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Faculty of Computer Science
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Modeling and Evaluation of the Influence of Networks on HTTP Video Streaming

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Outline

- HTTP Media Streaming in Comparison
- Mobile Network Architecture Differences
- Playback Modeling and Strategies
- Measurement Testbed
- Testbed Evaluations
- Conclusion
- Work in Progress

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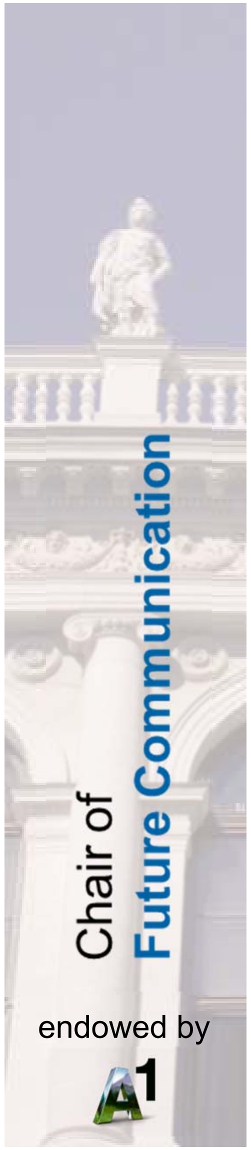
Streaming and HTTP content grows



TCP based streaming is a large factor in traffic mix
(fixed access peak ratio at ~54%)

	Upstream		Downstream		Aggregate	
Rank	Application	Share	Application	Share	Application	Share
1	Facebook	30.85%	HTTP	27.46%	HTTP	27.31%
2	HTTP	26.24%	YouTube	19.99%	Facebook	19.29%
3	SSL	6.05%	Facebook	17.62%	YouTube	18.23%
4	YouTube	6.01%	Windows Update	5.17%	Windows Update	4.70%
5	BitTorrent	3.83%	Android Market	4.09%	Android Market	3.75%
6	Ares	3.45%	Flash Video	2.96%	Flash Video	2.66%
7	Oovoo	2.57%	SSL	1.97%	SSL	2.48%
8	Skype	1.81%	RTSP	1.89%	RTSP	1.67%
9	Gmail	1.49%	Shockwave Flash	1.75%	Shockwave Flash	1.63%
10	Windows Update	1.48%	MPEG	1.67%	MPEG	1.53%
	Top 10	**83.77%**	**Top 10**	**84.57%**	**Top 10**	**83.26%**

SOURCE: SANDVINE NETWORK DEMOGRAPHICS

Top Peak Period Applications by Bytes - North America, **Mobile Access**;
Source: Global Internet Phenomena Report 2011

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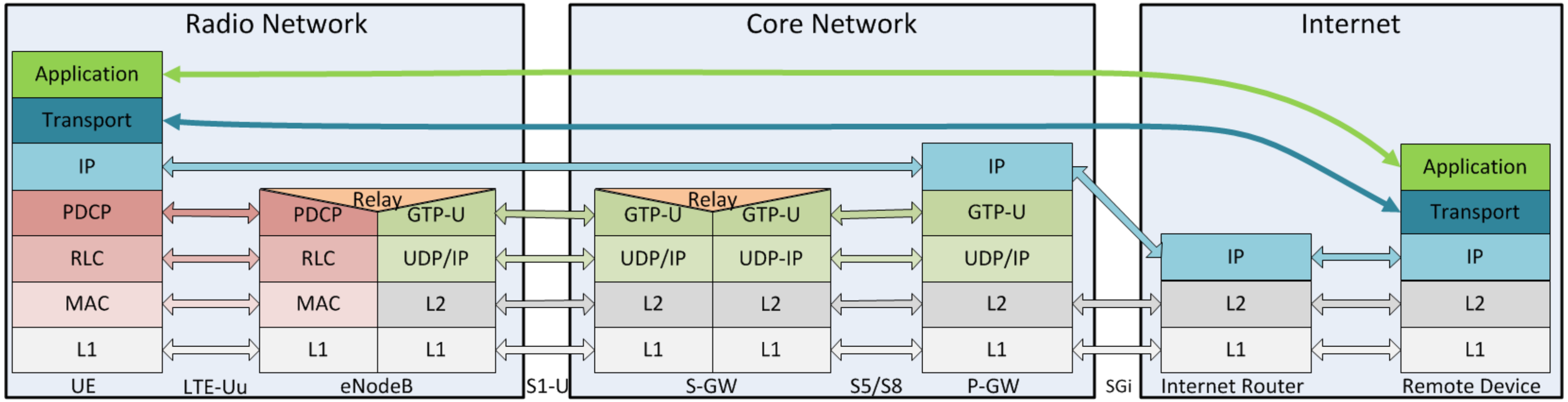
TCP/HTTP Media Streaming

	RTP	Progressive/simple HTTP	Adaptive HTTP
Appearance	Classical „textbook“ approach & wisdoms	Reality today, heavily used	
Transport Protocol	UDP	TCP (one to many)	
Transport Level Flow Control & Congestion Control	Explicit by server-application	Implicit (TCP)	
Control Information Exchange	Explicit (RTCP)	Implicit (TCP)	
Application Layer Flow Control	Server-side	Server-side pacing possible	Server and client-side pacing possible
Playback Control	Server-Side, pushed	Client-Side, pulled	

- TCP/HTTP originally not intended for video streaming
- Network layers influence new streaming approaches differently
- Qualitative evaluations
  - How and what to measure and compare to other protocols?
  - Which metrics to use?

Networks and Mobile Networks

- 3GPP architectures and protocols are unlike wired access networks
  - Deep mobile network protocol stacks
  - Tunneling concepts
  - Separate user and control plane
  - Interplay and time scales influencing application layer
    - Streaming that works for wired access might not in mobile nets



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Modeling Playback through Buffering

- Why Buffering?
  - Decoder would need only milliseconds of data at once
    - Network jitter and VBR cause variations in the received data rate
  - Playback stalls when buffer runs out of data → large buffer!
  - Playback should start as soon as possible → small buffer!

- Model playback as a simple buffer fill level equation:

$$buffer(t) = \sum_{0}^{t} data_{rcvd} - \sum_{0}^{t} data_{played}$$

- Buffer draining only way to influence the process from the client side
  - Initial playback start time and restart time after empty buffer

➔ Governing factors in any streaming playback strategy

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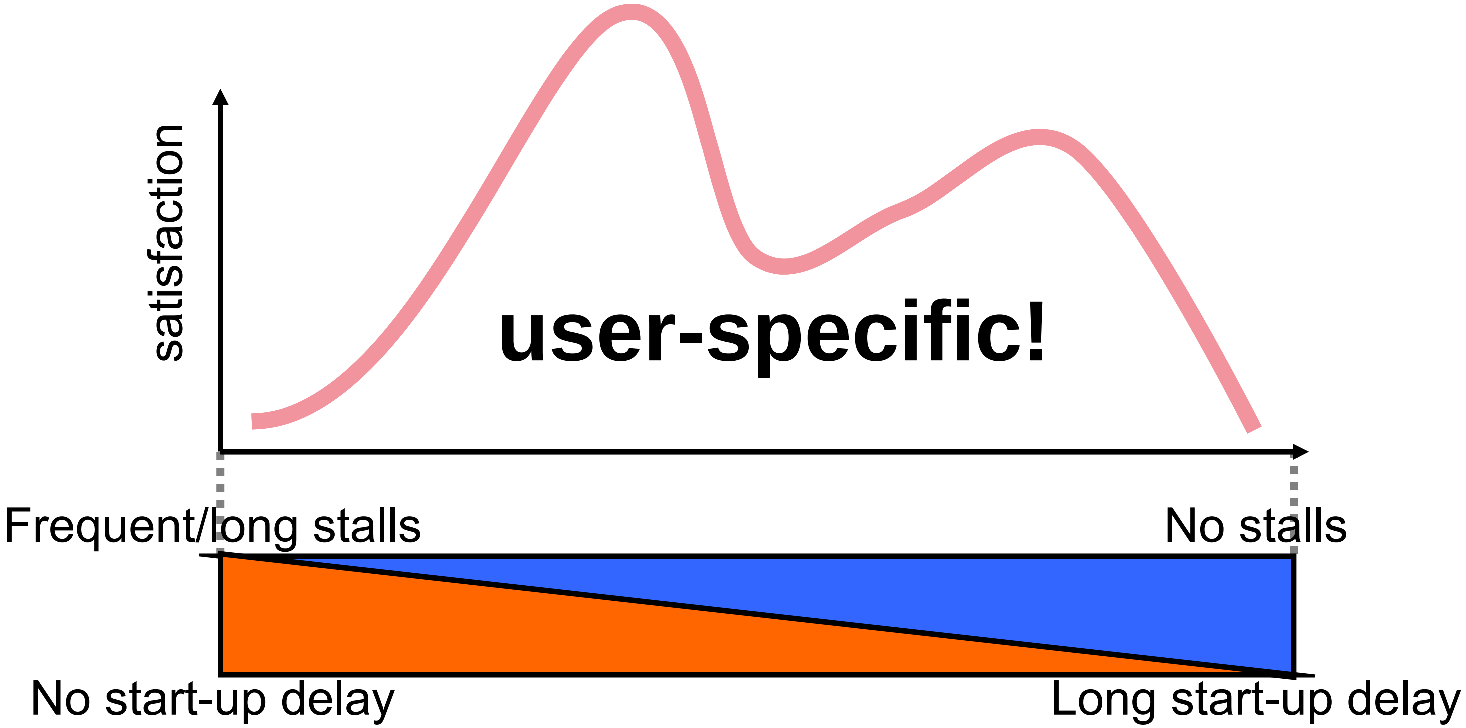
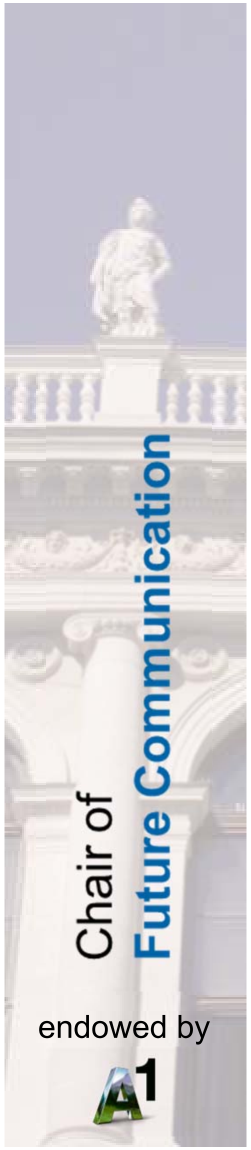
User Experience And Buffer Strategies

- Buffer strategy influences user experience
- Parameters (e.g.)
  - Start-up delay (▮)
  - Number and length of stalls during playback (▮)



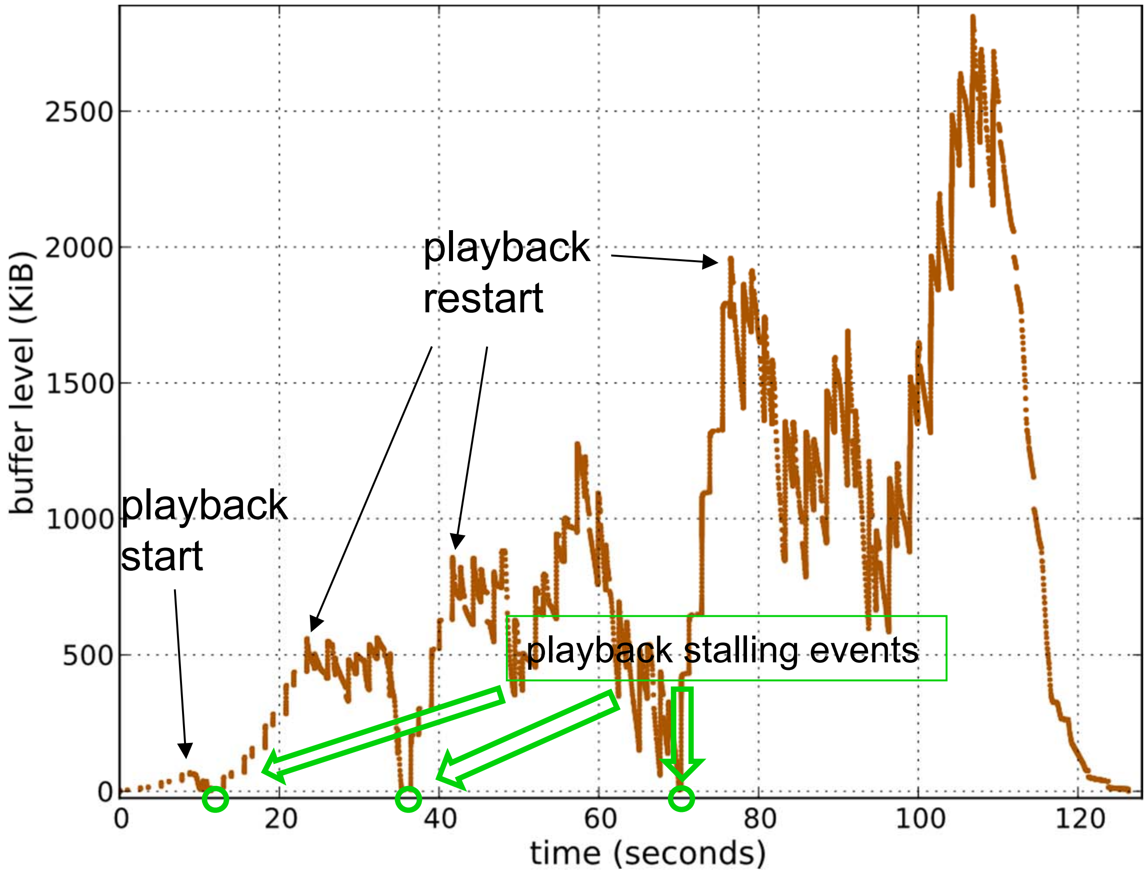
Extreme vs. Usable Buffer Strategies



- Range of possible user-visible trade-offs
  - Minimal buffering („**Playback stalling**“)
    - start immediately, stall immediately
  - Optimal optimal buffering („**Initial playback delay**“)
    - download exactly as much as you need to play back without any stalls
    - Impossible to implement -- requires perfect knowledge
  - **YouTube strategy**
    - Become more cautious on stalls → buffer increases with stall frequency
  - **Firefox HTML5 strategy**
    - Factor in download and playback rates
    - Less but longer stalls

YouTube Flash Player Strategy

- Start playing when buffer contains ≥2s video data
- If stalled, buffer ≥5s video data before restarting
- Compromise between small waiting times and number of stalls



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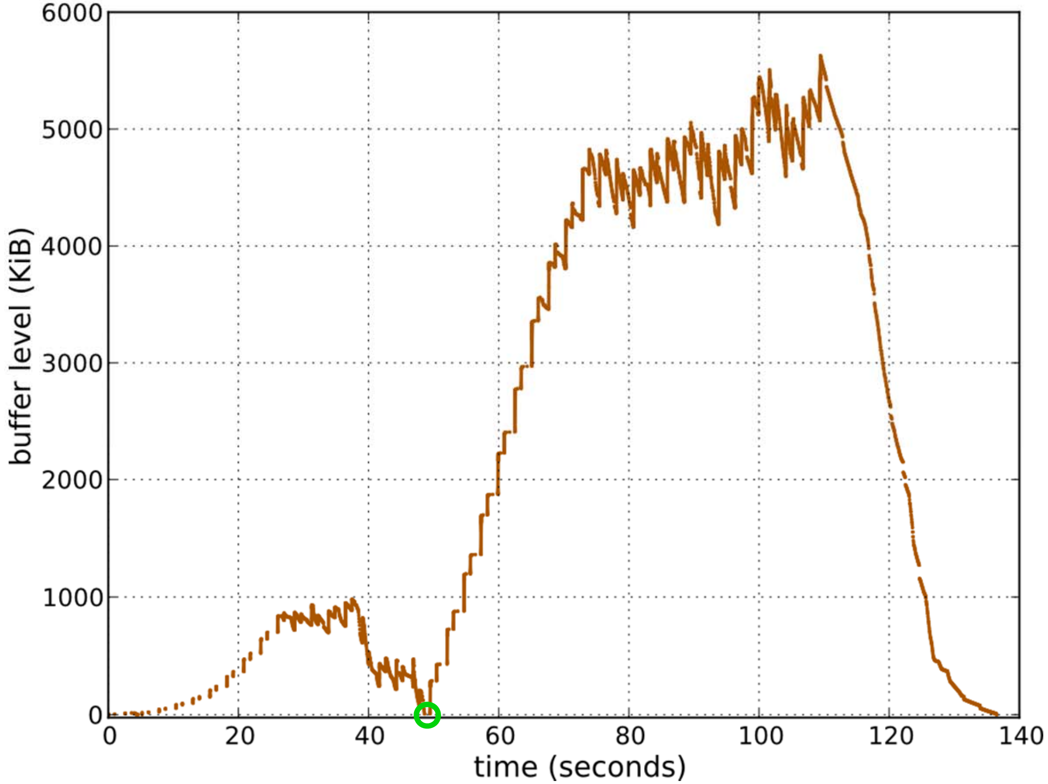
HTML5 Video Strategy in Firefox 4

- If $MA_{transmission} > MA_{bitrate}$ then buffer 20s of video data or for 20s, else 30s
- Limits stalling to few but long events, requires large buffer



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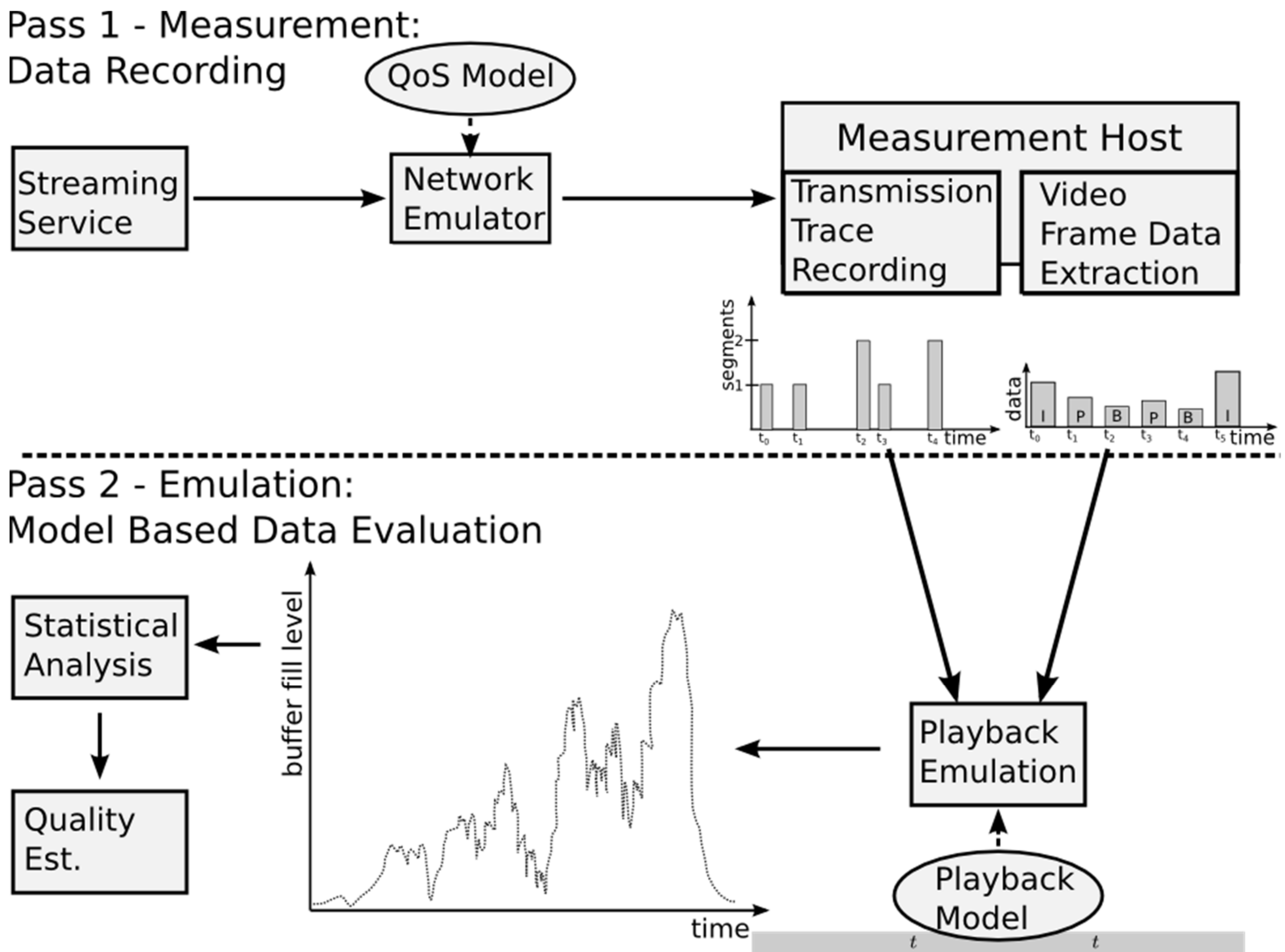
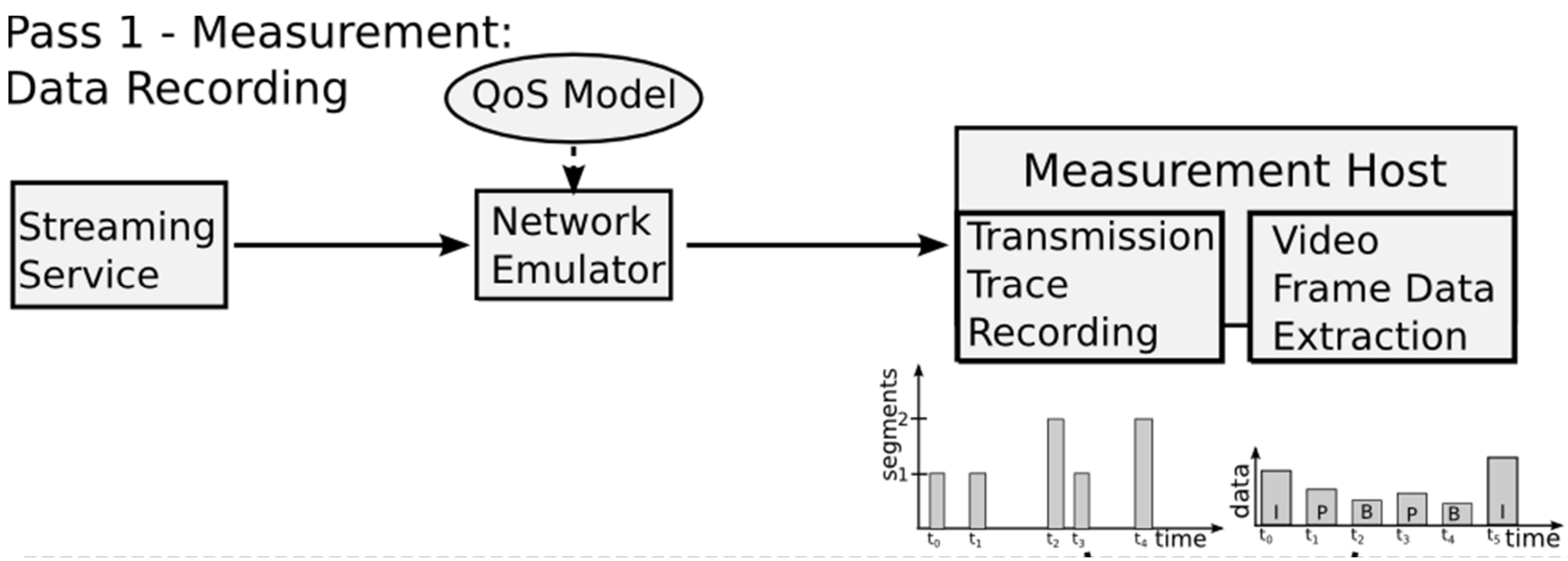
Measurement Testbed



$$\mathrm{buffer}(t) = \sum_{0}^{t} \mathrm{data}_{rcvd} - \sum_{0}^{t} \mathrm{data}_{played}$$

Measurement Pass 1: Recording

- Request content from local or Internet streaming service, download through network emulator
  - –Network emulator QoS models could represent different radio technologies, core network architectures, etc.
- Record network trace
- Decode video, record playback trace



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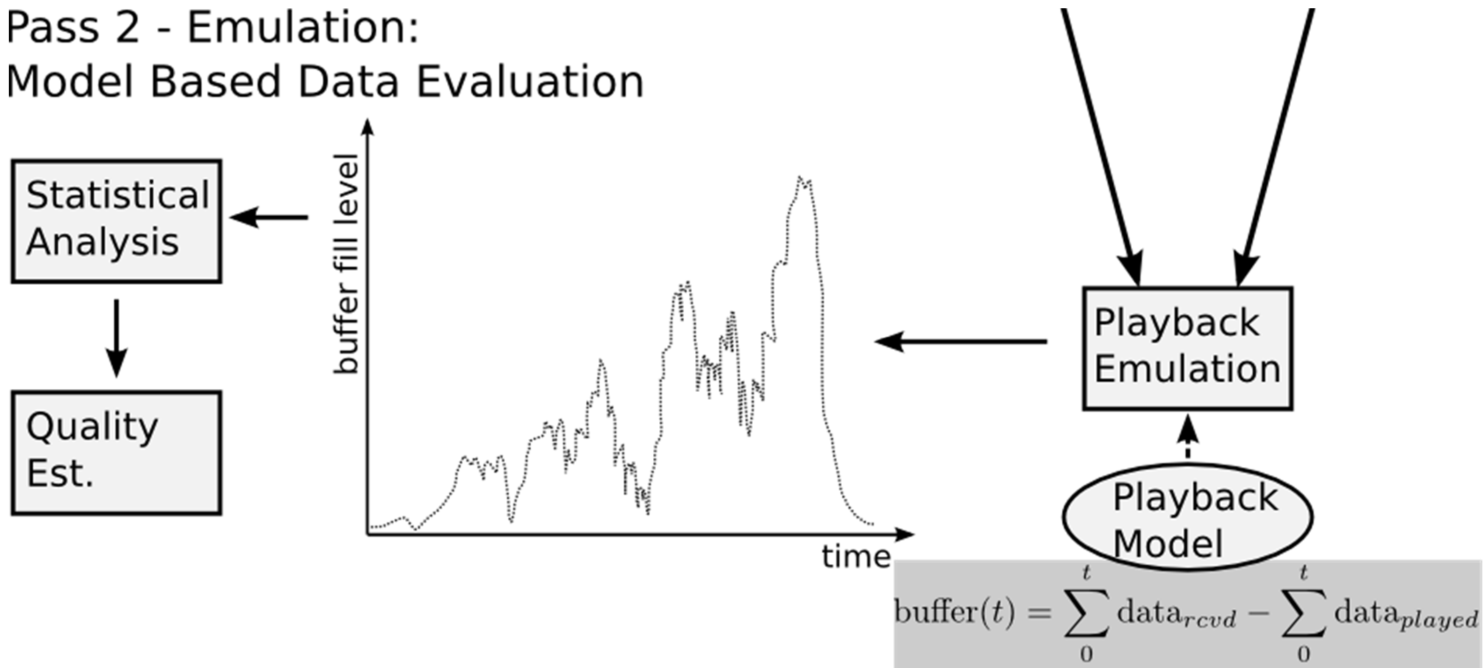
Measurement Pass 2: Playback Emulation

- Compare packet and decoder traces according to the general buffering model
- Can apply multiple playback strategies to the same trace!
- Evaluate for stalling statistics: Stalling duration, frequency, …
  - Potential input for further detailed QoE estimations



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Playback Strategy Trends: Total Stalling

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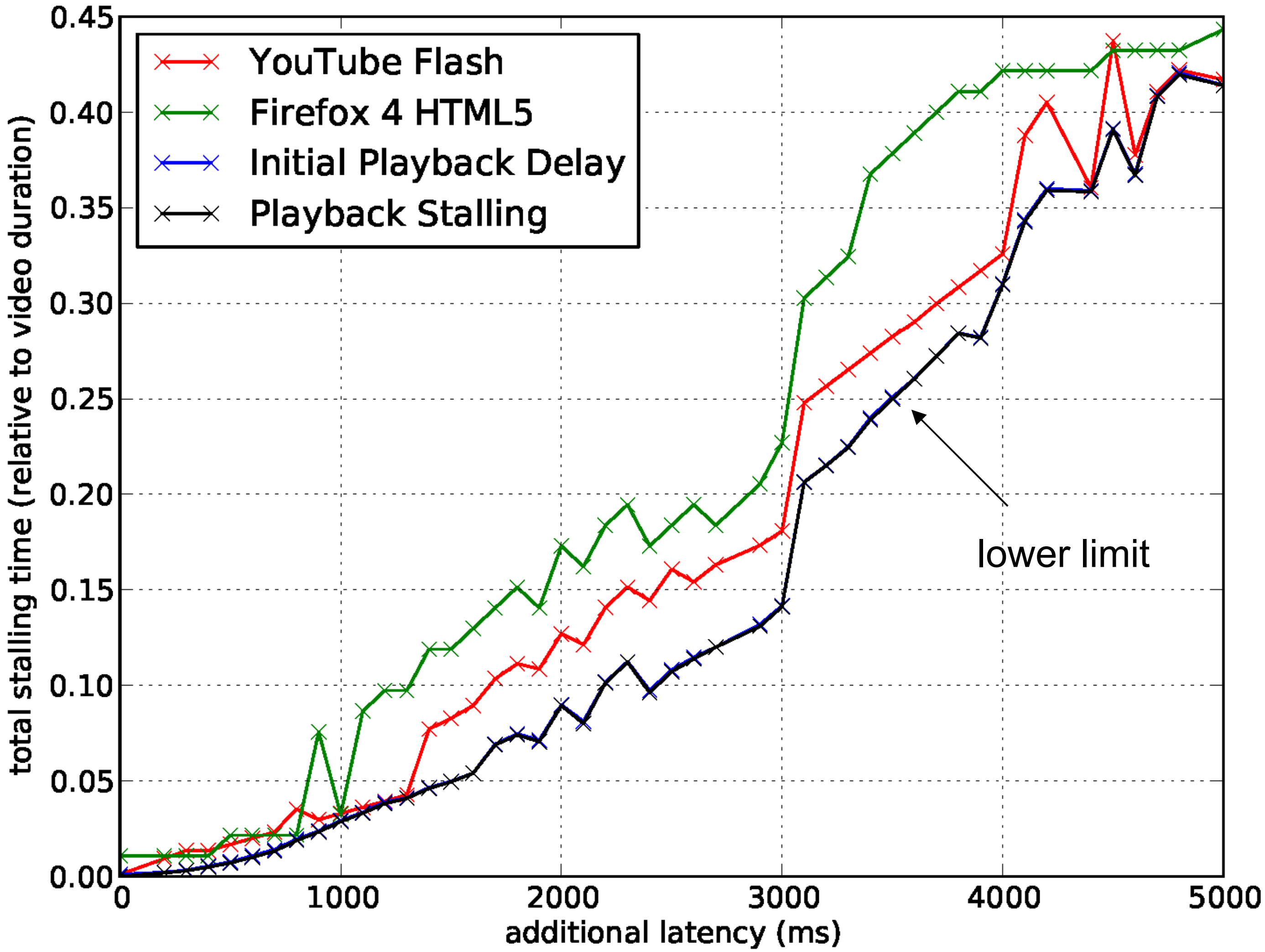

Playback Strategy Trends: Stall Frequency

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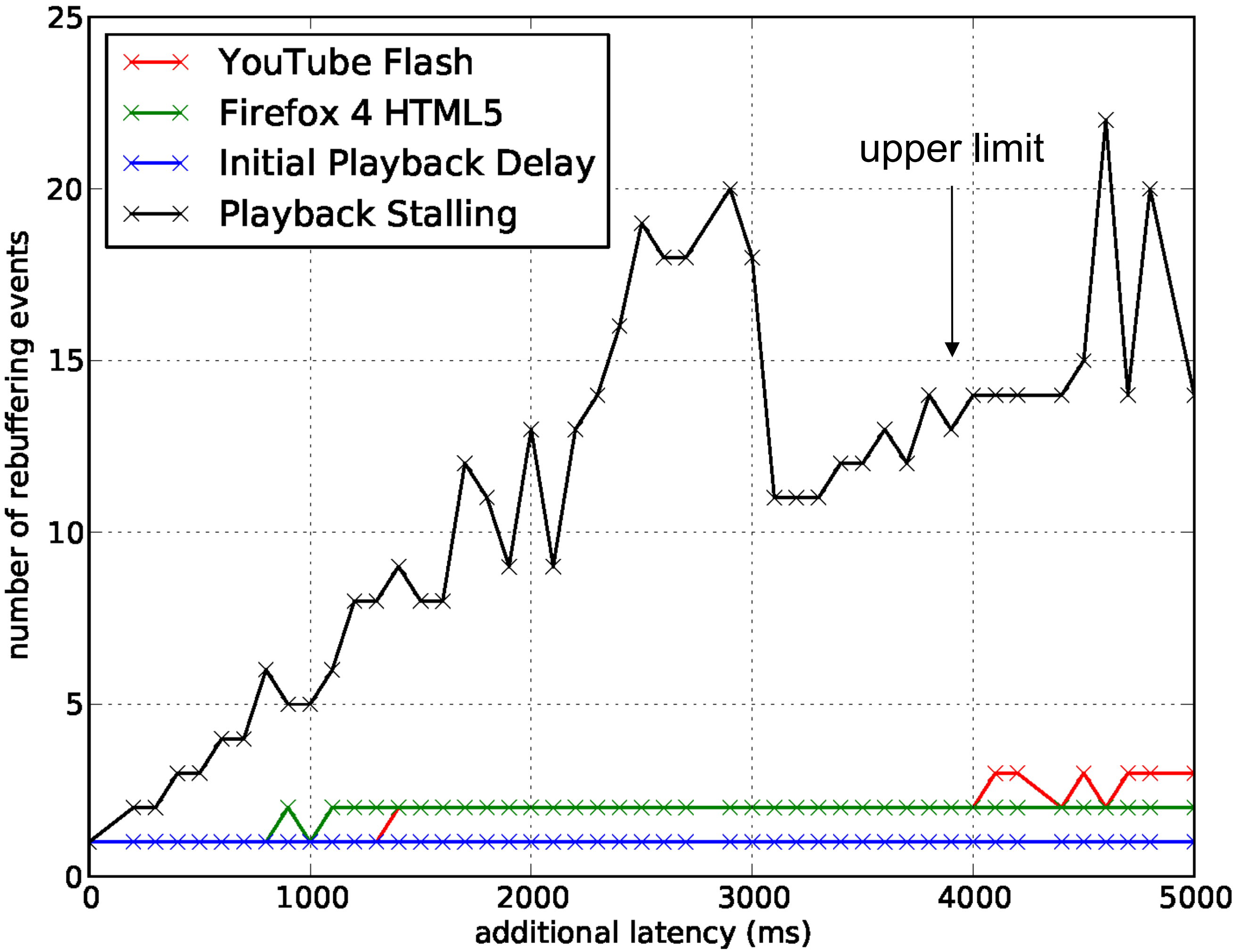

Includes initial delay

Conclusion

- New TCP-based streaming protocols are on the rise and will be a major traffic source
  - Generic evaluation and comparison approach necessary to cope with the multitude of different “protocols” and behaviors
  - TCP streaming requires different performance metrics compared to RTP
    - Approach: Stalling characteristics

- Choosing the right playback model can make a huge difference on the quality of the playback process
  - Currently used models (FF, YT Flash) may not be the best choices
  - Mobile viability only as an afterthought

- Simple HTTP-based streaming approaches have difficulties adopting to networks with high or varying latency or loss (e.g. mobile networks)
  - TCP features could prevent timely delivery of data

Work in Progress

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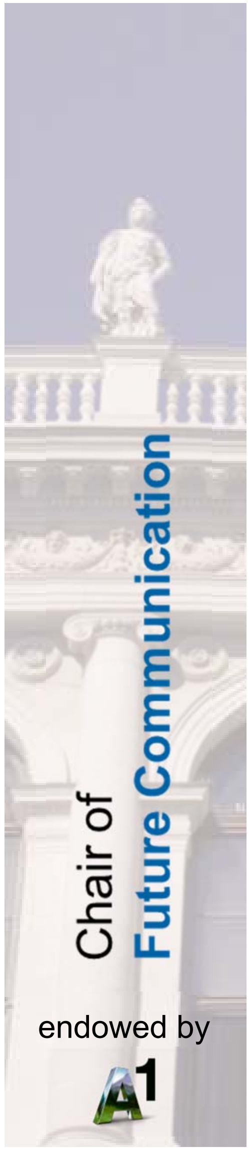
- Evaluation of a mobile operator core network dataset
  - Signaling and control traffic behavior and overhead?
  - Life cycle of PDP contexts

  ➔ Has streaming traffic a noticeable impact on the core network? How can it be modeled?

- Testbed emulation and simulation of adaptive streaming
  - Variations: DASH, Smooth Streaming, HTTP Live Streaming, ...
  - Explore universal adaptivity strategies, trade-offs and quality metrics
  - Testbed Emulation/Simulation of UMTS/LTE

Questions?



Thank you for your attention.