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Chair of Future Communication
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Modeling and Evaluation of Video Streaming

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HTTP Streaming Primer

Differences of RTP and HTTP streaming

RTP streaming
- Classical "textbook" approach, well researched behavior
- UDP and loss tolerant encoding enables implicit quality adaptation to current network conditions
- UDP transport prevents usage in the WWW
- Server-side "push-based" control scheme

HTTP streaming
- Reality today, in wide use (up to 50% of peak traffic)
- Multitude of different protocol incarnations, defined only by server and player behavior
- Client-centric "pull-based" control scheme
- Use of TCP means reliabilty, e.g., no intrinsic frame dropping

Measuring HTTP streaming

- RTP measuring metrics not applicable
- Network layers could influence new streaming approaches differently
- Hard to compare specific implementations
- Find generic mechanisms common to all
  → Buffering and playback strategies
  - Incorporate every possible behavior into a single testbed emulation
- Find suitable comparison metrics
  - Stalling duration
  - Number of stalls
  - Inter-arrival time of stalls
- Derive user quality from basic metrics

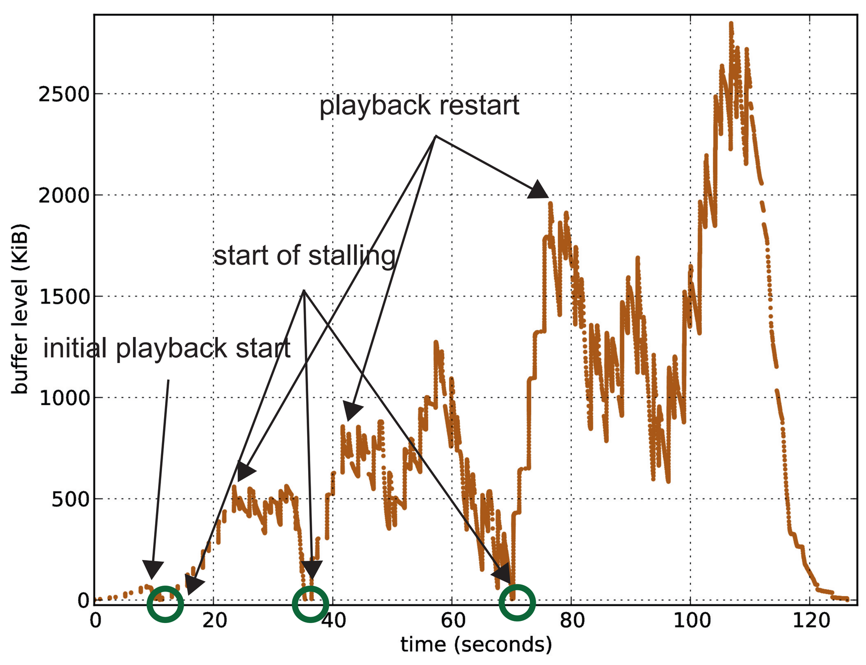
Necessity of buffering

- Video 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:

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

- Initial playback start time and restart time after empty buffer
  → Governing factors in any non-skipping streaming playback strategy

Playback Models & Strategies



YouTube Flash player strategy

- Start playing when buffer contains more than two seconds of video data
- If stalled, buffer at least five seconds video data before restarting
- Compromise between small waiting times and number of stalls

Theoretical Strategies

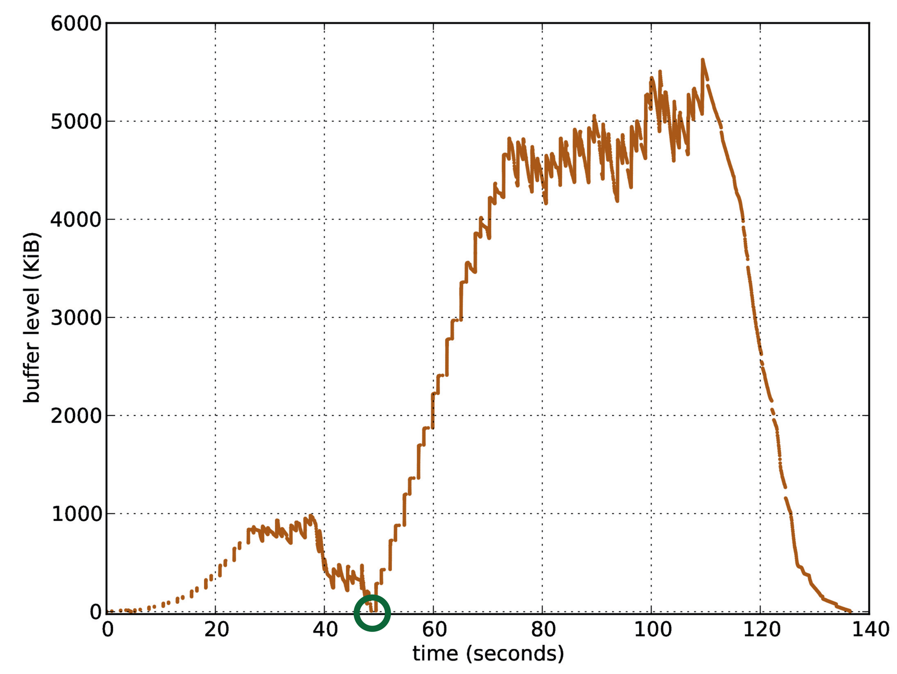
Demonstrate the range of possible stalling trade-offs, but are impractical in real situations.

Minimal buffering / Playback stalling

- Start immediately, stall immediately
- Starts playback as soon as there is at least one complete frame in the buffer
- Shortest initial playback delay
- Optimal in controlled situations with sufficient transmission rates at any time

Playback without interruption / Initial playback delay

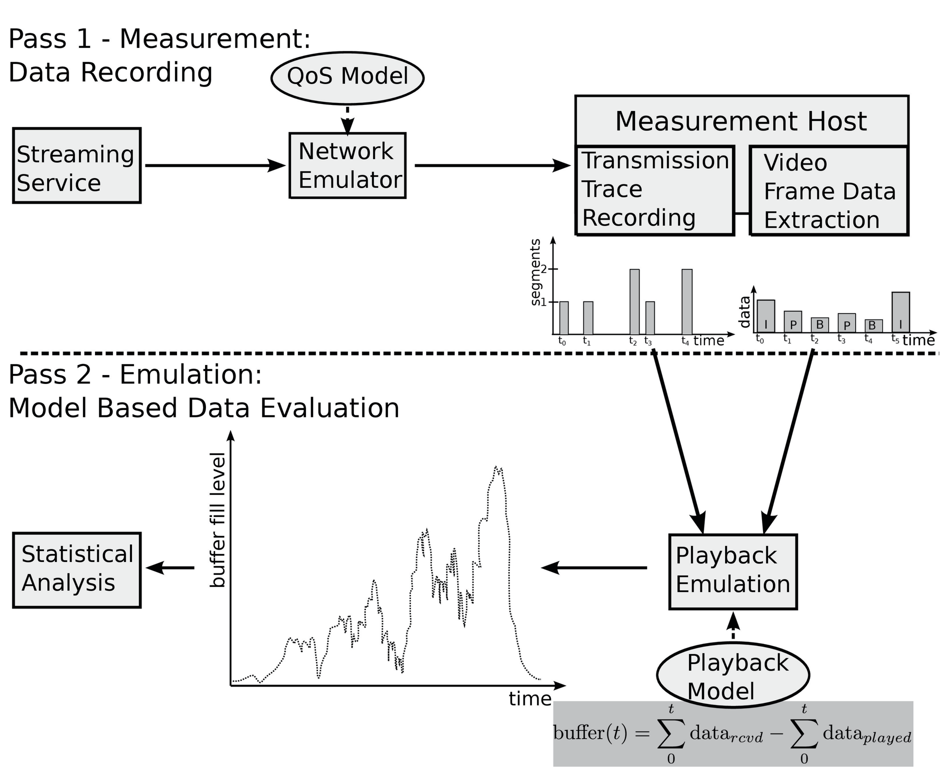
- Download exactly as much as needed to play back without any stalls
- Lower limit of total stalling time and number of stalls
- Impossible to implement − requires perfect knowledge
- Could be approximated by guessing transmission and bitrate



HTML5 video strategy in Firefox 4

- Factor in moving averages of transmission and playback bitrates
- If $MA_{transmission} > MA_{bitrate}$ then wait until 20s of video is in the buffer or for 20s in total, else 30s
- Limits stalling to few but long events, requires large buffer

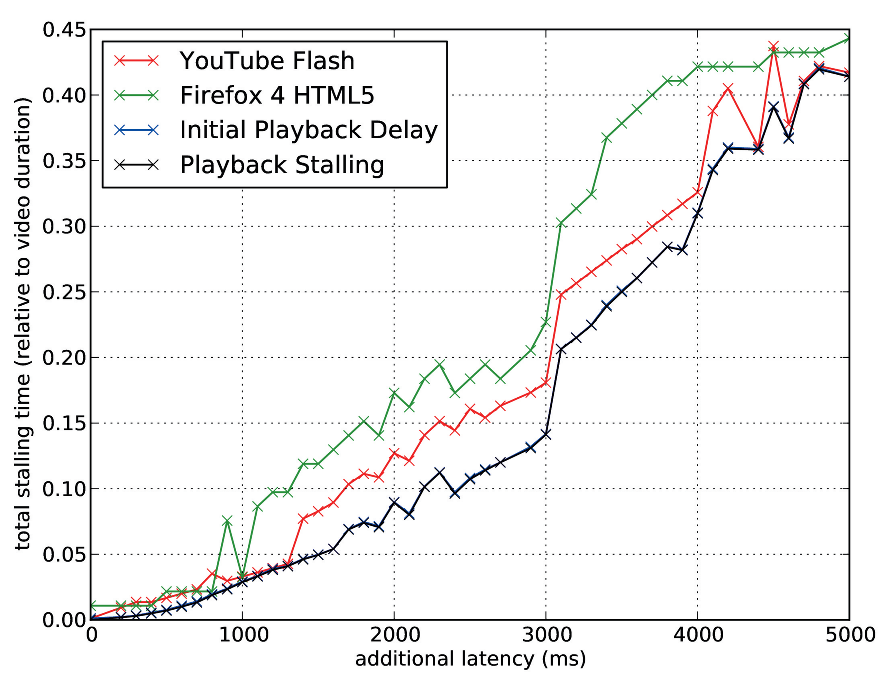
Measurement Framework



Measurement pass
- Request content from streaming server through QoS model in network emulator
- Record network and decoded video playback trace

Emulation pass
- Use trace files to do buffer fill level calculations according to playback startegies
- Can apply multiple emulated strategies to the same network trace
- Evaluate stalling statistics: stalling duration and frequency as potential input for QoE estimations

Evaluations



Impact of latency/loss on stalling characteristics

- Frequency: YT/FF suffer on average from one additional stall at a latency larger than 1000ms
- Lower total stalling limit given by theoretical strategies
- Impact of packet loss greater than 1% more noticeable, possibly due to TCP timeouts and retransmissions
- Practical implementations must make trade-offs between frequency and durations

Outlook

Adaptive Streaming Emulation

- Currently used strategies may not be the optimal choice for high latency networks (e.g. mobile networks)
- Adaptive streaming protocols as a possible solution
- Already many variations available, e.g. DASH, Smooth Streaming, HTTP Live Streaming
- Has a larger parameter space to observe and model
  - Segment retrieval times (i.e. client side throttling)
  - Quality adaptation through alternate segment encodings
- Transfer emulation testbed approach to adaptive mechanisms
- Explore strategies, trade-offs, and evaluation metrics feasible

Mobile Core Network Dataset

- Investigation of a one week mobile operator core network dataset
- Includes user traffic flow data, HTTP specifics and GTP signaling traffic between SGSN and GGSN
- Attempt to correlate mobile device types to GTP signaling patterns
- Determine PDP context life cycle and overhead
- Has streaming traffic a noticeable impact on the core network? How can it be modeled?