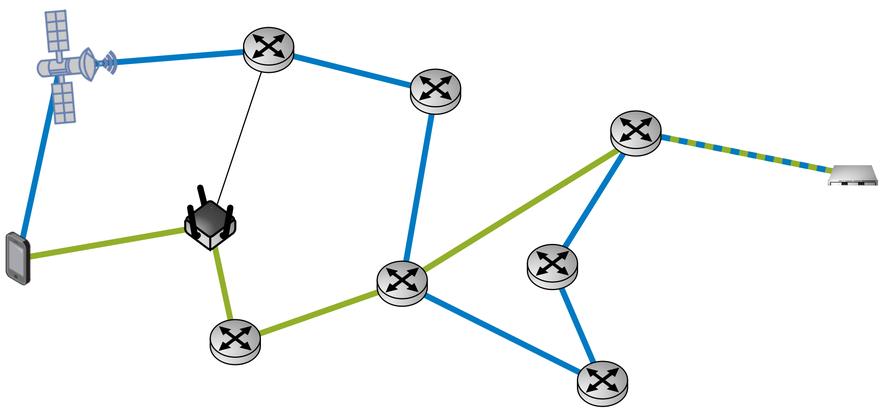
Chair of Network Architectures and Services
School of Computation, Information, and Technology
Technical University of Munich

Robustness as a Service with QUIC Extensions

Motivation

Modern networks are **user-centric**

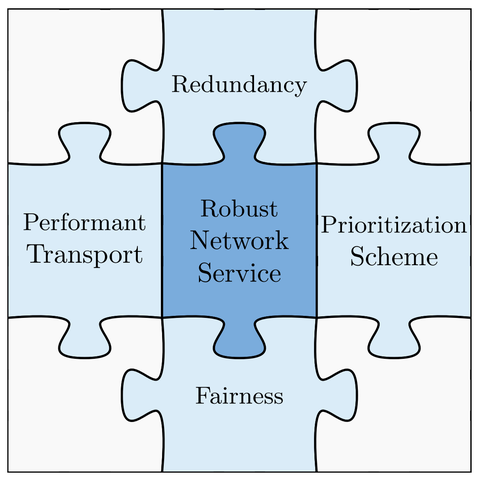
- demand ubiquitous connectivity
- *multihomed* wireless and mobile devices
- frequent handovers across heterogeneous paths



Goal

Investigation of robust technologies their interplay

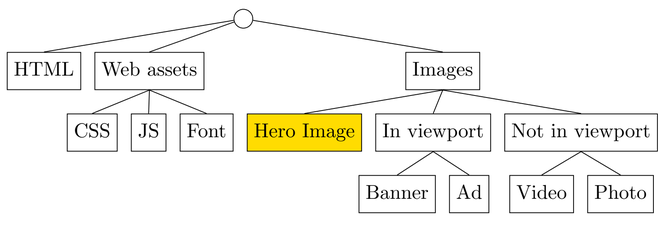
- build atop existing infrastructure
- treat as a joint optimization problem

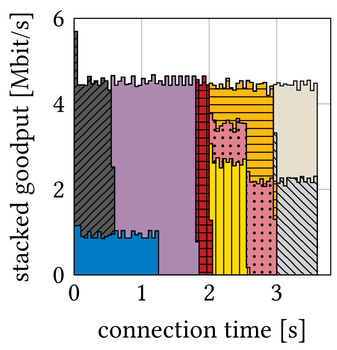


Weighted Hierarchical Fairness for HTTP/3 Streams

Multiplexed strict priorities at multiple aggregation levels [3]

- relative **weights** (= max-min fair *guarantees*) [4]
- byte-granular redistribution of unused bandwidth
- earlier arrivals of key Web assets in parallel
- fallback-safe HTTP/3 extension [5]

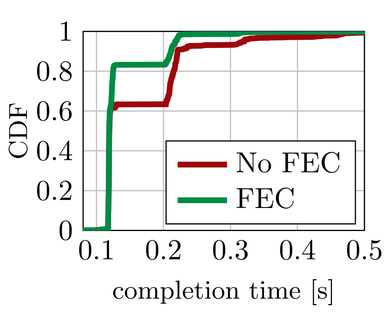


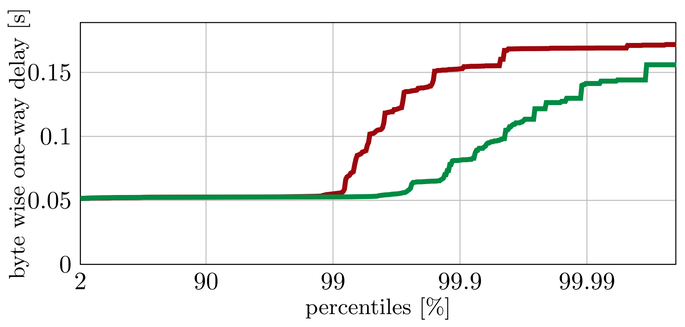


Forward Error Correction (FEC) in QUIC

Coding scheme to protect against burst packet losses

- application-specific repair symbol scheduling
- significant improvements to the end-to-end one-way delay
- applicable to bulk and incremental transfers [3]

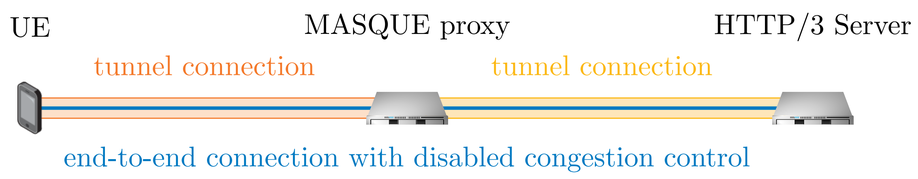




Current Research

MASQUE-based Peformance Enhancing Proxies [1]

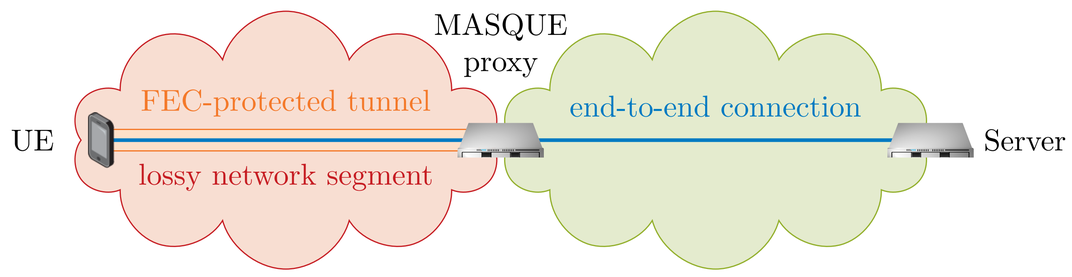
- chained tunnels enable split congestion control loops
- realistic HTTP/3 traffic emulation with BrowsEm [2]
- measurement of scheduling policies at intermediaries



Outlook

Transparent enhancements for low-latency applications

- equip arbitrary protocols with error correction
- localize FEC overhead to lossy last-mile segments
- adjust FEC need dynamically, leveraging multiple paths



[1] P. Bokelmann and D. Petri. MASQUE-based Performance Enhancing Proxies. Proceedings of the Seminar Innovative Internet Technologies and Mobile Communications (IITM). 2025.
[2] K. Holzinger, F. Klein, D. Petri, S. Lachnit, S. Gallenmüller, and G. Carle. BrowsEm: Model-based Web Site Loading Emulation. In *Proceedings of the ANRW*, Madrid Spain, July 2025. ACM.
[3] K. Holzinger, D. Petri, S. Lachnit, M. Kempf, H. Stubbe, S. Gallenmuller, S. Gunther, and G. Carle. Forward error correction and weighted hierarchical fair multiplexing for HTTP/3 over QUIC.
[4] N. Luangsomboon and J. Liebeherr. HLS: A packet scheduler for hierarchical fairness. In *2021 IEEE 29th International Conference on Network Protocols (ICNP)*, pages 1–11, 2021.
[5] K. Oku and L. Pardue. Extensible Prioritization Scheme for HTTP. RFC 9218, June 2022.

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