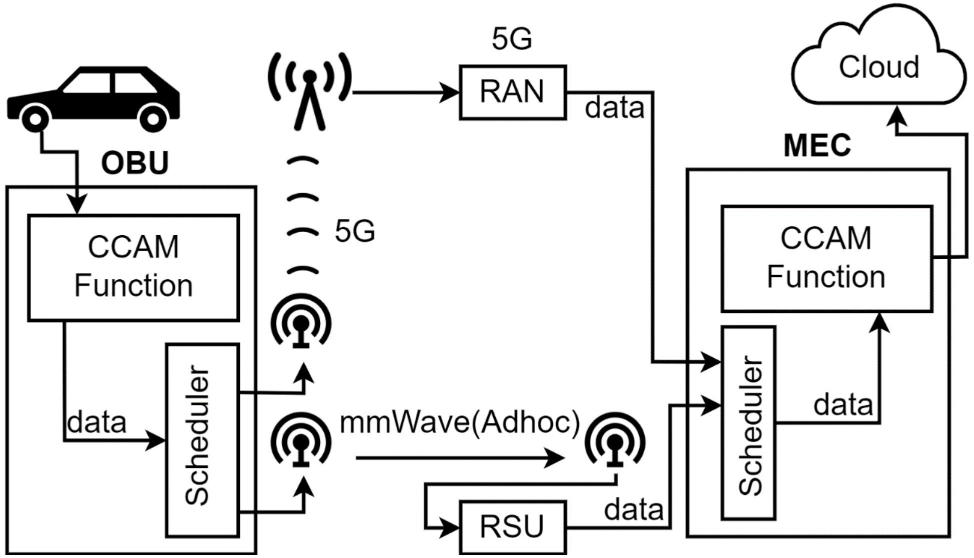


Options for realizing Multipath schedulers

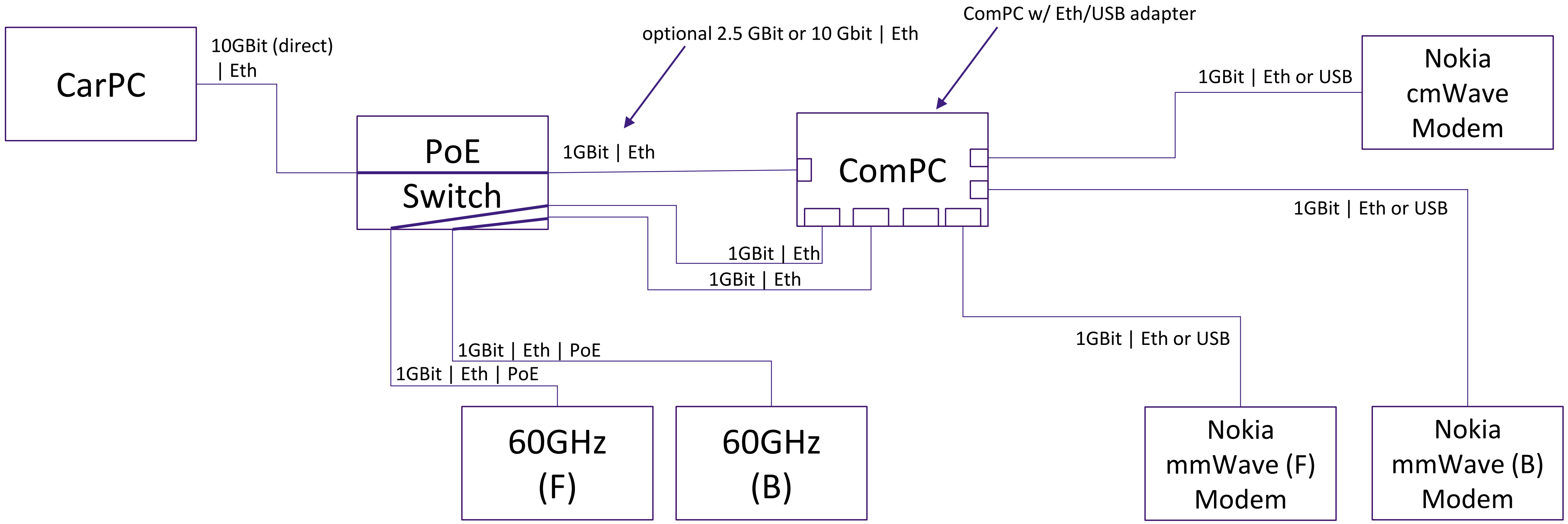
- Scheduler in user space (e.g. MPQUIC)
  - Flexible
  - Slow
- Scheduler as software switch on the ComPC
  - Restricted
  - Fast
  - Programming in terms of the domain specific language p4

Realization (I)

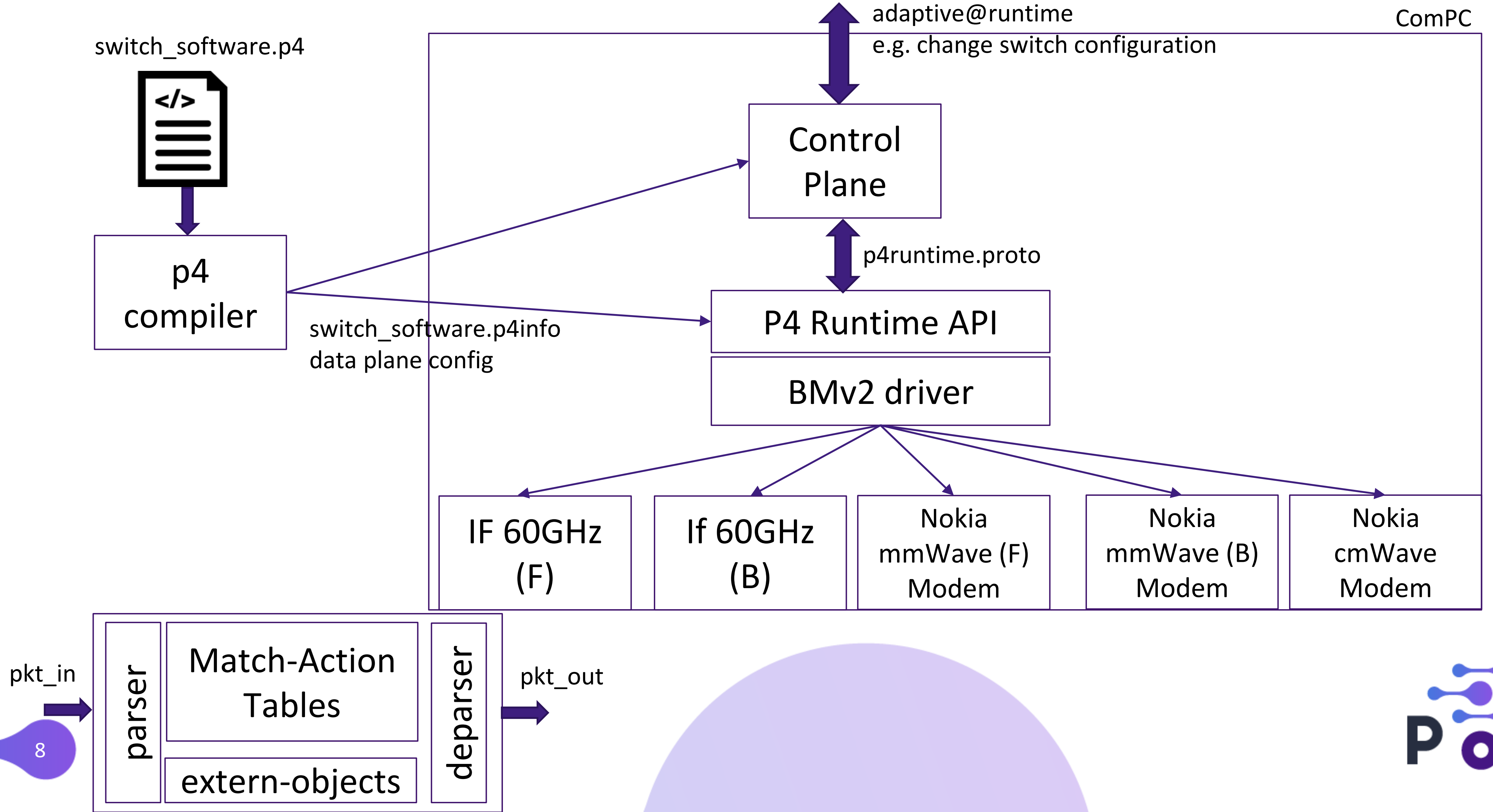
- Scheduler on a separate ComPC
  - realized as a software data plane switch programmed using the p4 language
  - passing packets to the CCAM functions
  - merge client traffic in uplink and distribute server traffic in downlink according to scheduling rules



Realization (Hardware)

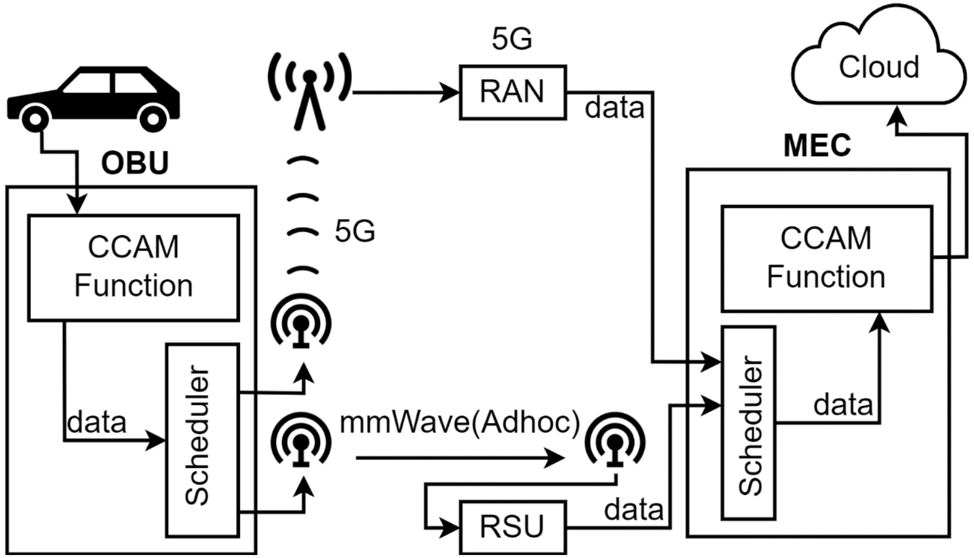


Realization (Software)



Realization (II)

- Scheduler on a separate ComPC
  - realized as a software data plane switch programmed using the p4 language
  - passing packets to the CCAM functions
  - merge client traffic in uplink and distribute server traffic in downlink according to scheduling rules



- Scheduling rules
  - matching on predefined packet rules and deciding on their mapping
  - rules of the form
    - match on CAM → map to interface A, or match CPM → map to interface A,B
    - match all packets → map to all interfaces (current)
    - match packets, check if seen before → if yes, drop
    - Typ A message has higher prio than Typ B message

Summary and conclusions

- CCAM messages require throughput and reliability
  - even different grades of throuput and reliablity for different messages
  - adaptive scheduling of streams to mutliple available communication technologies comes to the rescue
- We provide flexible model-based Multi-connectivity schedulers on the data plane to
  - explore the scheduling design space of throughput vs. reliability
  - allow optimizations on top

Thank you!

PoDIUM

Co-funded by the European Union

@PoDIUM_EU

PoDIUM Project

podium-project.eu

Prof. Dr. Amr Rizk
University of Duisburg-Essen
Leibniz University Hannover
E-mail: amr.rizk@ikt.uni-hannover.de