TCP in 5G mmWave networks

Time and path diversity

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Objective

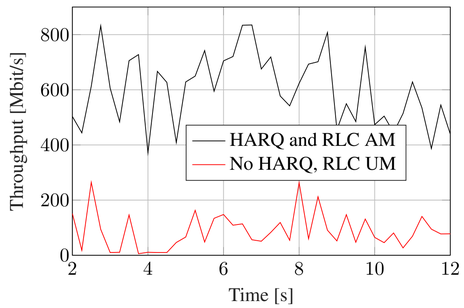
Evaluate **MP-TCP** on mmWave + LTE networks

- What is the best combination of paths?
- Which congestion control (CC) algorithm to use?

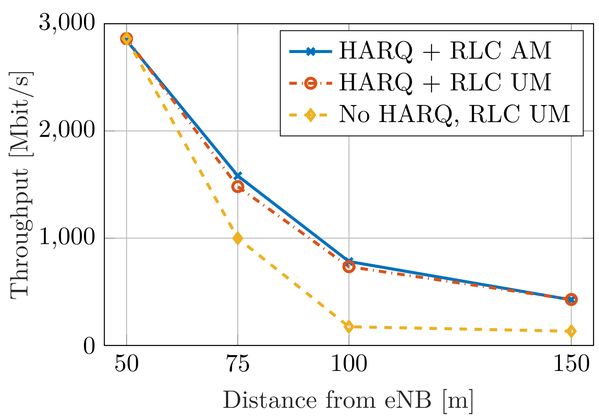
mmWaves and TCP

Challenges: blockage and high variability

Example: throughput over time In NLOS condition

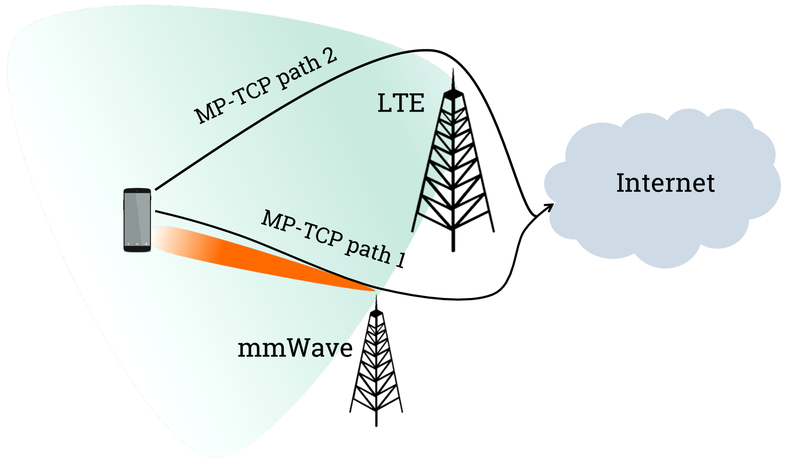


Lower-layer retransmissions (*time diversity*) increase the throughput...



... but it is possible to achieve a higher throughput with *path diversity*

Multipath TCP



- Exploit **path diversity** with multi-connectivity
- **Design** goals of MP-TCP
  1. Improve throughput
  2. Be fair with other TCP flows
  3. Avoid congestion
- Congestion control algorithms
  - **Coupled** – OLIA, **BALIA** – the congestion window of all the paths are **dependent** on each other (NewReno based)
  - **Uncoupled** – each path is **independent**, any TCP CC (e.g., **CUBIC**) can be used

References

[1] M. Polese, R. Jana, M. Zorzi, ***TCP in 5G mmWave Networks: Link Level Retransmissions and MP-TCP***, accepted for presentation at the 2017 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)

[2] M. Polese, R. Jana, M. Zorzi, ***TCP and MP-TCP in mmWave Mobile Networks***, to appear on IEEE Internet Computing magazine, special issue on 5G

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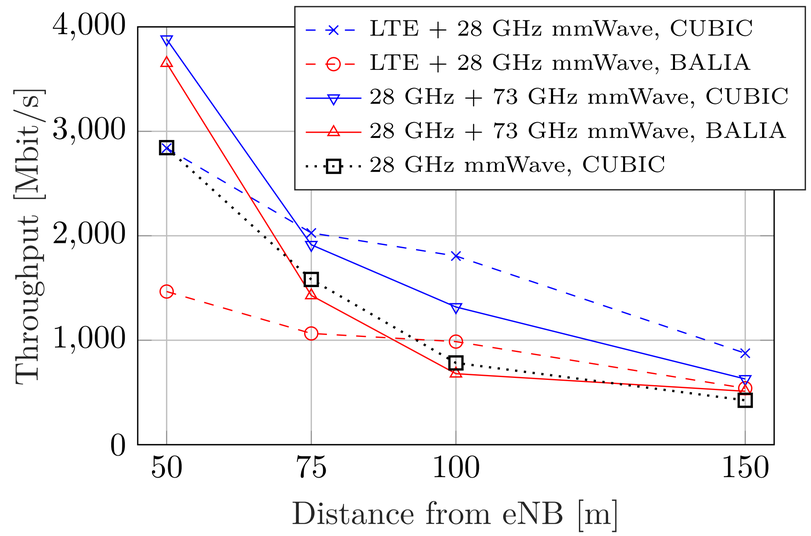
Performance evaluation



Path choice

Dashed vs **solid** lines: at large distance, **mmWave 28 GHz + LTE** performs better than mmWave 28 GHz + mmWave 73 GHz

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

CC algorithms

Red vs **blue** lines: the uncoupled CC with CUBIC performs better than coupled BALIA. BALIA may perform worse than the single path TCP

→ State of the art CC algorithms do **not** meet the **MP-TCP design goals** in a mmWave scenario