End-to-end performance of next generation mmWave networks

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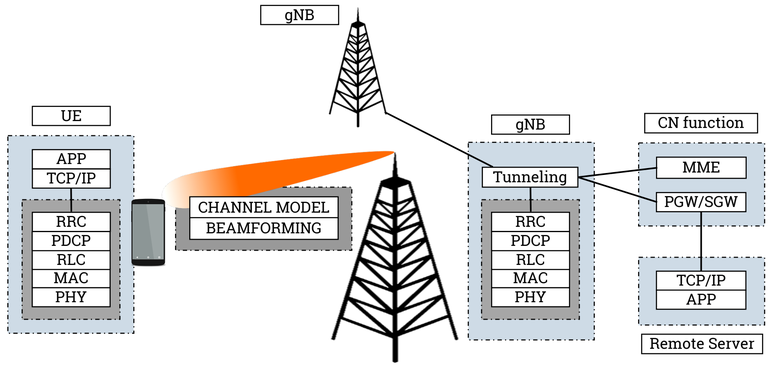
Research activities in collaboration with Michele Zorzi (supervisor), Andrea Zanella, Marco Giordani (UNIPD), Sundeep Rangan, Marco Mezzavilla and Menglei Zhang (NYU Wireless) and Rittwik Jana (AT&T Research Labs). See **mmwave.dei.unipd.it** for a list of references.

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Objective

mmWave communications are an enabler of future mobile networks

- user experience depends on end-to-end performance
- mobility and interaction with higher layers are still unexplored

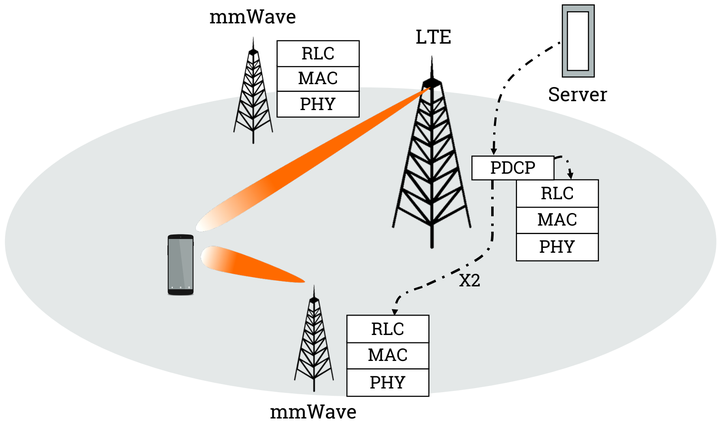


ns-3 simulator

- End-to-end simulator with full TCP/IP and 3GPP-like stacks
- 3GPP 6-100 GHz channel model – NYU channel model – tracing-based model
- Dual Connectivity
- Low-latency MAC & PHY

Mobility in mmWave networks

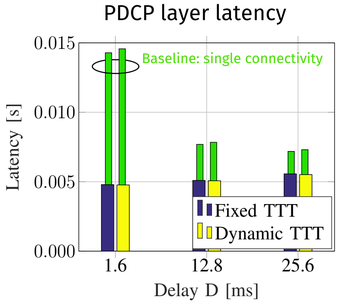
Dual Connectivity architecture for LTE and mmWave



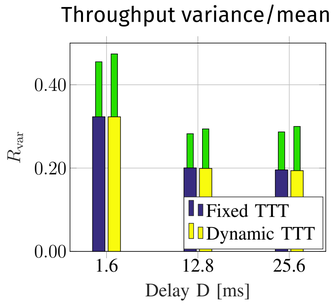
- PDCP layer aggregation
- Track the UE SINR across multiple mmWave eNBs
- Provide more stable connectivity
- Fast mobility procedures
  - Fast switching
  - Secondary Cell Handover

First evaluation of handover in cellular mmWave with dynamic models + e2e protocol stack + DC architecture

PDCP layer latency



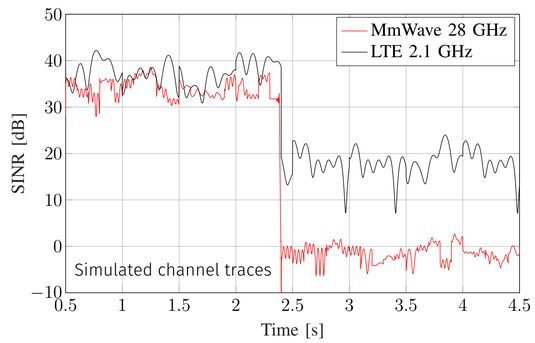
Throughput variance/mean



- Smarter mobility
- Lower latency
- Smaller throughput variations

Transport protocols for mmWave

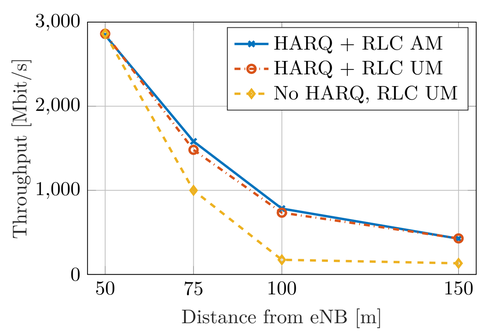
Challenges: blockage and high variability



Emerging issues: packet losses and bufferbloat

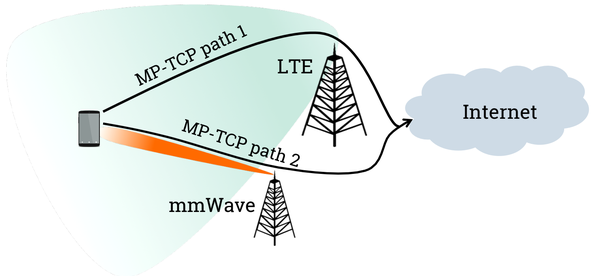
Time diversity

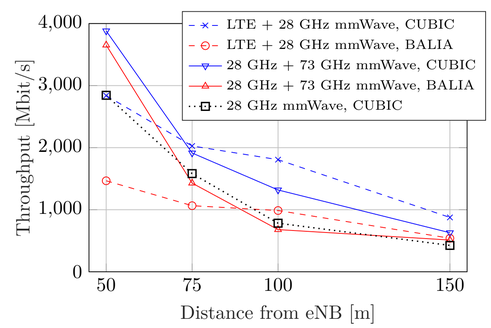
HARQ and RLC retransmissions



Path diversity

Multipath TCP over LTE or mmWave





A **reliable subflow** with low bandwidth helps more than a high capacity, unreliable path

Coming soon: cross-layer approach