



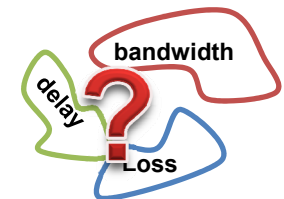
Quality of experience optimized scheduling of YouTube video streaming

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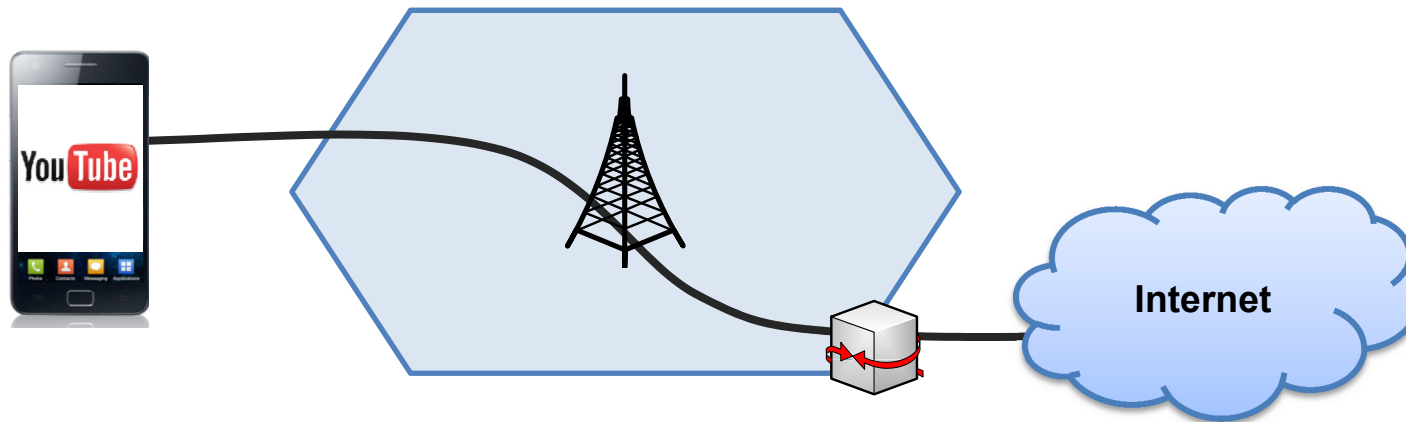
University of Würzburg

Trend towards Quality of Experience

- ▶ Keep customers happy, attract new customers
- ➔ **Improving subjective quality perception of end-users**
- ▶ Shift from Quality of Service (QoS) to Quality of Experience (QoE)
 - QoS: packet loss, delay, jitter, ...
 - QoE: subjective experience/satisfaction of users of a service
- ▶ *Example:* web user interested in short page load times
VoIP user interested in speech quality
video user interested in video quality and smooth
payout w/o interruptions
- ▶ What are key **QoE influence factors** and appropriate **QoE models**?
- ▶ How to control QoE? How to **optimize QoE**?



QoE optimized scheduling of YouTube



- 1) How to model YouTube Quality of Experience?
- 2) What are requirements for optimal video transmission with respect to QoE?
- 3) Utilizing buffered YouTube playtime for QoE-oriented scheduling in OFDMA Networks.

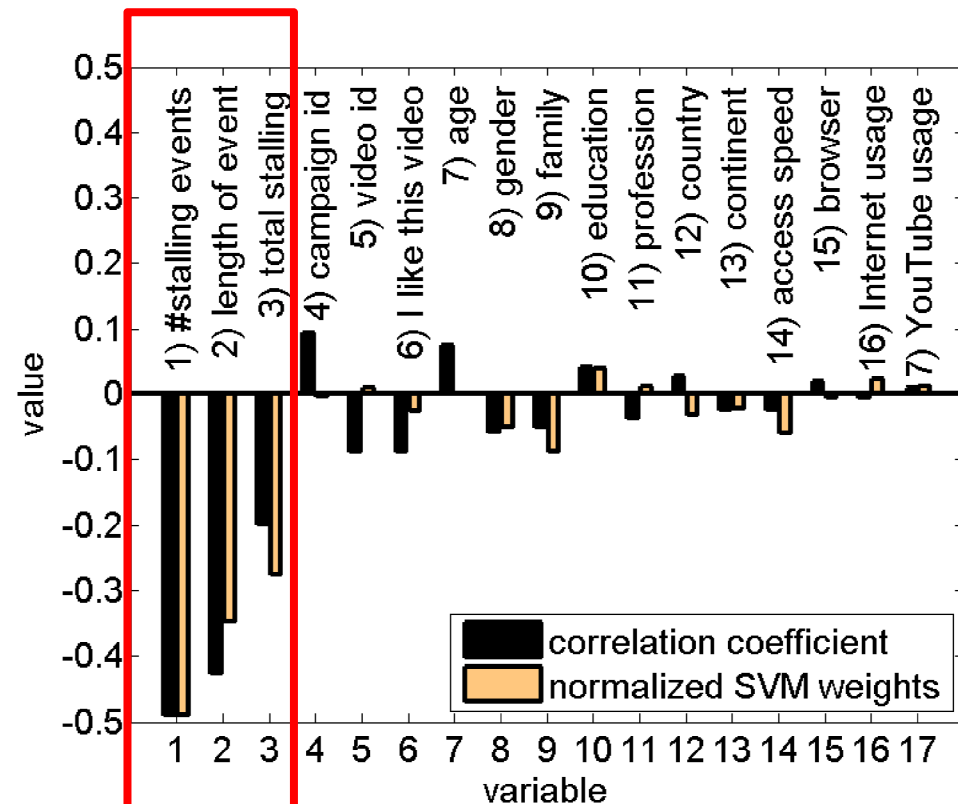
QoE issue: waiting, waiting, waiting...

You **Tube**



Key influence factors on YouTube QoE

- ▶ Derive key influence factors on QoE
- ▶ Interesting: no correlation of QoE and
 - video characteristics like resolution, type of content, ratio of audio/video, etc.
 - users preference, whether they liked video
 - demographical features

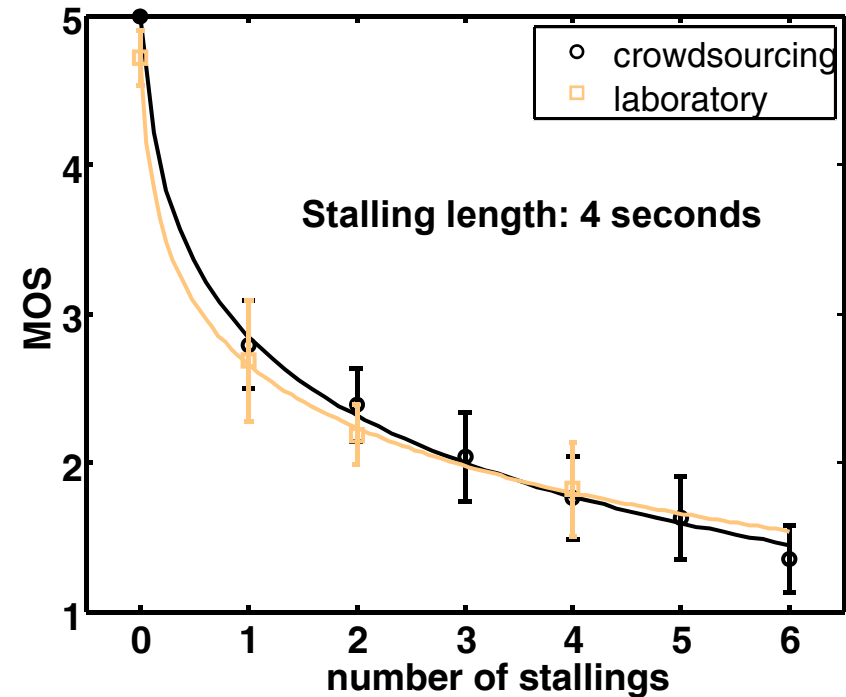


Hoßfeld, Seufert, Hirth, Zinner, Tran-Gia, Schatz
Quantification of YouTube QoE via Crowdsourcing

- ▶ **Stalling frequency and stalling duration determine the user perceived quality**

YouTube QoE model

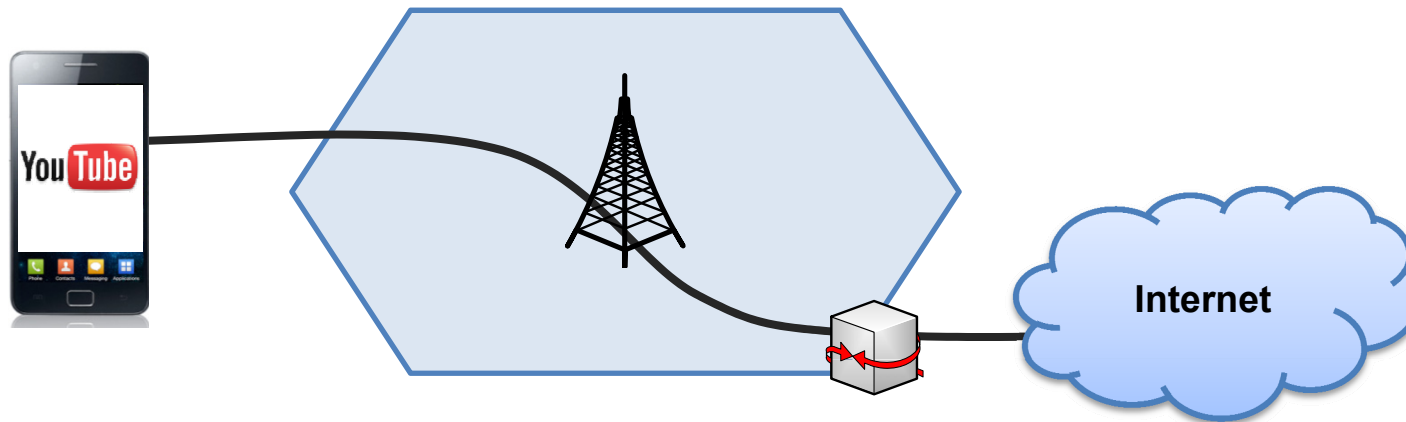
- ▶ Lab studies with UniWue's CrowdSourcing and at FTW's i:Lab
- ▶ Mapping functions between MOS and stalling pattern, i.e. event length and the number of stalling events, are provided



Hoßfeld, Seufert, Hirth, Zinner, Tran-Gia, Schatz
Quantification of YouTube QoE via Crowd sourcing

➔ **Users only accept almost no stalling or only short stalling**

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Video bit rate as information

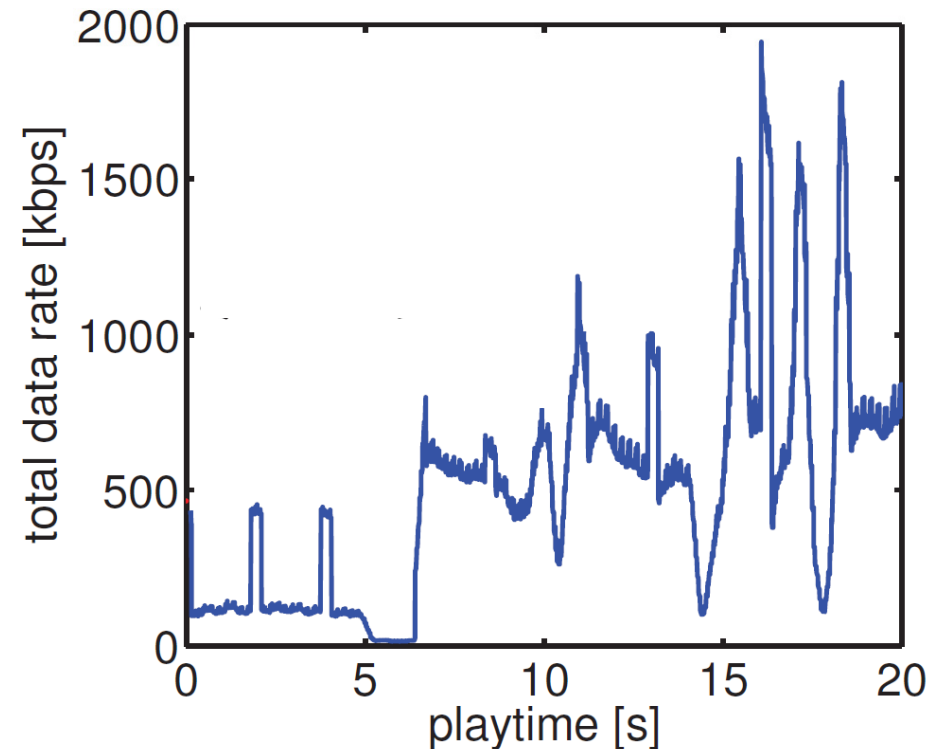
- ▶ Stalling occurs, if video bit rate $V >$ network bandwidth B
 - ▶ No stalling although $V > B$
→ reason: initially buffered video data (and actual video duration)
 - ▶ Stalling sometimes occurs, if $V < B$ → reason is variability of video codec
- **Video bit rate as only information is not sufficient to avoid stalling**

Scene changes have to be considered!

▶ Scene changes may lead to significant changes of video bitrate

▶ Options for improved approximation

- Statistical description of frame sizes per scene
- Complex frame size models taking into account correlations across scenes



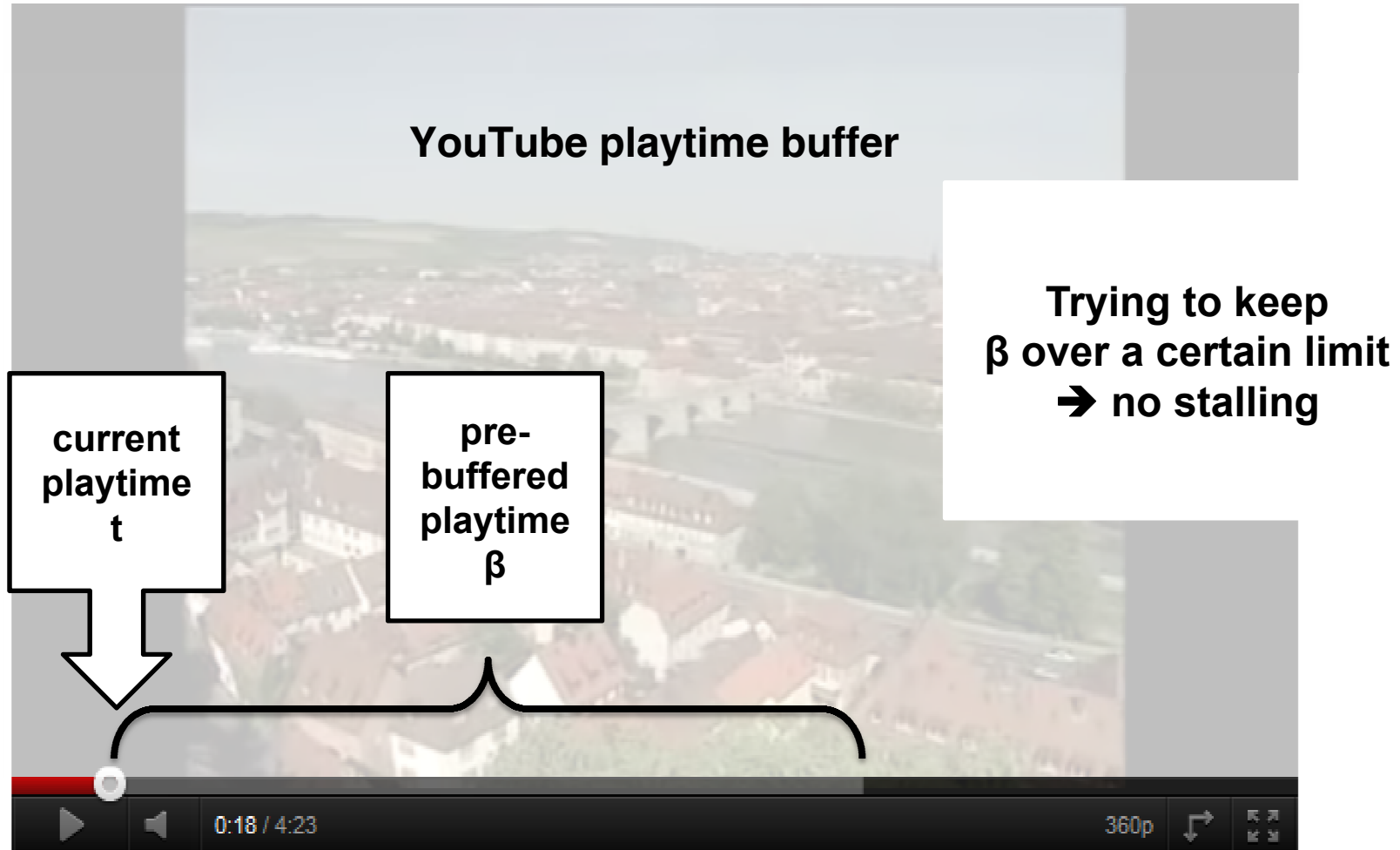
▶ But: YouTube videos are short!

➔ **Specify sizes of all frames in meta information of video file**

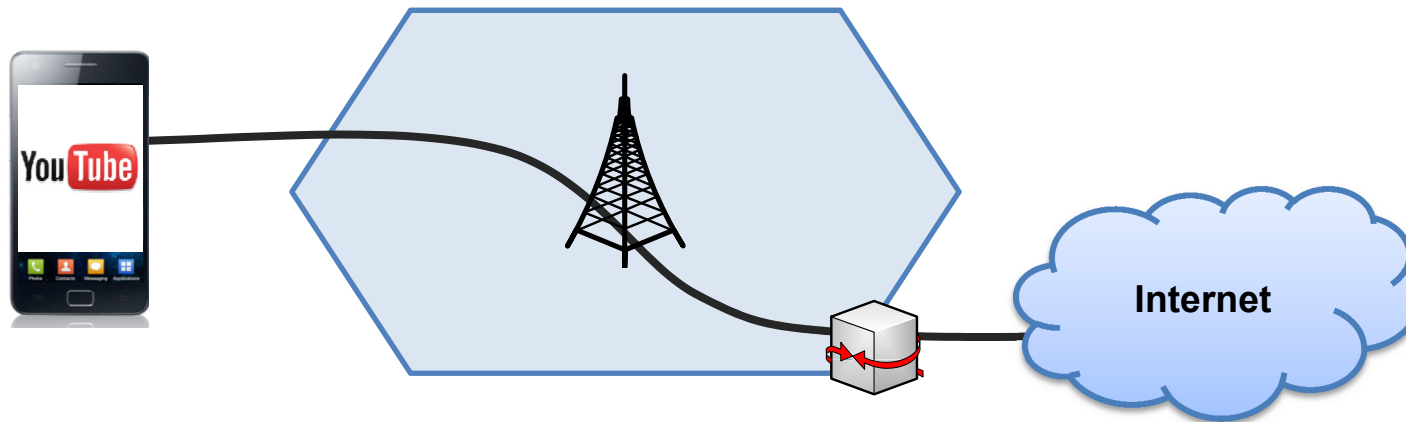
➔ **Statistical approximation of video characteristics**

Buffered playtime as information

- ▶ Feedback application information: buffered playtime of the player

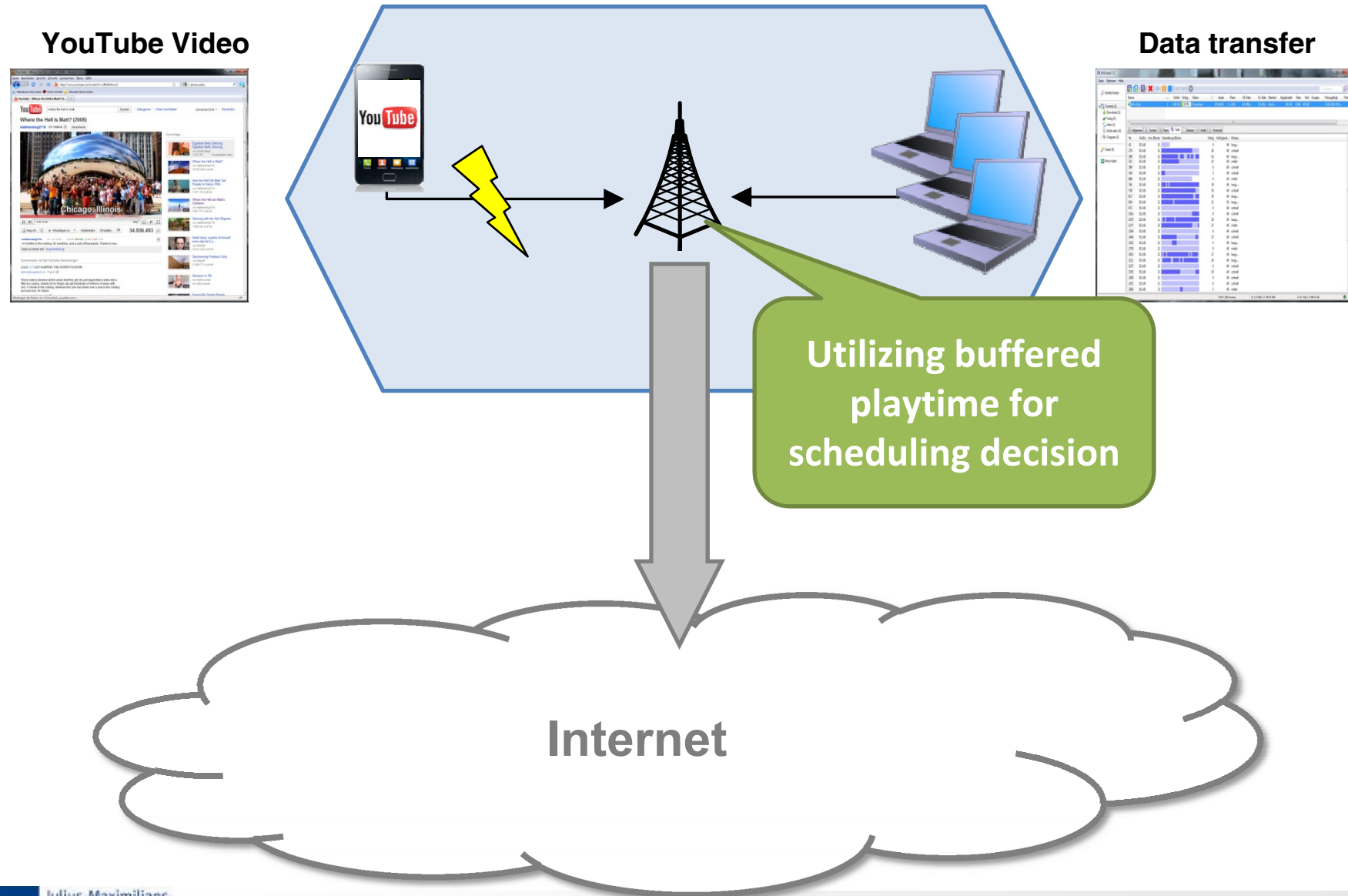


QoE optimized scheduling of YouTube

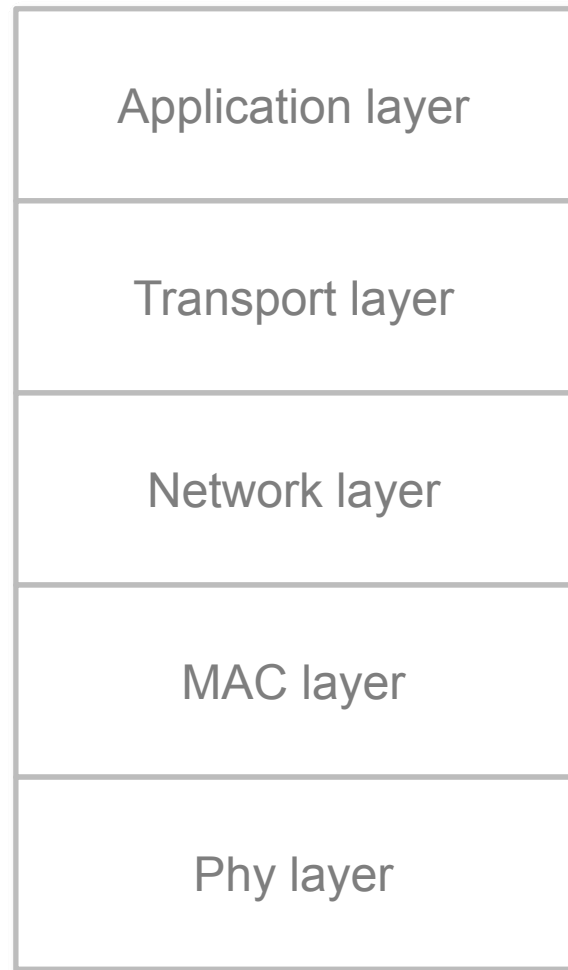


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Scenario: Improving YouTube download quality



Simulation



Client		Server
YouTube Flash Player		YouTube Download Server



- TCP (TCP New Reno including slow start and congestion control)

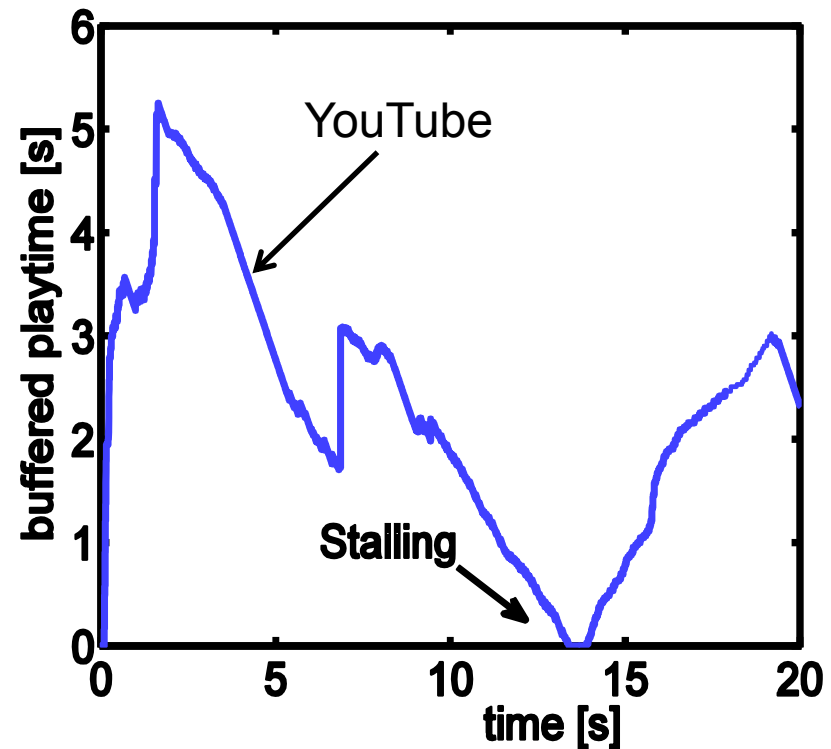
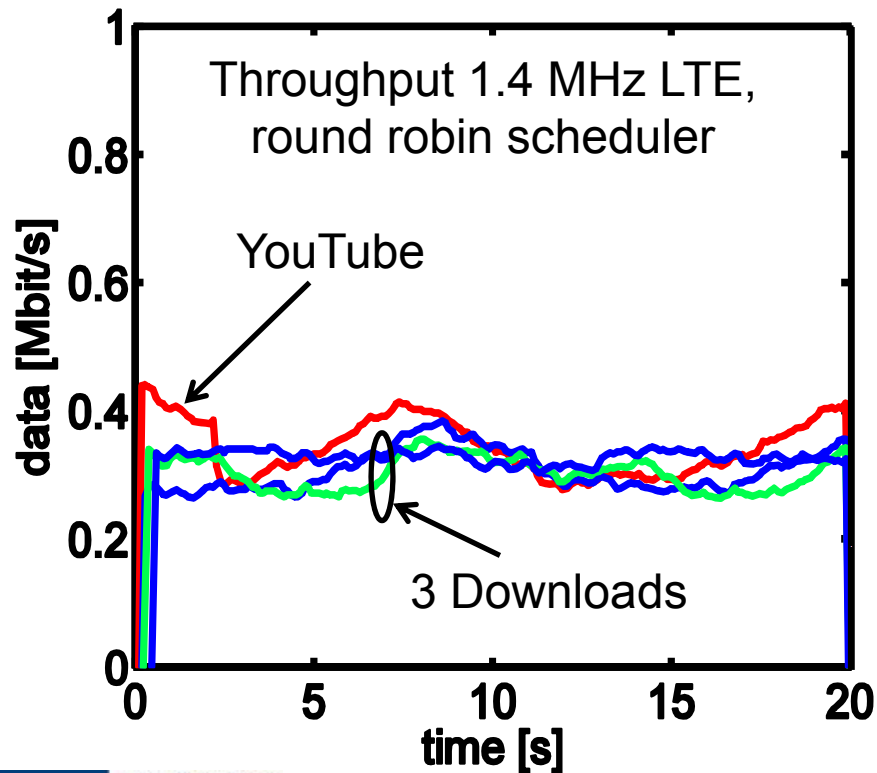
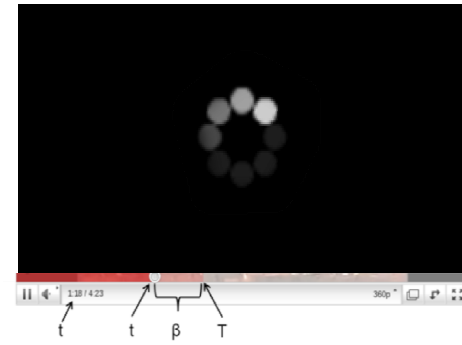
- Simple fixed MAC layer packet fragmentation,
- Simple packet retransmissions

- LTE Downlink Link Level Simulator, Vienna University of Technology, LTE Release 8
- Error-free signalling and control channels

Application unaware scheduling

► Case 1 – Application *unaware*

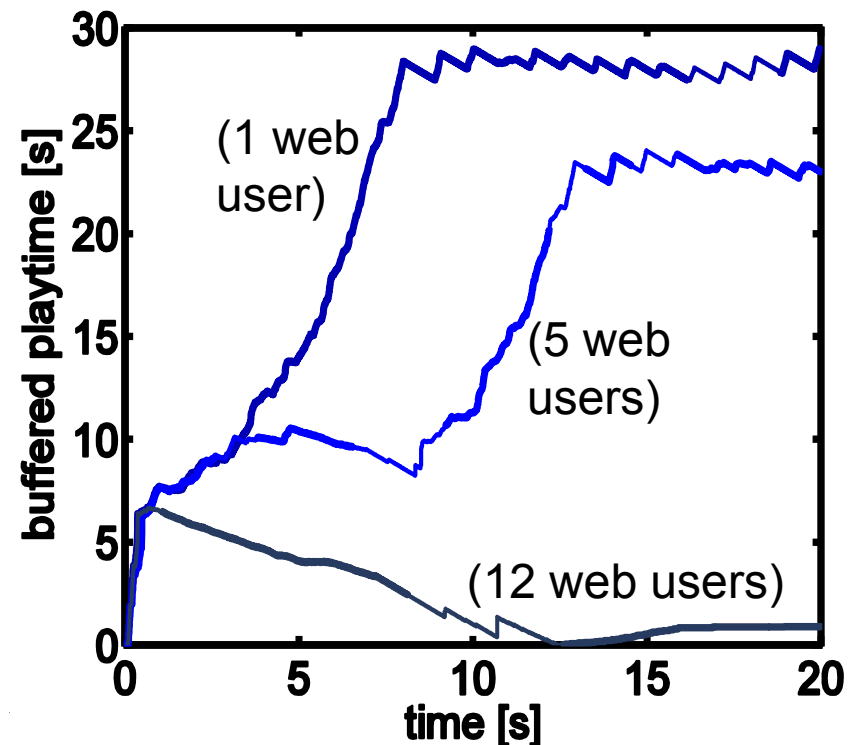
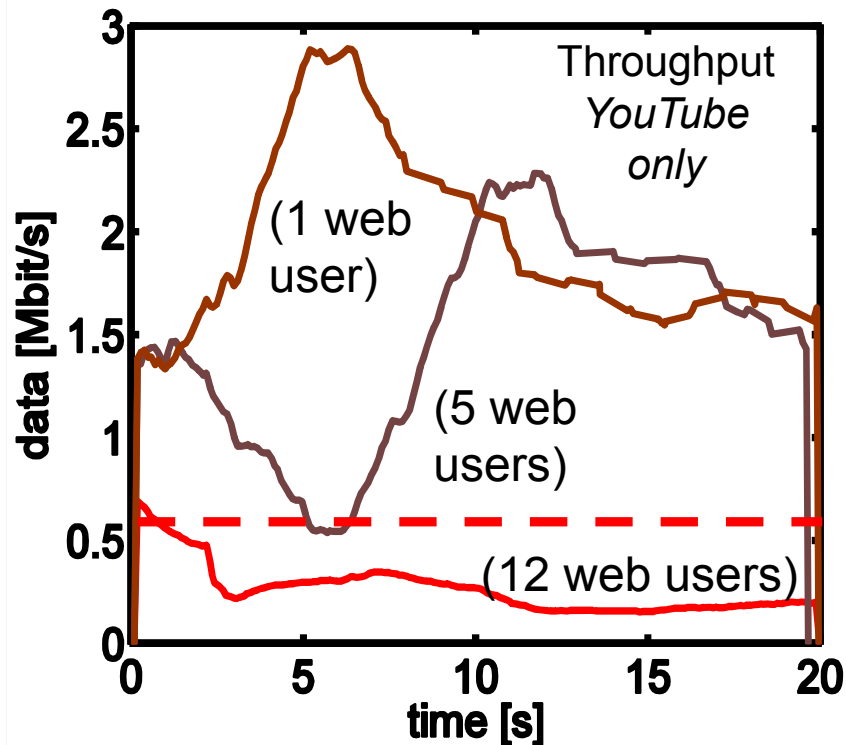
- Fair share with respect to network throughput
- Download performance: good 
- YouTube quality: bad 





Application unaware scheduling

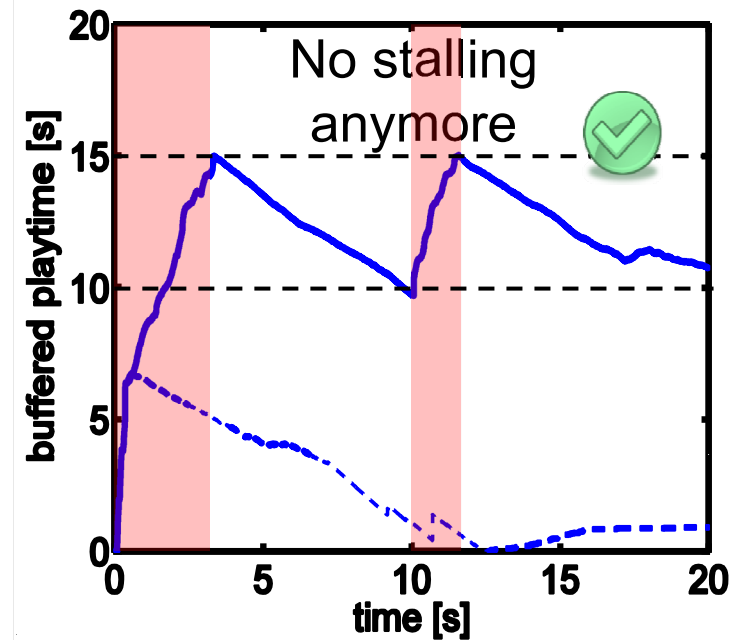
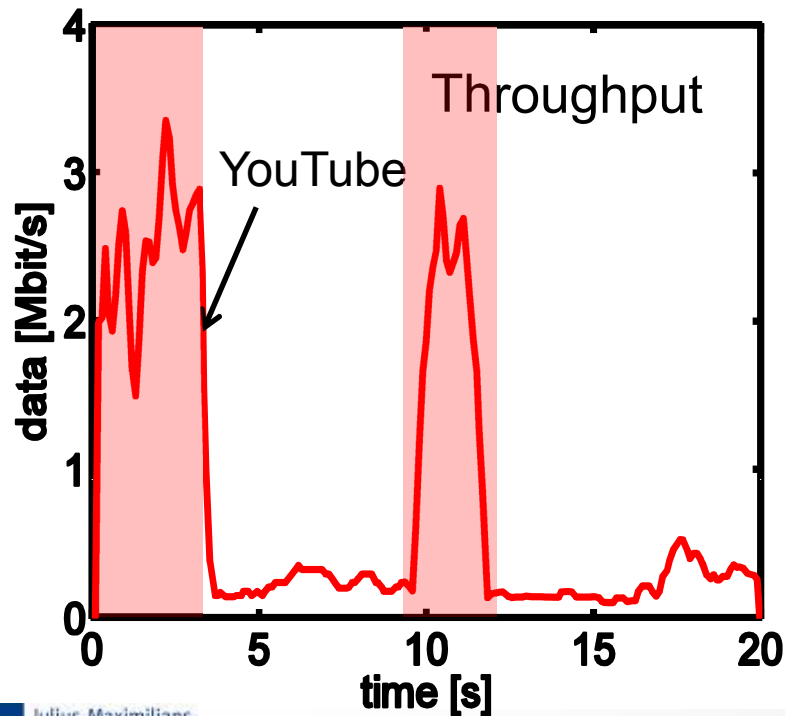
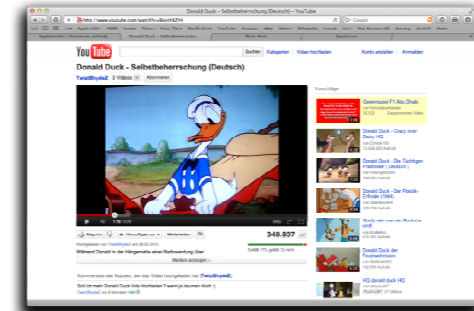
► Case 2 – Application *unaware*

- YouTube + 1, 5, and 12 web users
- Statistical web user model: one main object, # embedded objects
- YouTube quality good for 1-5 users
- YouTube quality bad for 12 users



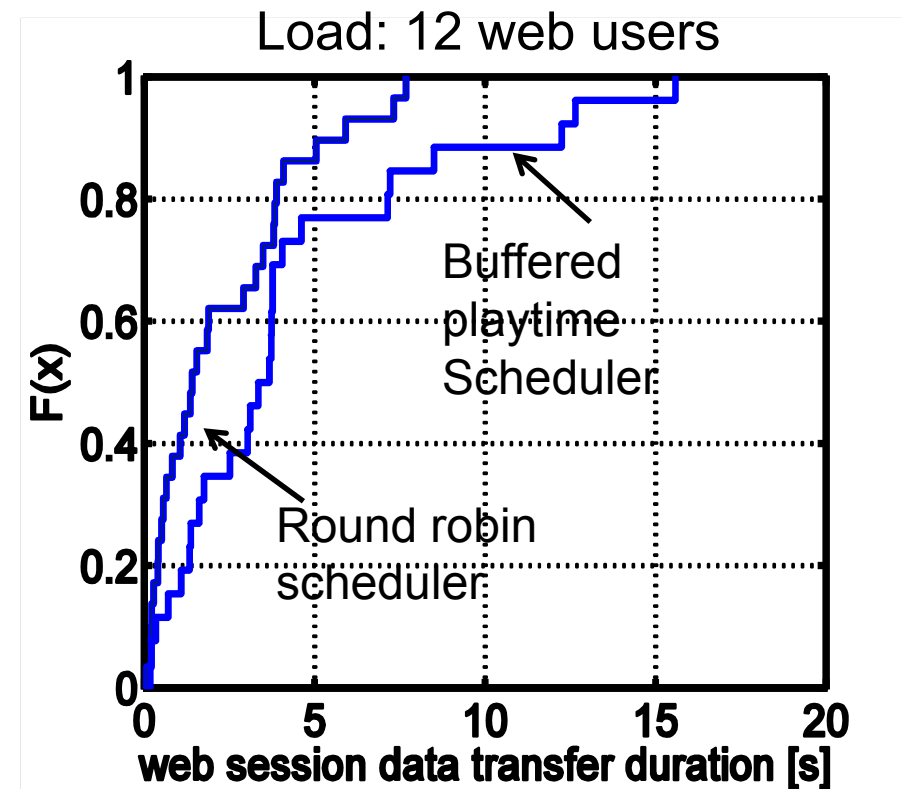
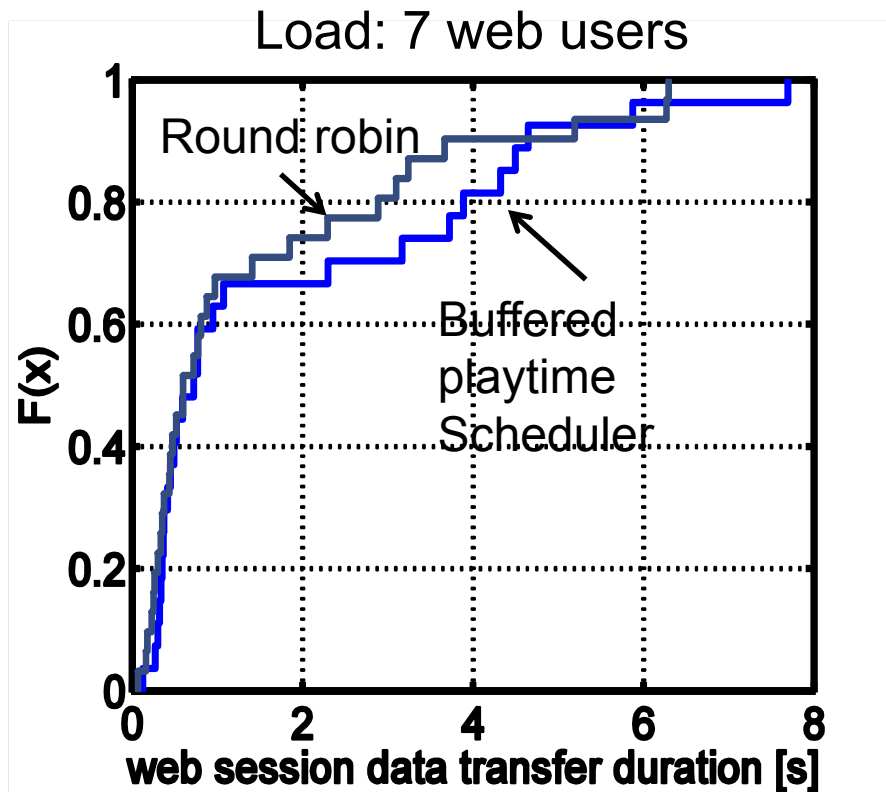
Utilizing YouTube playtime buffer

- ▶ Case 3 – Application aware
 - YouTube + 12 web users
 - YouTube is prioritized in case of low YouTube buffer
 - E.g. buffered playtime $\beta < 15$ s
 - YouTube is playing fine 
 - Download performance only marginally influenced 



Intelligent access control & schedules

- ▶ Future Work: Impact on other users
- ▶ *Here: impact on web users*
- ▶ Application aware: Utilizing YouTube playtime buffer



References

▶ Journal Articles

Tobias Hoßfeld, Florian Liers, Raimund Schatz, Barbara Staehle, Dirk Staehle, Thomas Volkert, Florian Wamser
Quality of Experience Management for YouTube: Clouds, FoG and the AquareYoum.
PIK - Praxis der Informationverarbeitung und -kommunikation (PIK), 2012.

Barbara Staehle, Florian Wamser, Matthias Hirth, David Stezenbach, Dirk Staehle
AquareYoum: Application and Quality of Experience-Aware Resource Management for YouTube in Wireless Mesh Networks.
PIK - Praxis der Informationsverarbeitung und Kommunikation, 2011

▶ Conference Articles

Tobias Hoßfeld, Sebastian Egger, Raimund Schatz, Markus Fiedler, Kathrin Masuch, Charlott Lorentzen
Initial Delay vs. Interruptions: Between the Devil and the Deep Blue Sea.
QoMEX 2012, Yarra Valley, Australia, July 2012.

Tobias Hoßfeld, Raimund Schatz, Michael Seufert, Matthias Hirth, Thomas Zinner, Phuoc Tran-Gia
Quantification of YouTube QoE via Crowdsourcing.
IEEE International Workshop on Multimedia Quality of Experience - Modeling, Evaluation, and Directions (MQoE 2011), Dana Point, CA, USA, December 2011

Barbara Staehle, Matthias Hirth, Rastin Pries, Florian Wamser, Dirk Staehle
Aquarema in Action: Improving the YouTube QoE in Wireless Mesh Networks.
Baltic Congress on Future Internet Communications (BCFIC), Riga, Latvia, February 2011

Florian Wamser, Barbara Staehle, Rastin Pries, David Stezenbach, Sebastian Deschner, Dirk Staehle
YouTube QoE-Aware Gateway Selection in Future Wireless Networks.
EuroView2010, Würzburg, Germany, August 2010.

Barbara Staehle, Matthias Hirth, Rastin Pries, Florian Wamser, Dirk Staehle
YoMo: A YouTube Application Comfort Monitoring Tool.
New Dimensions in the Assessment and Support of Quality of Experience for Multimedia Applications, Tampere, Finland, June 2010

▶ Research Report

Tobias Hoßfeld, Thomas Zinner, Raimund Schatz, Michael Seufert, Phuoc Tran-Gia
Transport Protocol Influences on YouTube QoE.
Technical Report No. 482, July 2011.