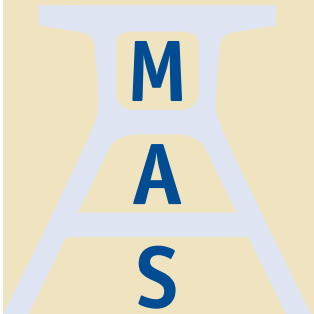

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Open-Minded

Scalability of Future Mobile Networks

Through Network Independent Application Layer Mobility and Context Monitoring

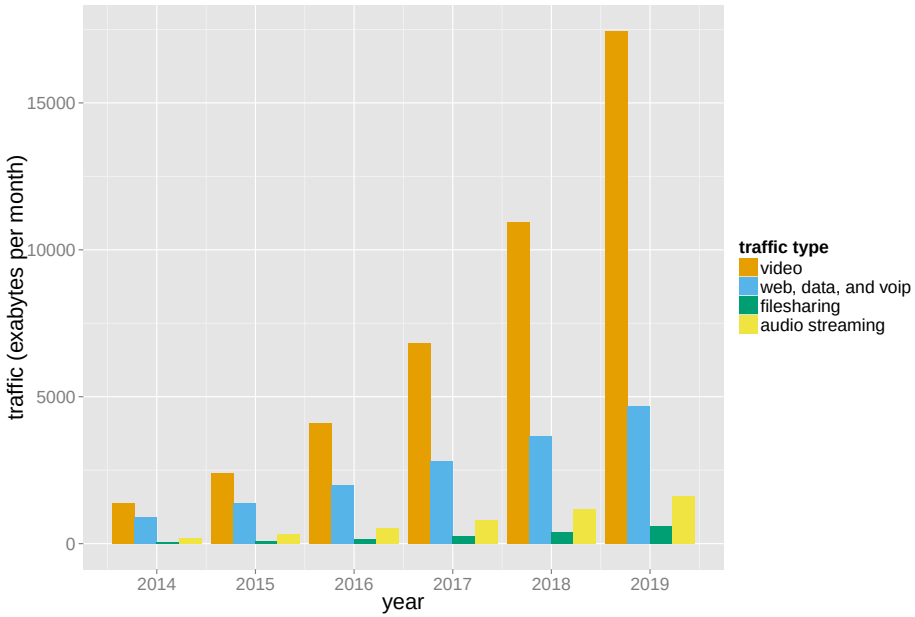
Florian Metzger ■ 2015/12/10

Modeling of Adaptive Systems

https://www.mas.wiwi.uni-due.de/en

Motivation

QoS and QoE of TCP Streaming in Mobile Networks?



source: Cisco VNI 2014

YouTube

NETFLIX

Motivation

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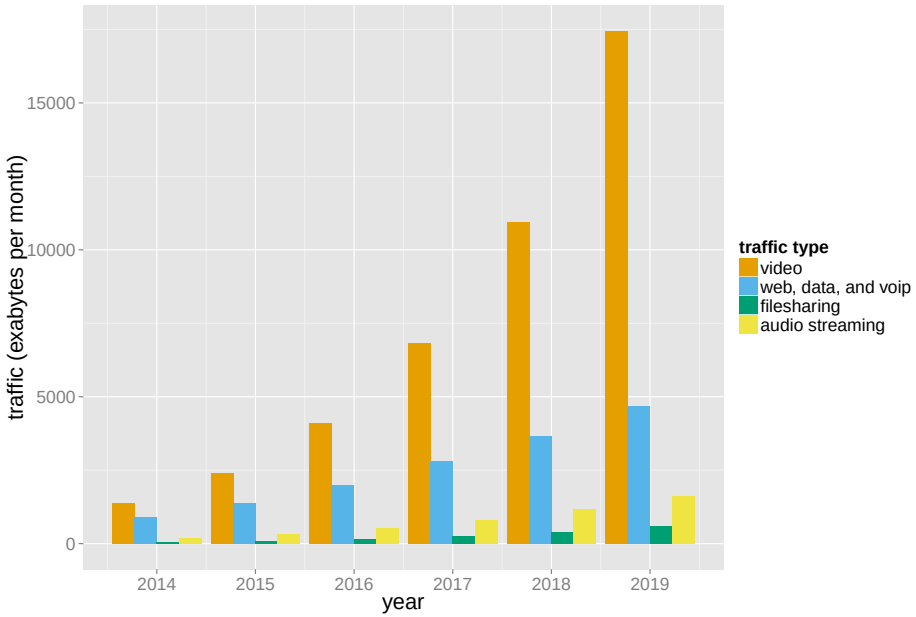

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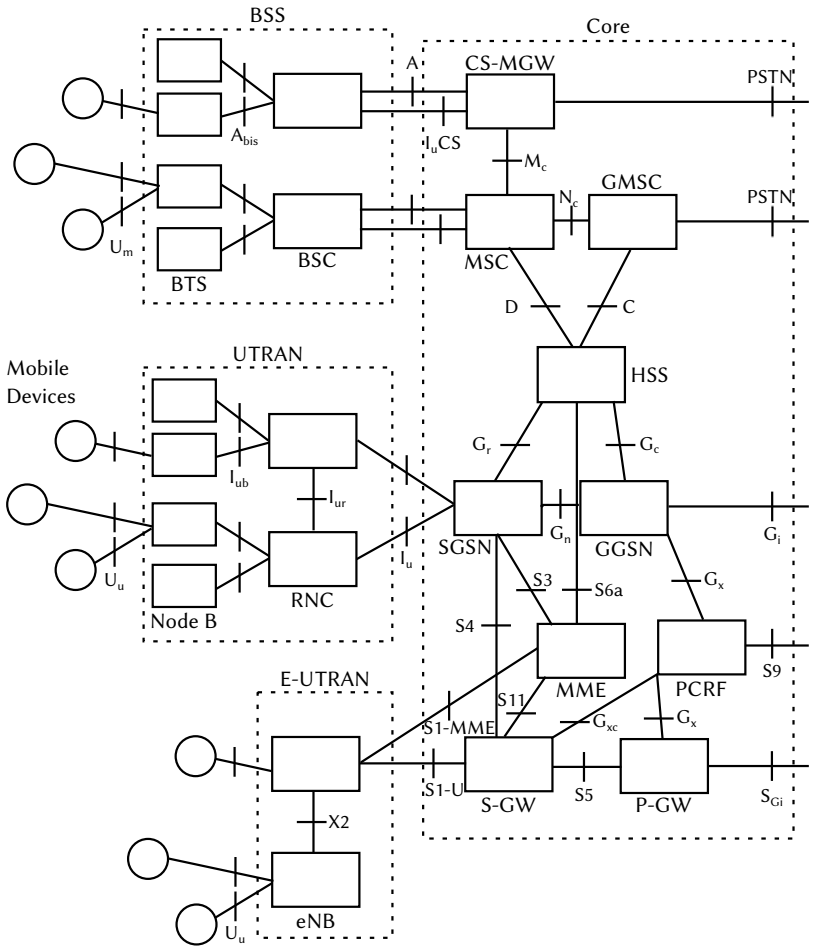
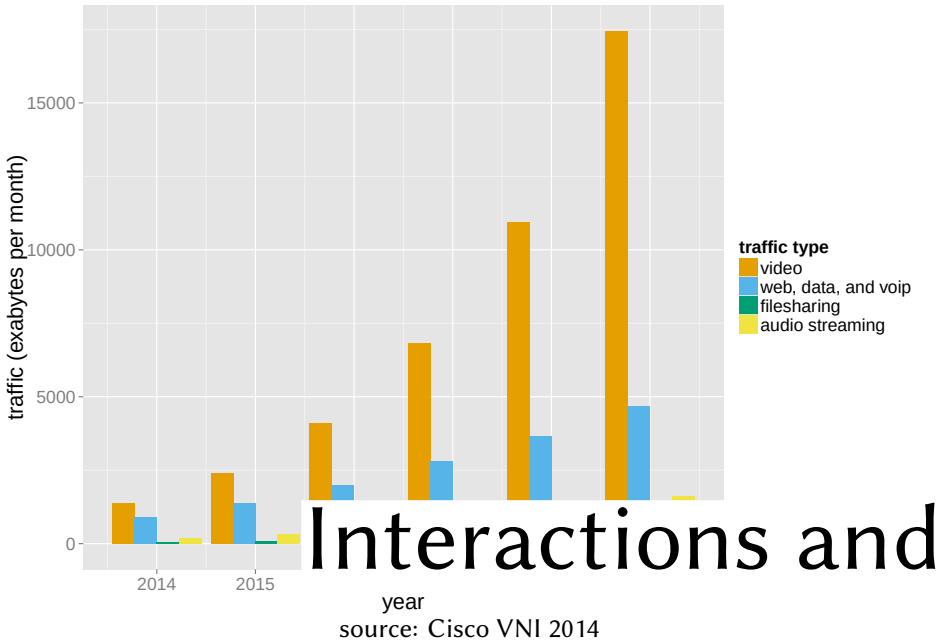
NETFLIX



Motivation

QoS and QoE of TCP Streaming in Mobile Networks?



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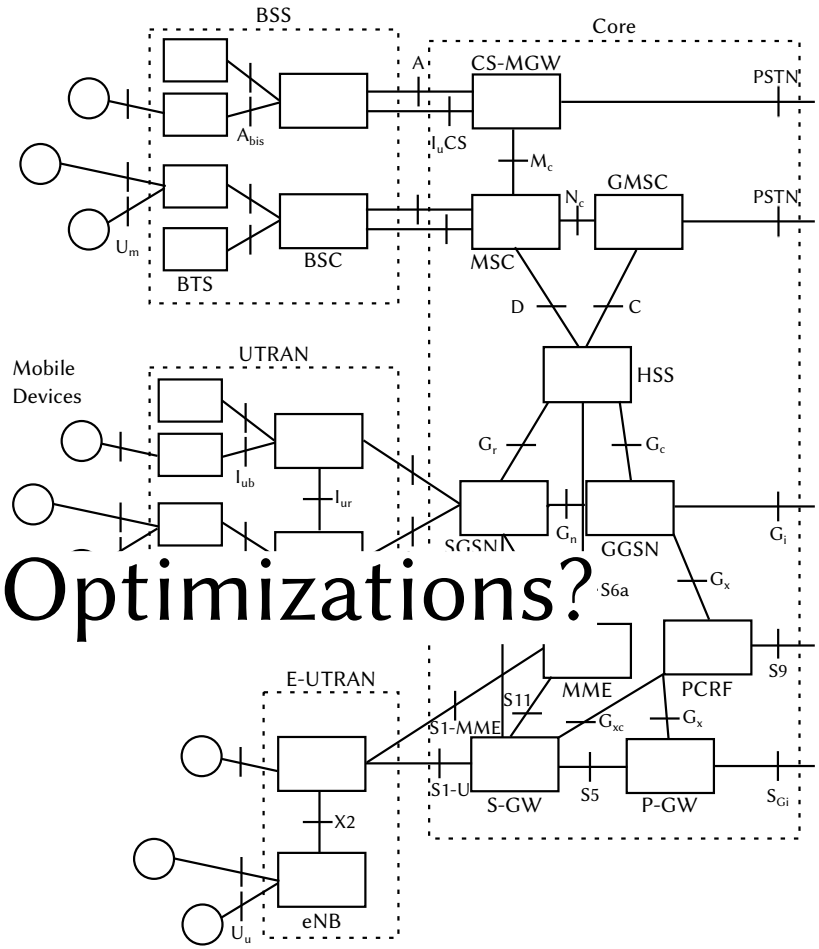


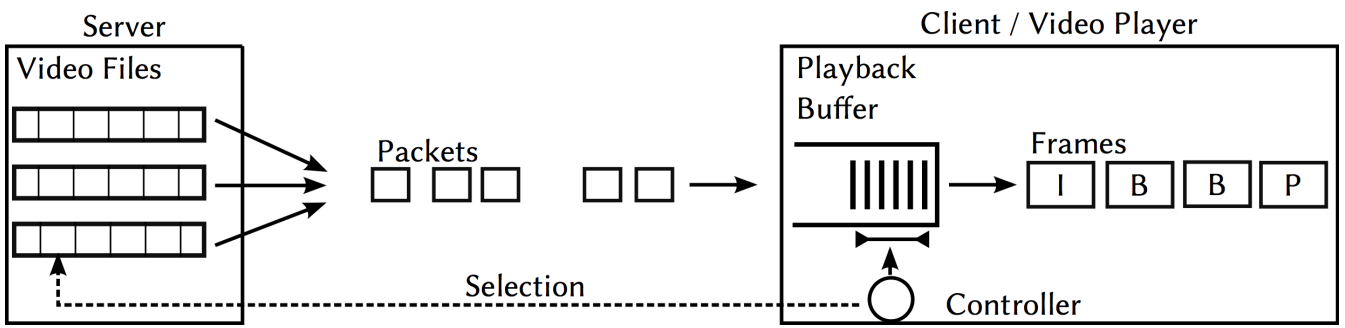
Interactions and Optimizations?

YouTube

NETFLIX

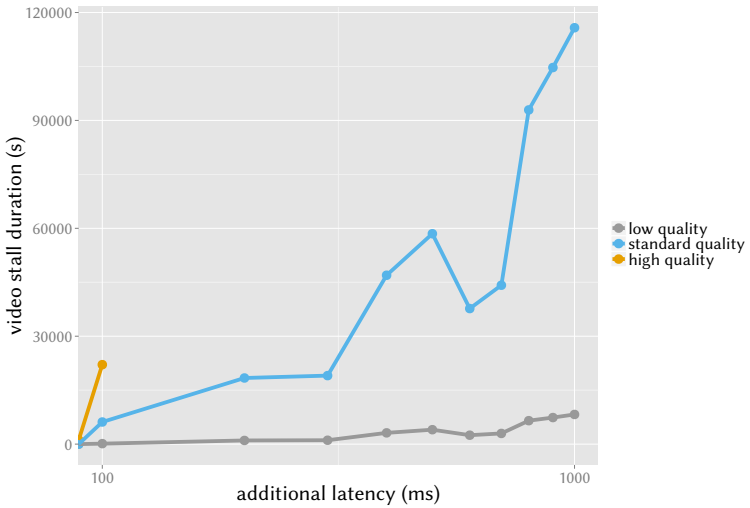
- Control plane is communicated explicitly by the network entities and baseband
- All user traffic is encapsulated into tunnels
- Mobility support, signaling and anchors in the net
- Other, off-path entities hold and communicate more state (e.g. MME, HSS, PCRF)

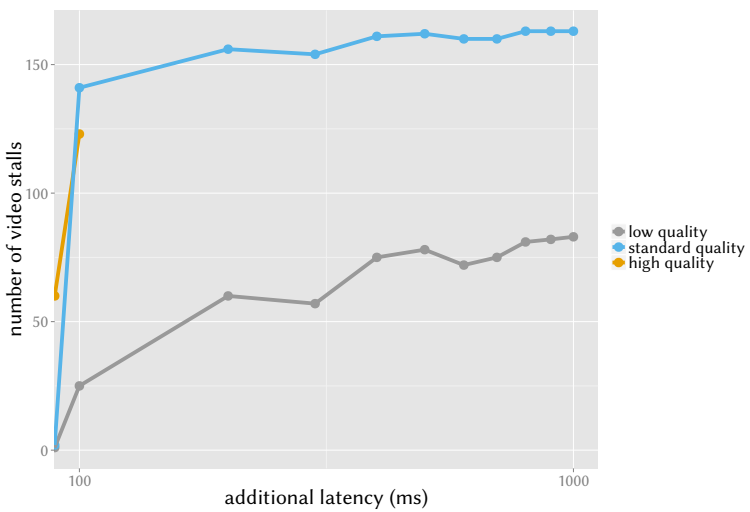
- Fixed protocol stack (TCP+HTTP) distinguished only through buffering and quality level adaptation strategies
- TCP and TCP-streaming not designed with mobility in mind
- Impact of mobile nets and signaling on QoS and QoE?



Interaction Scenario #1

Segment Retrieval and High Latency



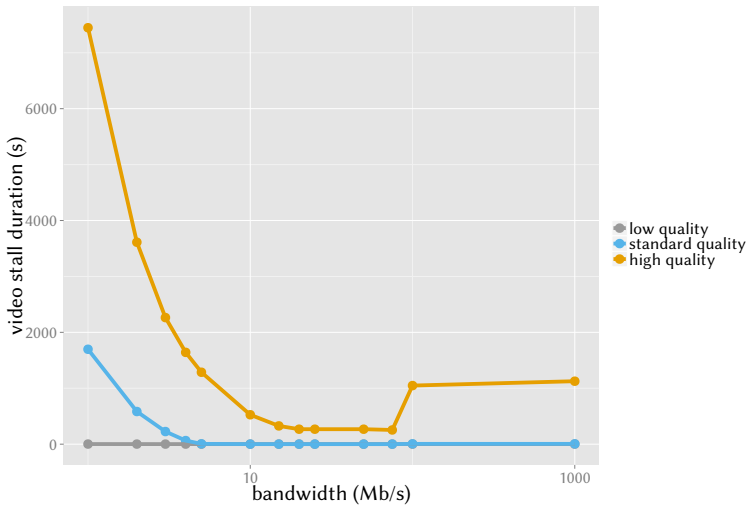


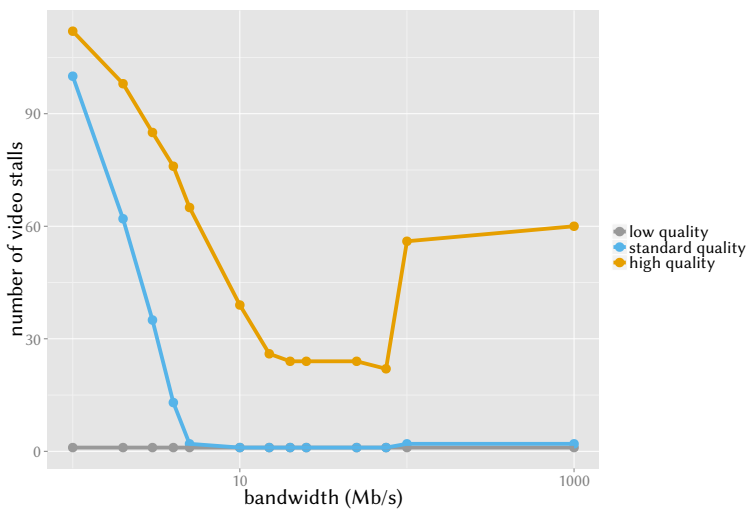
- HQ video did not complete in time at higher latencies
- Demonstrates the effects of a bad streaming strategy:
  - New segments were only requested when the previous one had arrived
  - → Stop-and-wait behavior, overly sensitive to latency
  - In this case a simple change helps: Request new segments ahead of time to ensure back-to-back transmission
- High latency (and variation) is a common feature of mobile nets!

→ Need for testing to find other unexpected interactions!

Interaction Scenario #2

High Bandwidths and Buffering



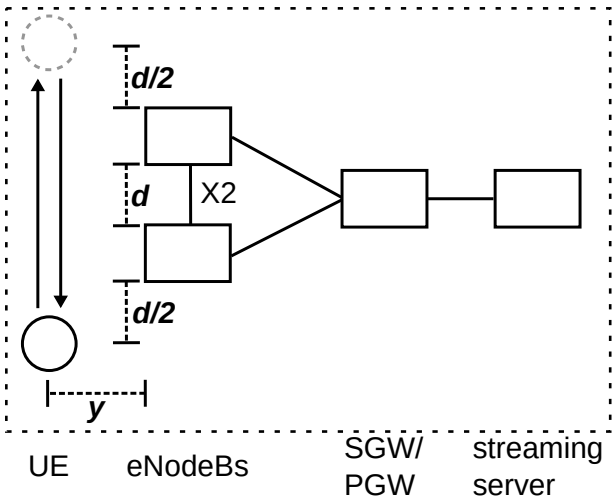


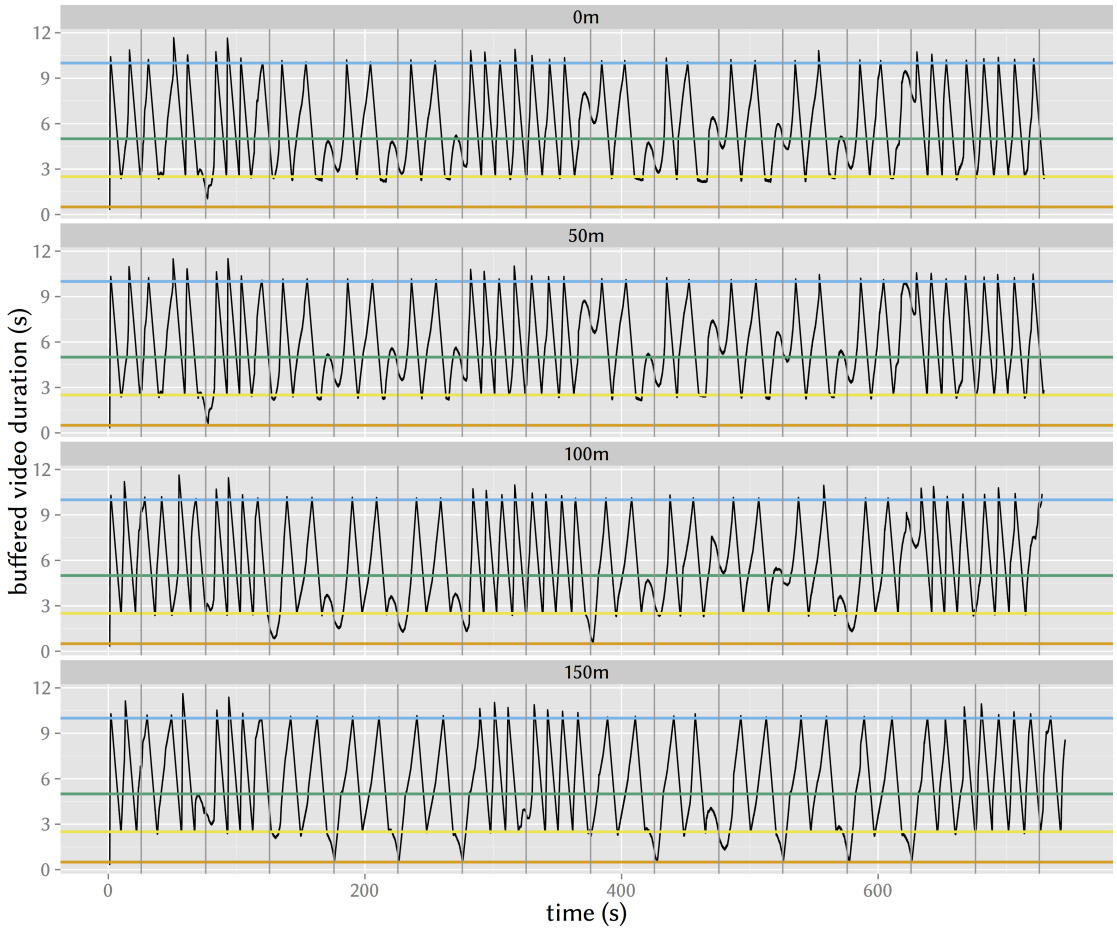
- Stalls at higher bandwidths
- Suspiciously appears above the radio capacity ($\approx 80\ \frac{\text{Mbit}}{\text{s}}$)
- Possible explanations:
  - Excessive buffering in the net
  - Negative interaction of TCP and HARQ
  - Packet buffers fill, nothing will be dropped, TCP won't back down

  → Bufferbloat
  - Further investigation needed

Interaction Scenario #3

Device Mobility





→ Low buffer and stall events at further distances

- Streaming players need to be aware of drops in connectivity

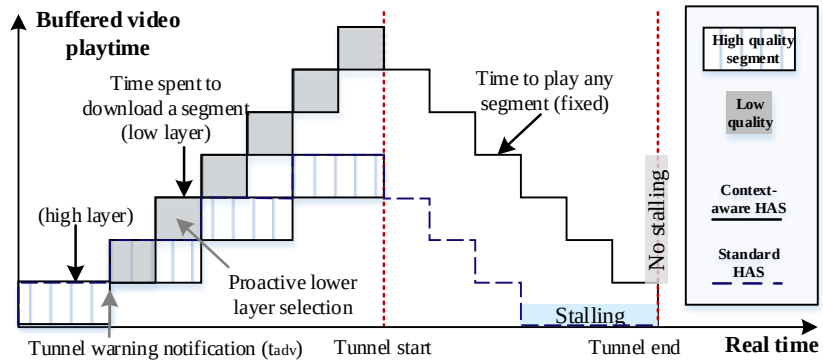
Mobile Streaming and Context Factors/Monitoring

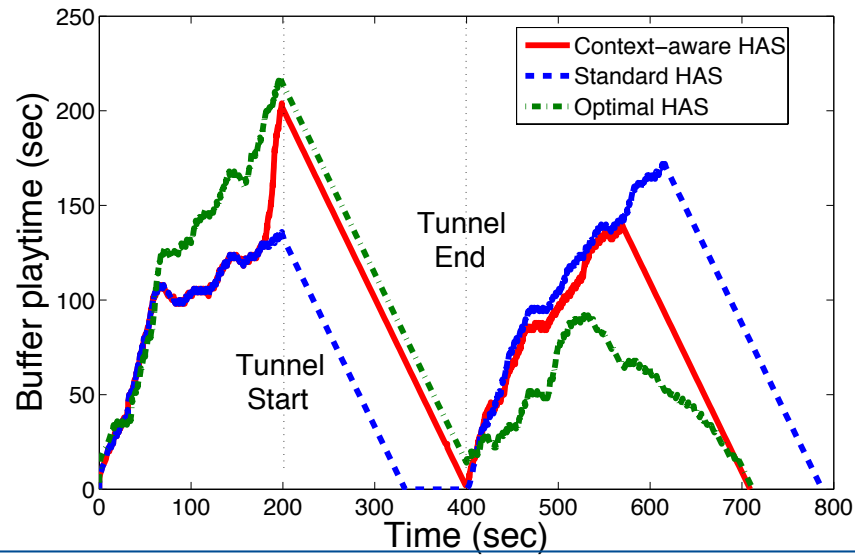
- Extend the handover blackout to other events of variable lengths, e.g.:
  - Horizontal and vertical handovers
  - Areas with low radio coverage and insufficient throughput
  - (Car) traffic tunnels
  - Subway, metro traffic and tunnels, etc.
- Does network-assisted mobility help or hinder in such scenarios for streaming?
- Could **application-layer** mobility in conjunction with **context-monitoring** even provide similar or better results?
  - Mobility as context factor
  - Requires good predictors, e.g. by deriving information from past patterns
  - Provide an interface with every available context information to applications so that they can conduct appropriate QoE optimizations themselves
  - Passing information up the protocol stack, no network assistance

"Tunnel" Scenario

Context-Based Solution

- Use context and context predictors in adaptive streaming strategies
- Compute optimal context-based buffering and quality level selection strategy to ensure best QoE
  - Prevent stalling, but still do not excessively buffer ahead
  - Optimize segment quality level while still avoiding stalling
- Knowledge of upcoming event through context, advance time is critical

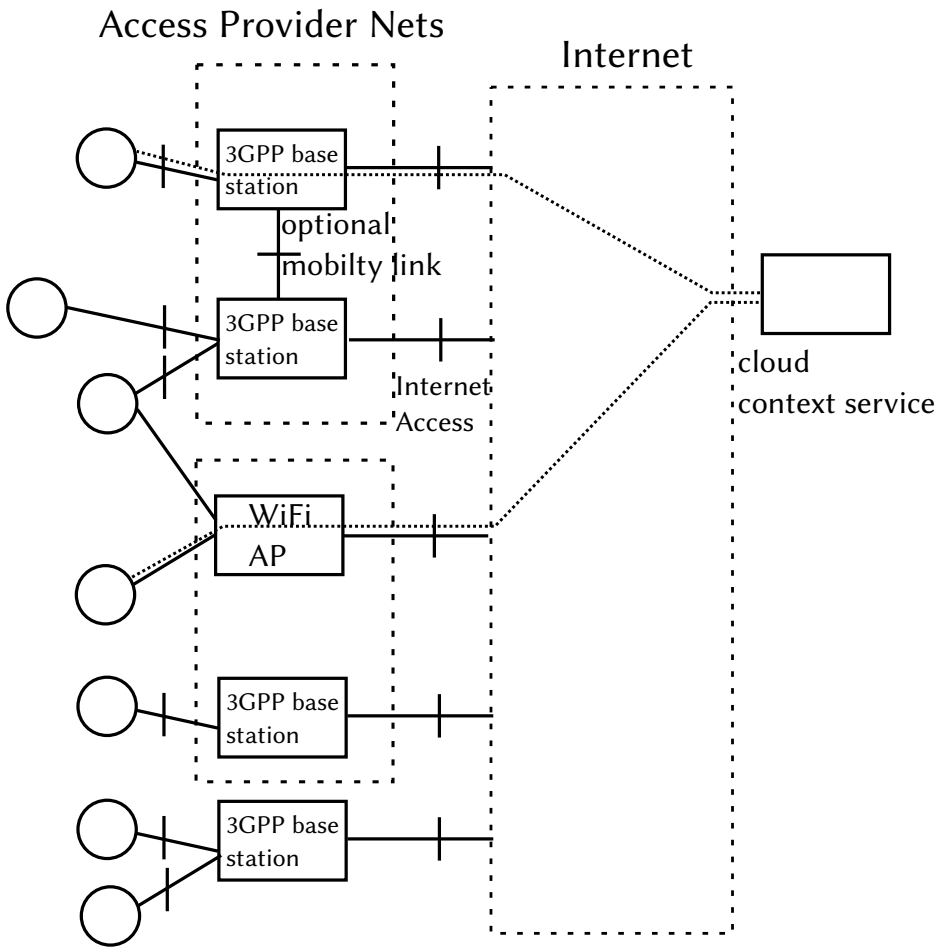




- "Tunnel" scenario easily transferable from TCP video streaming to other applications
- Is mobility support really necessary for many applications today?
  - Web/HTTP traffic consists of many small objects, could easily completely forgo network-assisted mobility and just reorder/schedule around
  - VoIP and other real-time communication:
    More tricky, but, e.g. adapt existing over-the-top mobility solutions (SIP proxy)

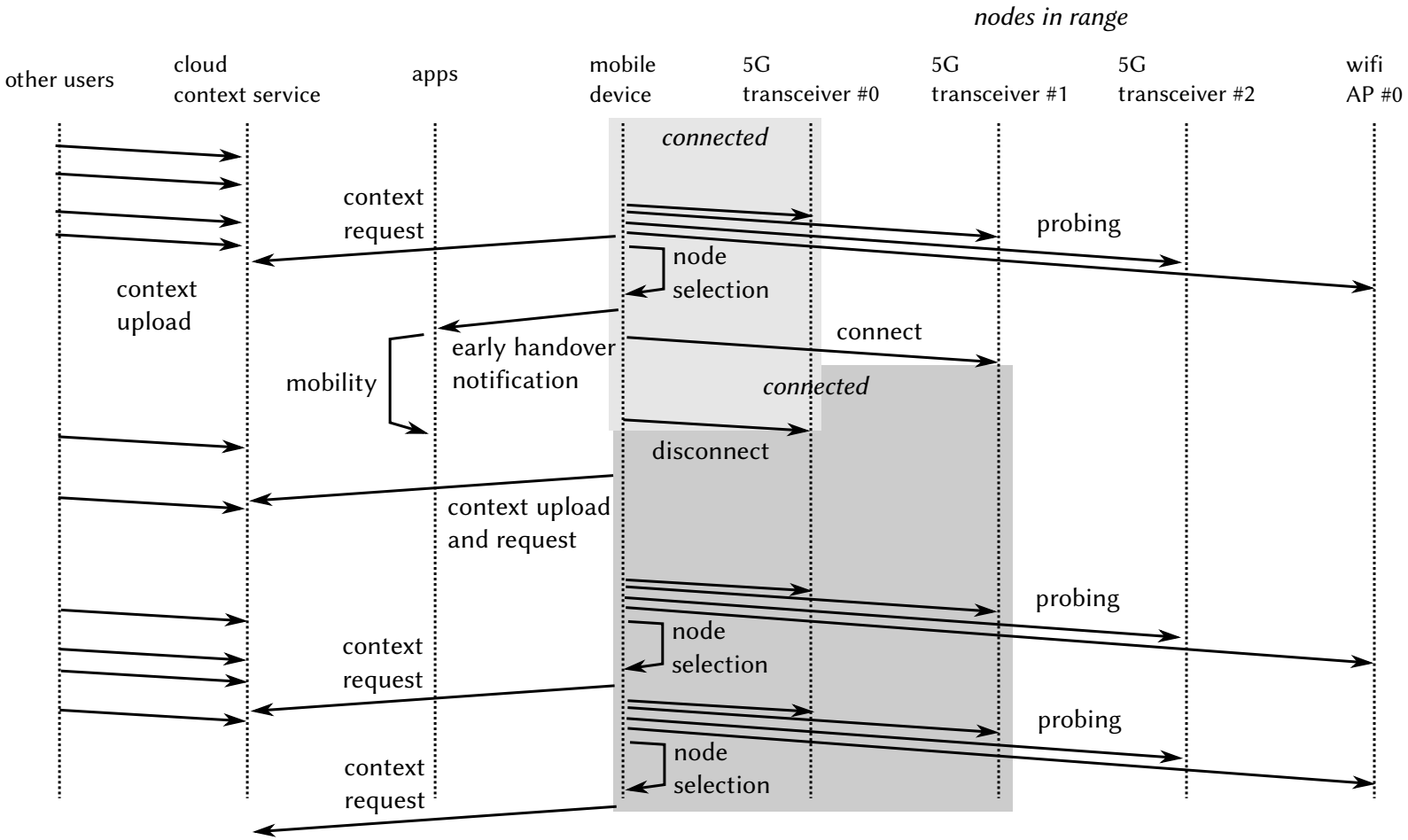
→ Streamlining for future mobile architectures

- Remove global mobility support
- Provide a trimmed down architecture with only the essentials
- Increase scalability/performance by removing most control plane procedures, just provide a bare-minimum bit-pipe access
- Solve remaining issues and provide missing features over-the-top


Access Provider Nets
Internet
3GPP base station
optional mobilty link
3GPP base station
Internet Access
cloud context service
WiFi AP
3GPP base station
3GPP base station

Streamlining for Future Mobile Architectures

Application-layer Mobility Example for Handover



Summary

- Much potential for (negative) interactions and feedback loops between mobile signaling and (amongst others) streaming
  - E.g. stalling events during handover
  - Requires good understanding and deep investigation
- Applications could orchestrate their own mobility using context monitoring
- Mobility scenarios and mobility prediction merit further investigation

- **Goal:** Reduce network complexity, increase scalability by moving exiting network features and relinquish control to the application layer

Thanks!

E. Liotou, T. Hoßfeld, C. Moldovan, F. Metzger, D. Tsolkas, and N. Passas.
"Enriching HTTP Adaptive Streaming with Context Awareness: A Tunnel Case Study".
In: *ICC* (2016). Under review, submitted in October 2015.

F. Metzger, E. Liotou, C. Moldovan, and T. Hoßfeld.
"TCP Video Streaming and Mobile Networks: Not A Love Story, But Better With Context". In: *Computer Networks Special Issue on Big Data* (2016). Under review, submitted in October 2015.

F. Metzger. "Evaluating Reliable Streaming in Mobile Networks". PhD thesis. Apr. 2015.

F. Metzger, C. Steindl, and T. Hoßfeld. "A Simulation Framework for Evaluating the QoS and QoE of TCP-based Streaming in an LTE Network".
In: *Teletraffic Congress (ITC 27), 2015 27th International*. Sept. 2015, pp. 168–176.

Questions!