Combining Stream Switching with Fine-grained Intra-stream Adaption for Adaptive Video Streaming

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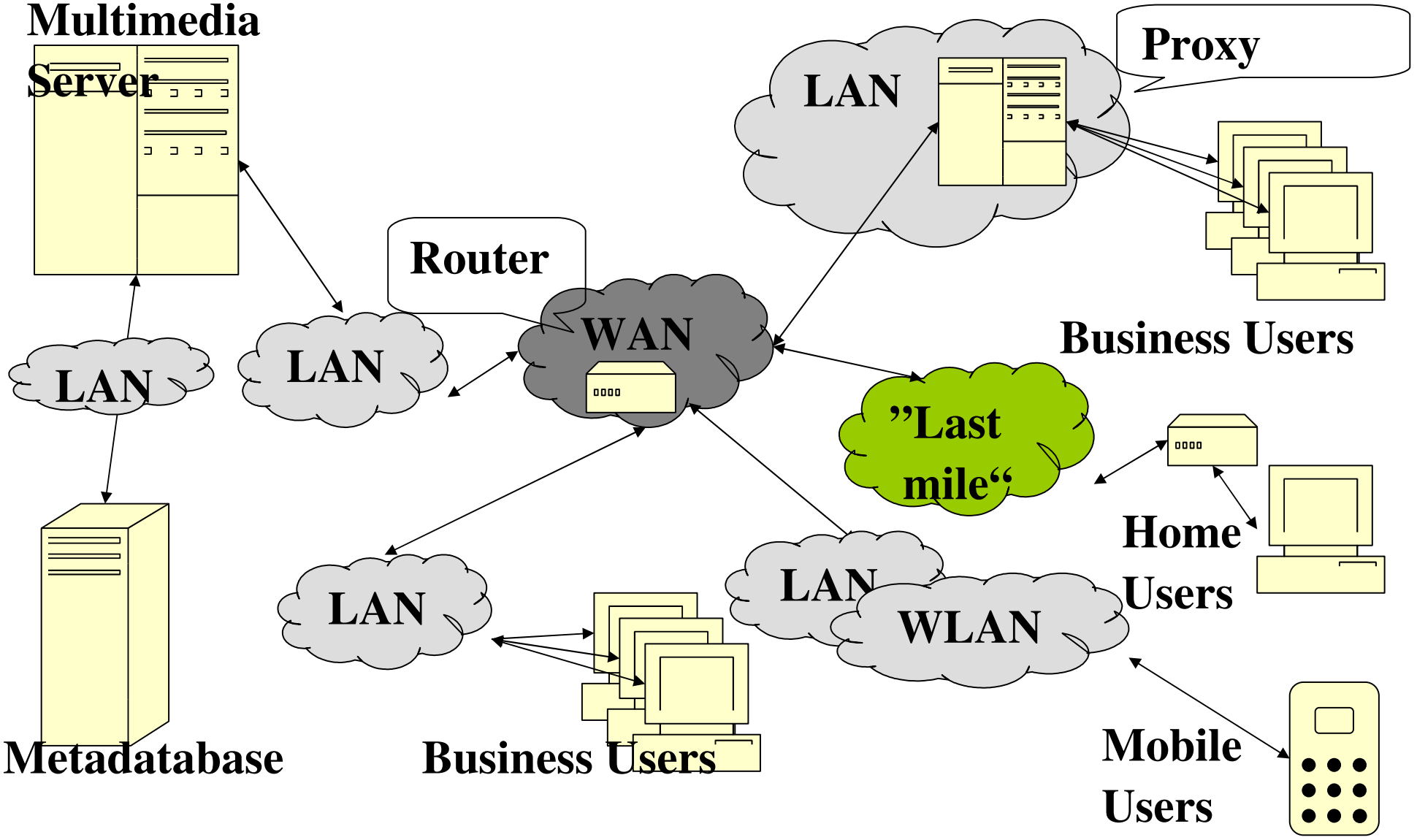
VASE - A Video-Adaptive Streaming Environment

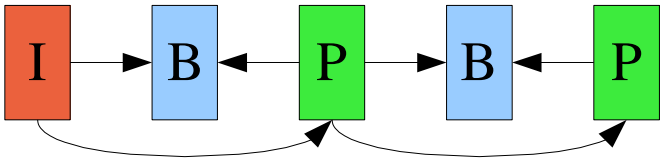


Usage Environment

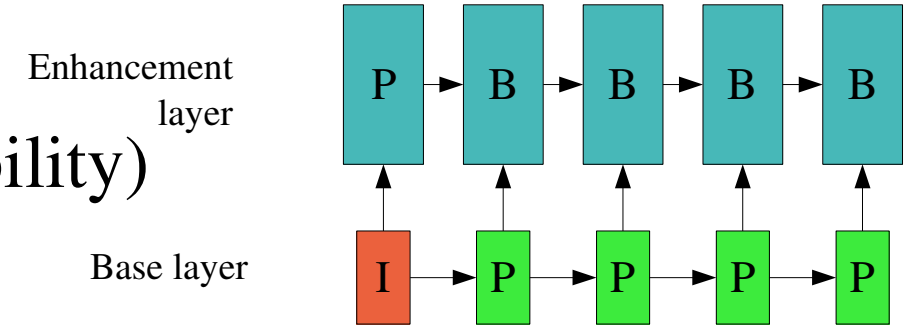
- Unicast Video on Demand (VoD)
- Video+Audio streaming via Cable or xDSL
  - Downstream: max. ~1 Mbps
  - Upstream: ~128 kbps
- Server is somewhere in the Internet
  - Best effort network with multiple users
  - Changing bandwidth
  - Changing latencies (20 ms - 200 ms)

Scalable Codecs

- Temporal



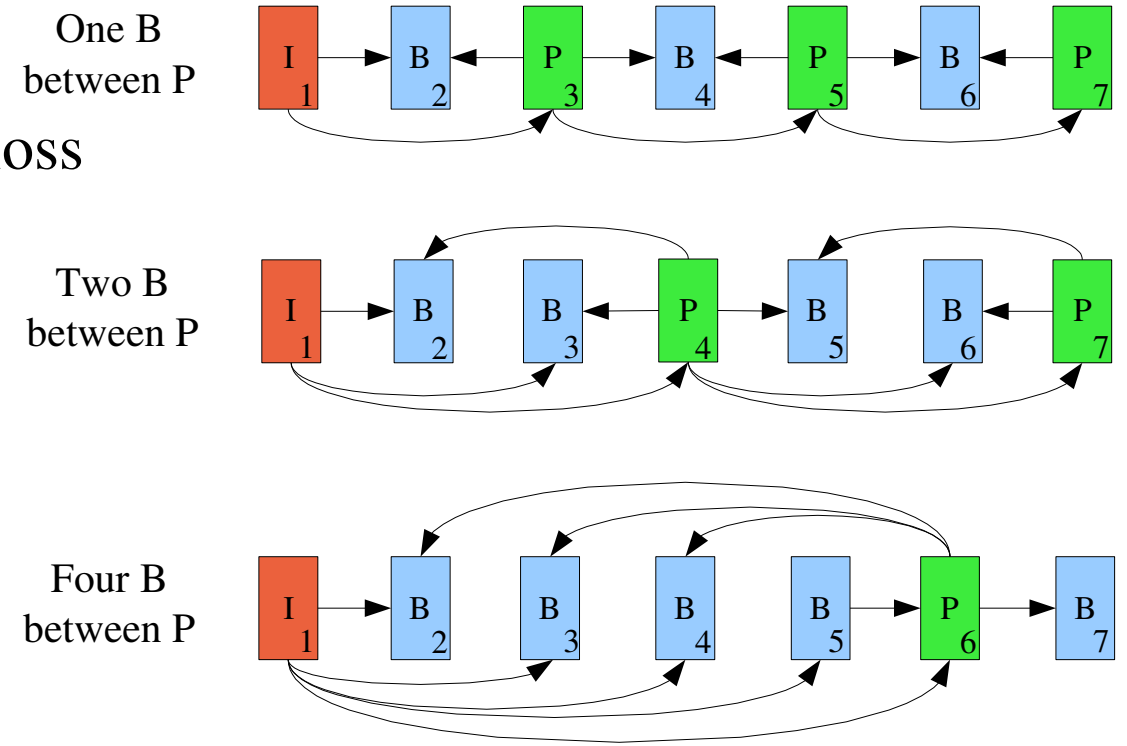
- Signal-to-Noise (SNR)
  - FGS (Fine Granular Scalability)



- Spatial
  - use with re-scaling: special case of SNR
  - different quality up/down-scaling algorithms
- Big goal: The universal scalable video codec

Temporal Scalability

- Frame Patterns
  - Variable patterns
    - IPPPPBPPPBPPBIPIIIIPPBBP....
  - Static patterns
    - I-Frame: sync, loss

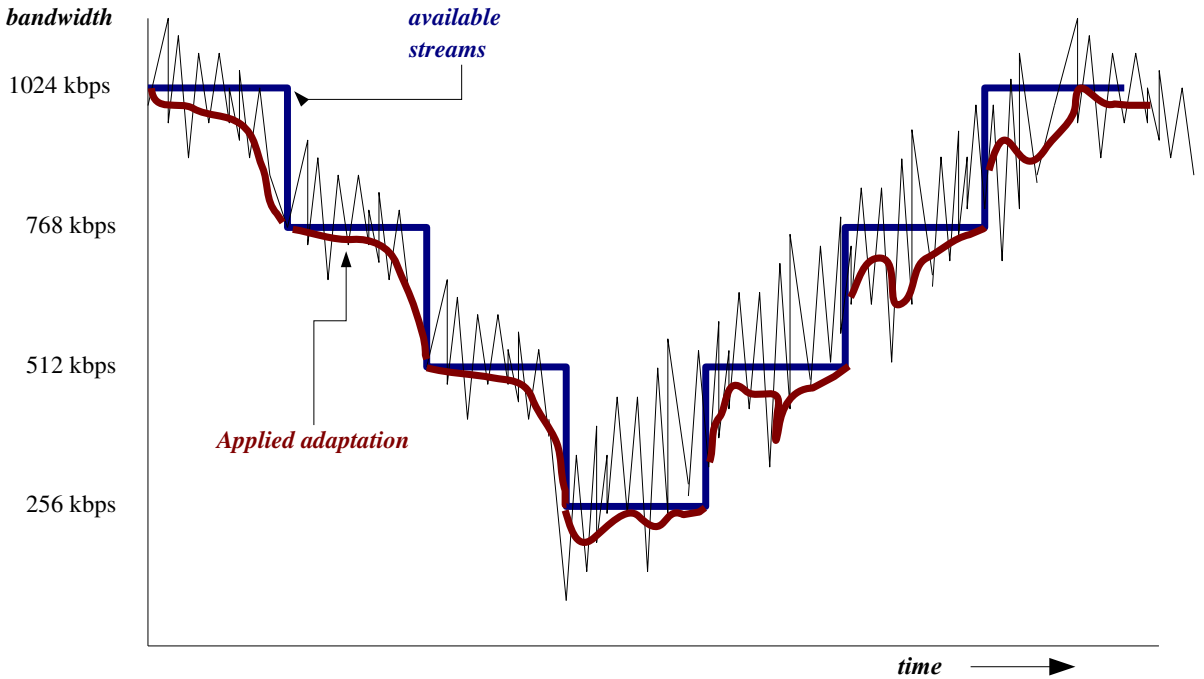


High Number of B-frames

- Pro's
  - Increased scalability (but low fps not wanted?!?)
  - BUT: Larger pool for choice of (intelligent) dropping
- Con's
  - Increased file size (reference distance)
  - Increased encoding/decoding time
  - Increased buffer requirements

Stream Switching

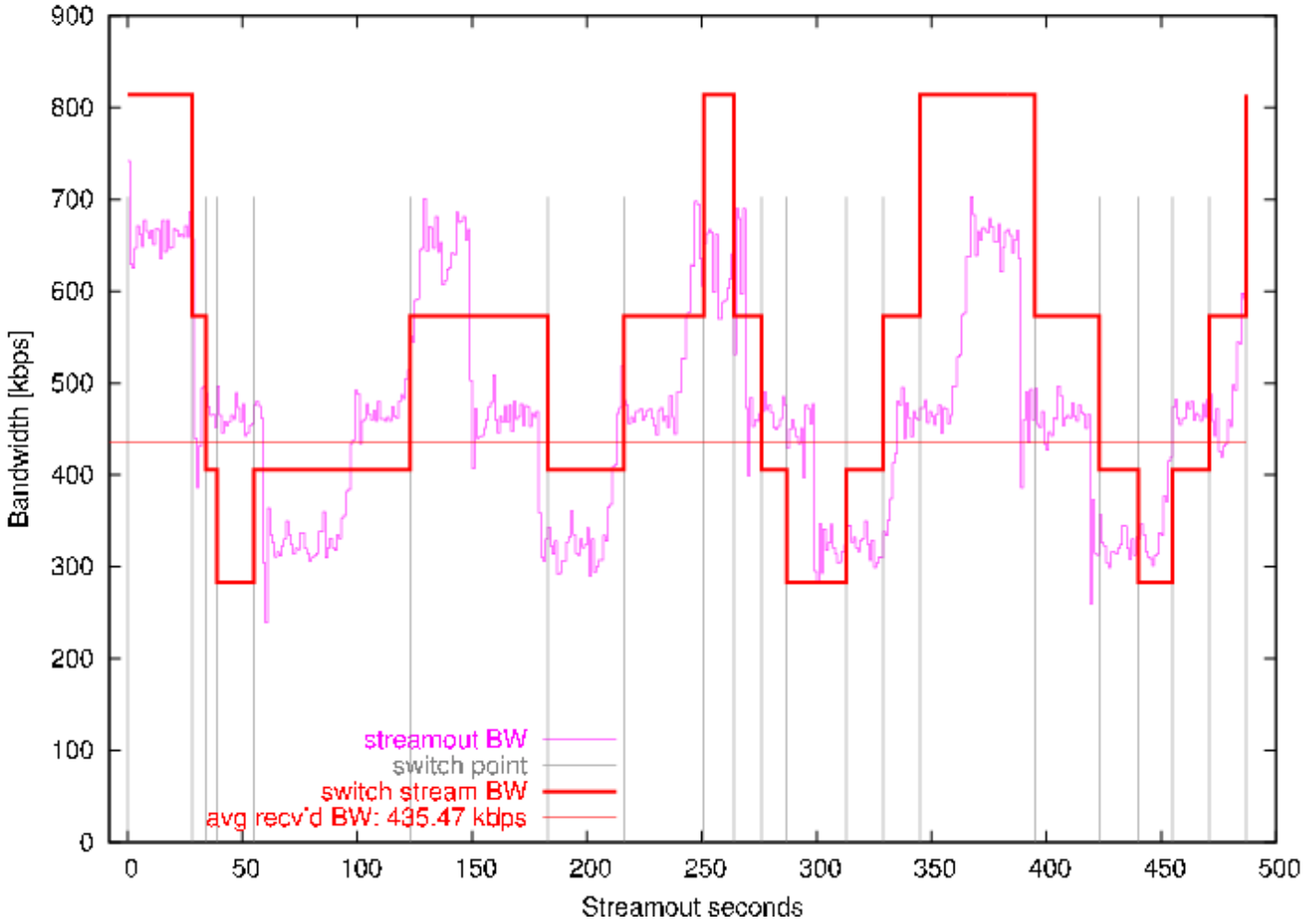
- In-stream adaptation:
  - Scalable codecs are bound to certain ranges
    - dont drop more than 50% of frames!
    - high coding overhead for FGS with small base layer
- Client buffer too high or low
- Switch streams and start adapting again!



Stream Switching and Adaptation

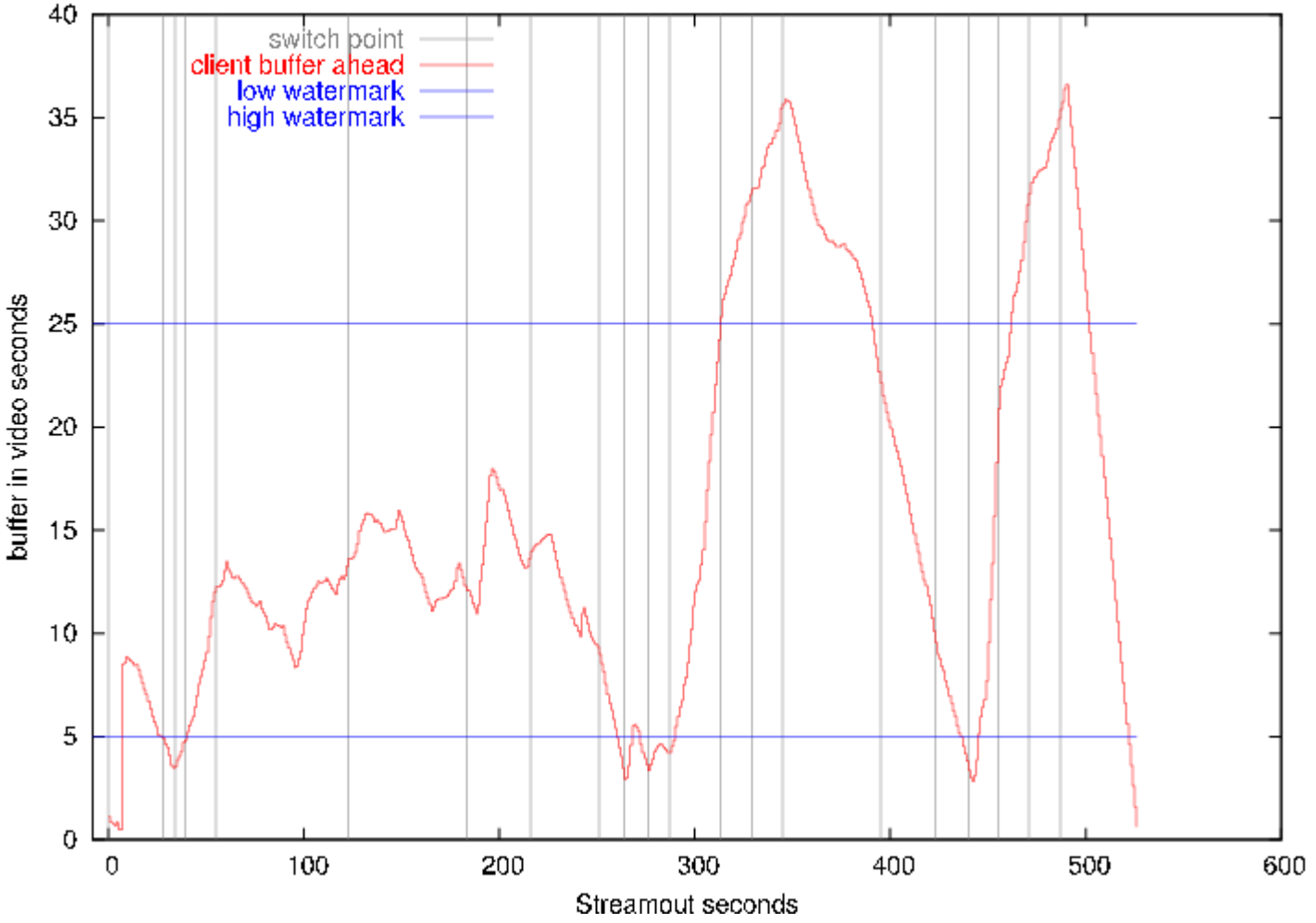
- Multiple streams each -30% BW => -1.5dB PSNR loss
- In-stream Temporal Adaptation
  - ***Helps to overcome buffer underruns or switch-downs***
  - High B-frame dropping leads to up to -6 dB PSNR loss!
  - Less than 15 fps (from 25fps) not acceptable
- More fine grained in-stream SNR adaptation needed!
  - FGS?
  - Wavelet-based SVC?

Stream Switching w/o Temp Adapt



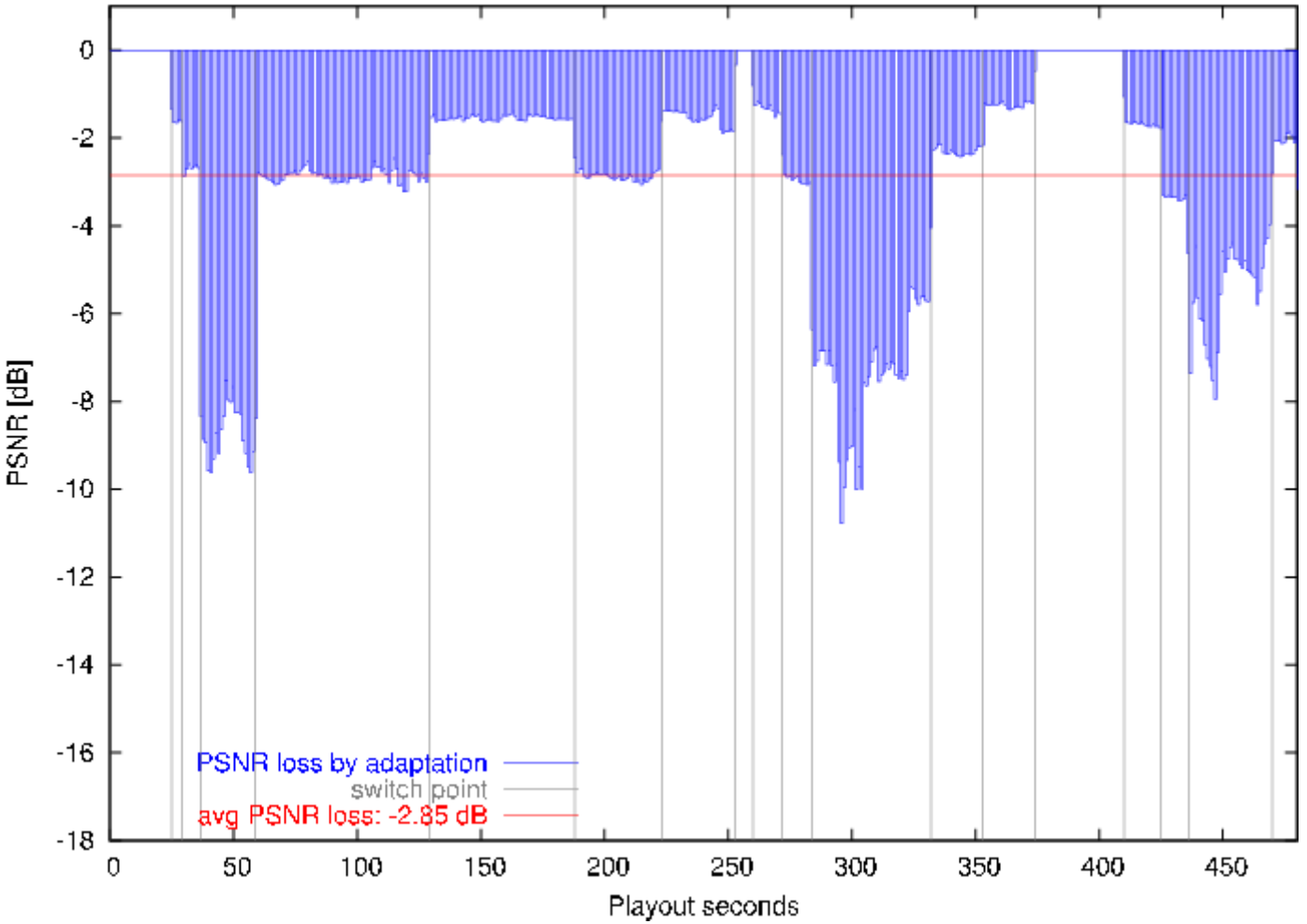
Network bandwidth

Stream Switching w/o Temp Adapt



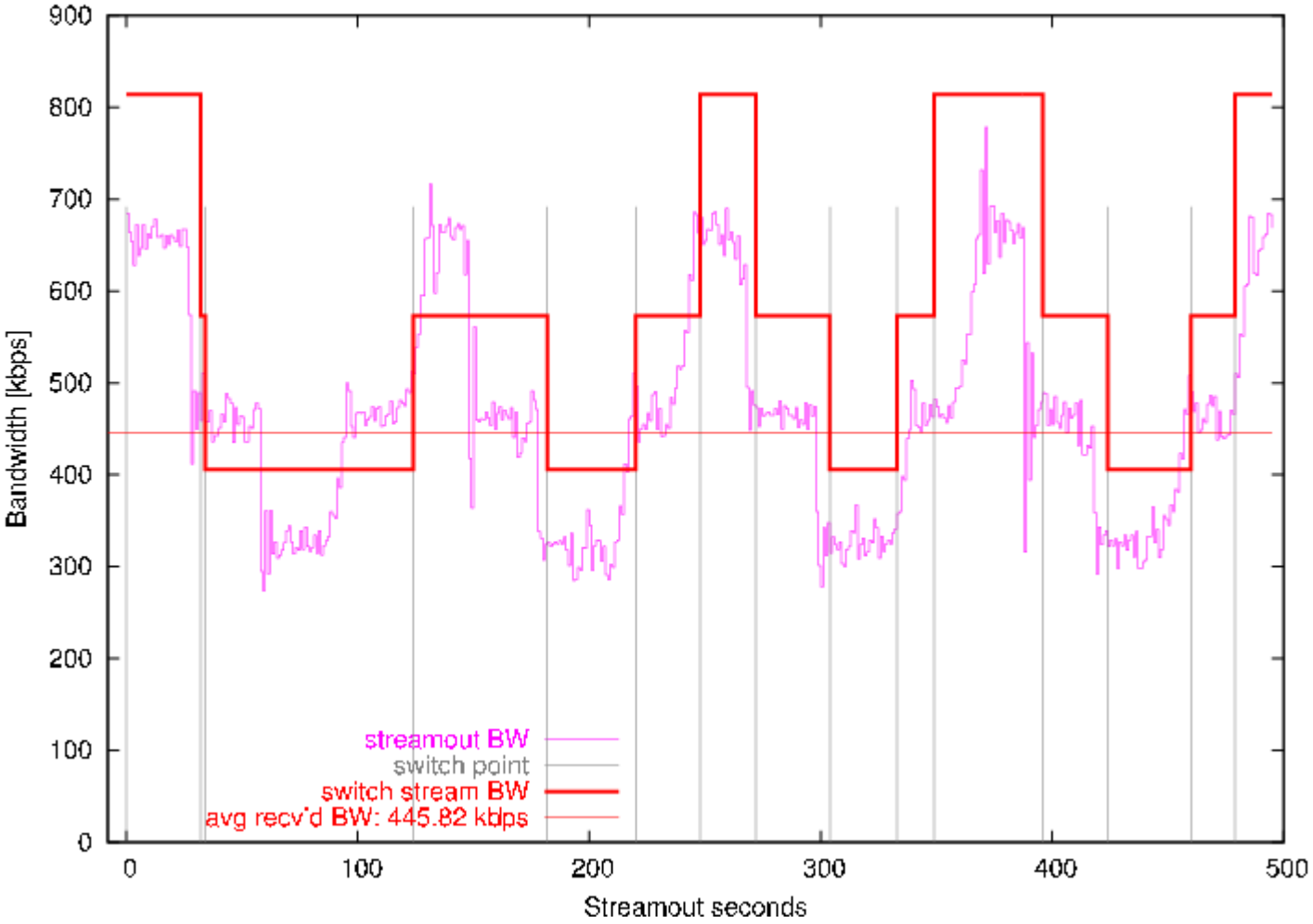
Client buffer fill level of available playout seconds

Stream Switching w/o Temp Adapt



Qualitative reduction caused by adaptation

Stream Switching with Temp Adapt



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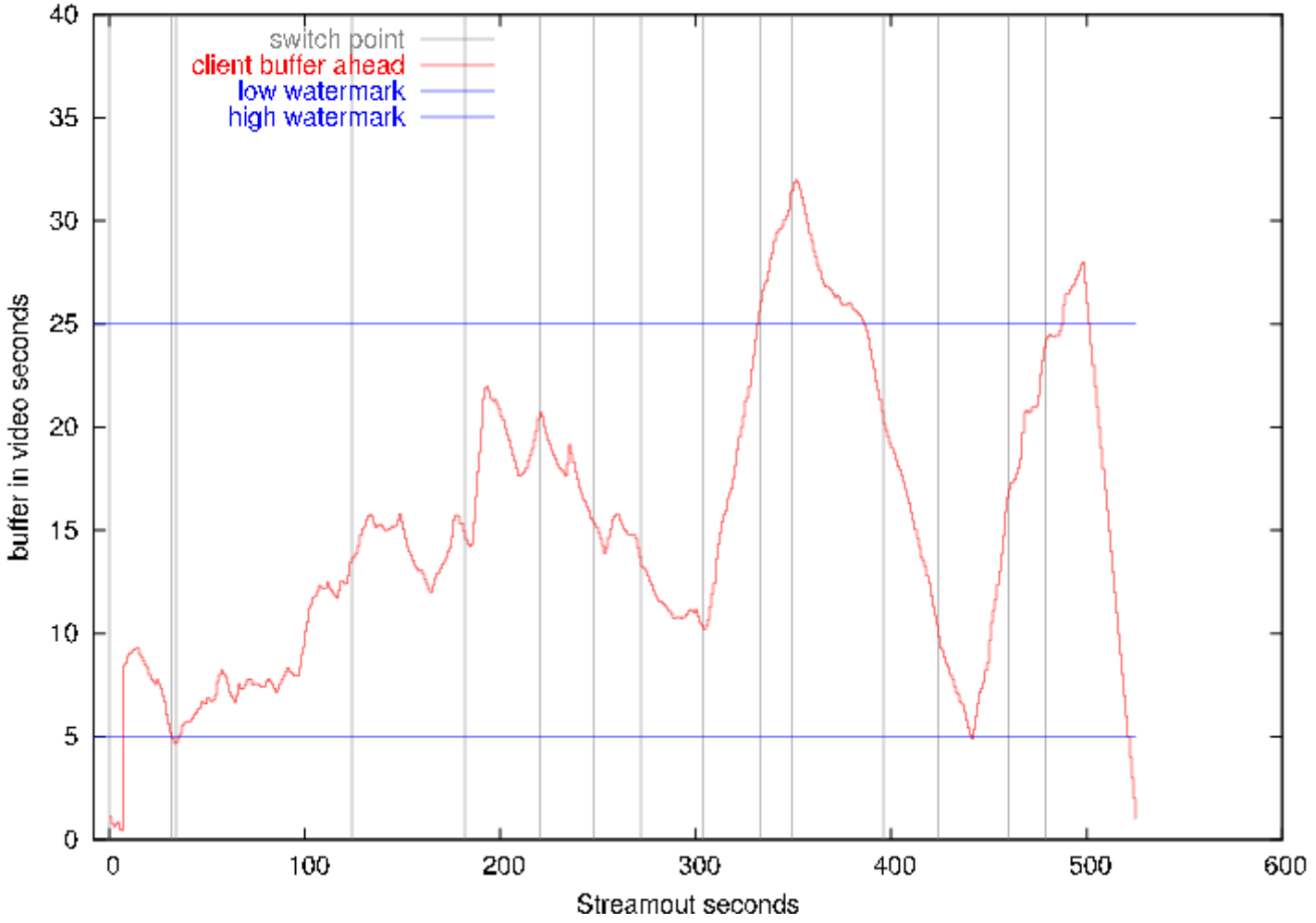

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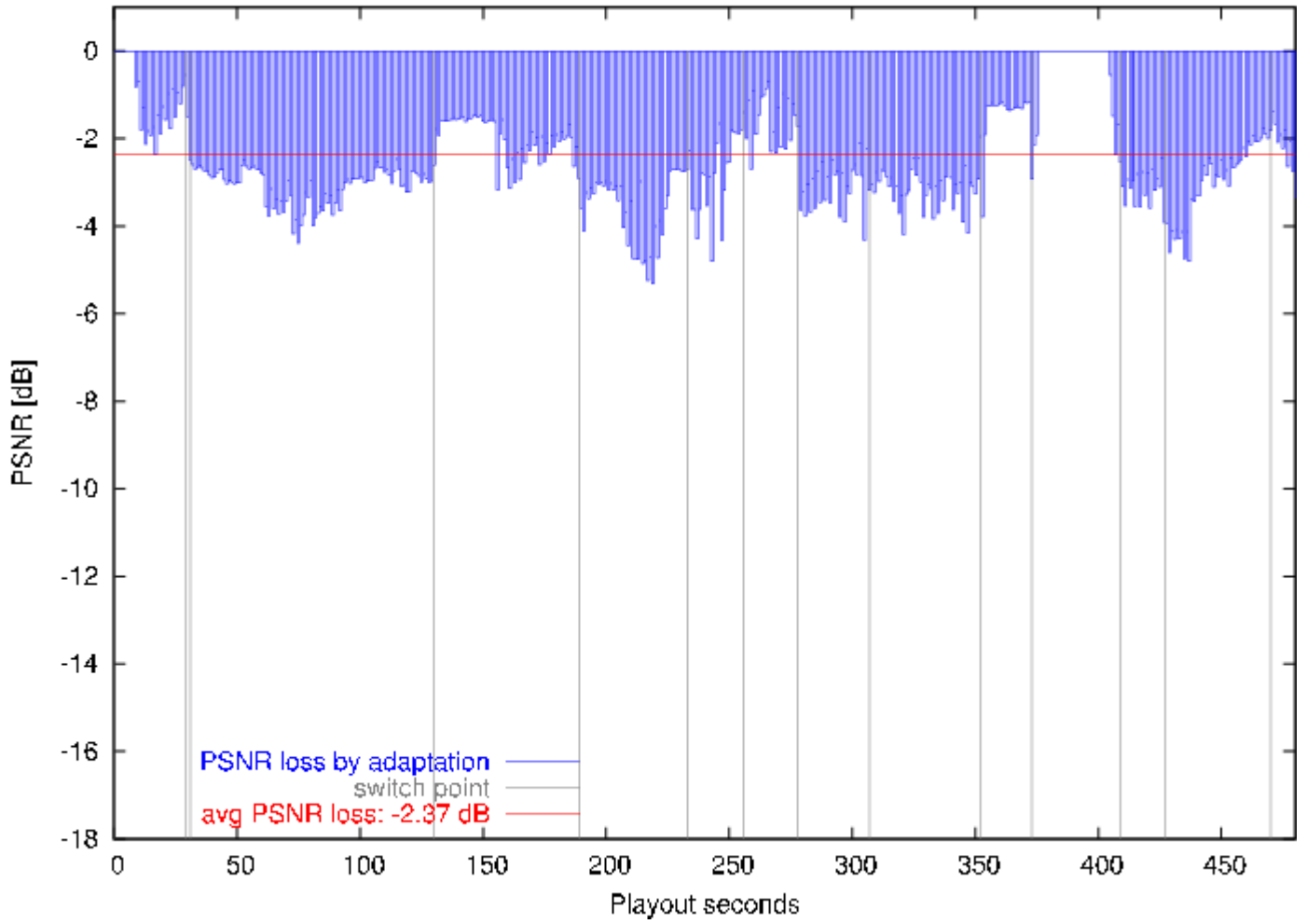

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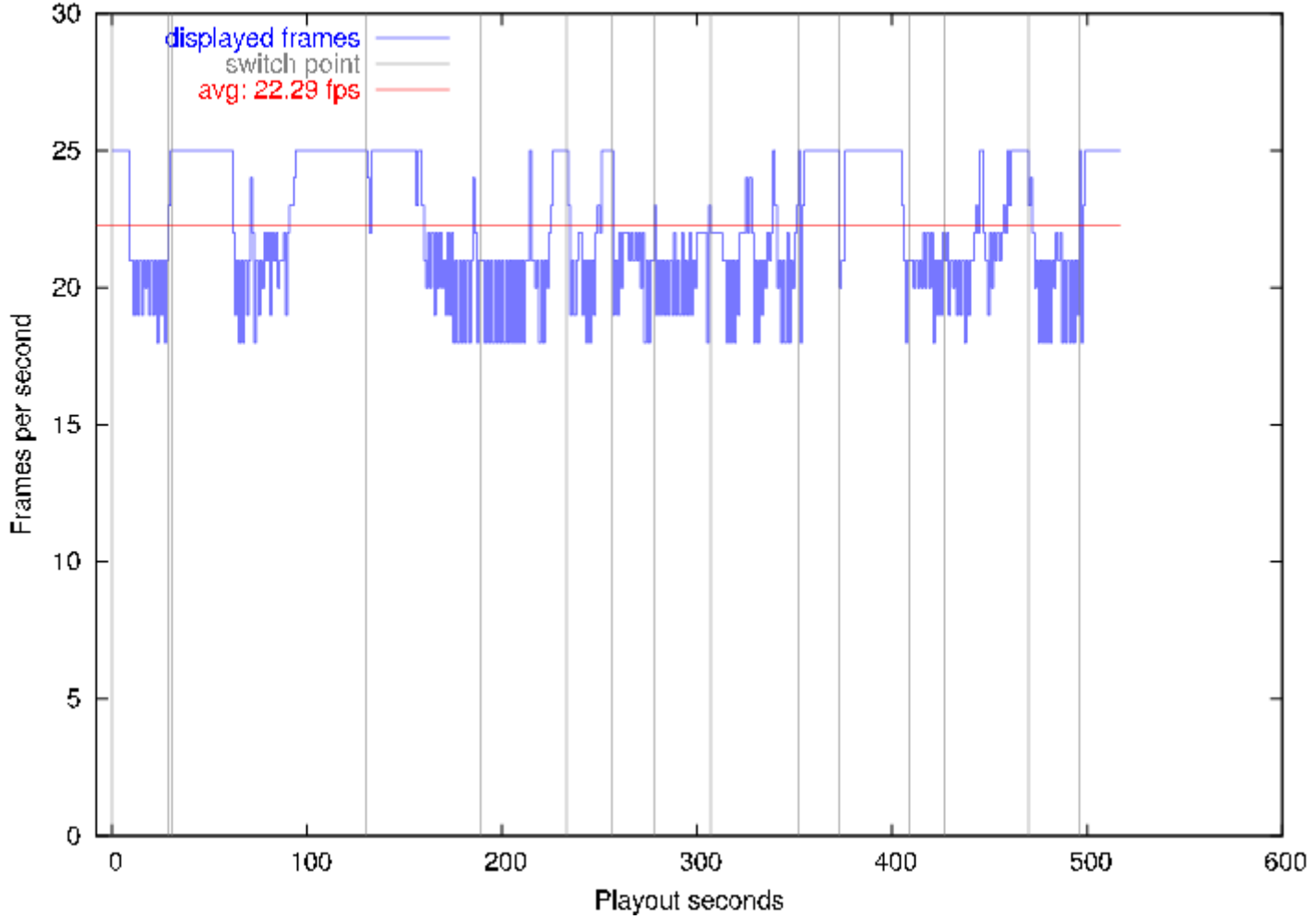

Visual frame rate per playout second after temporal adaptation

Conclusion

- In-stream adaptation:
  - Scalable video codecs (Temporal, SNR, Spatial)
  - Specialization&Analysis on temporal (B-frame) adaptation
- Stream switching (+ in-stream adaptation)
- Combination of both
  - stabelizes client buffer
  - prevents major quality loss by unneccessary switching
  - better user satisfaction
- even better results with more fine-grained adaptation (FGS, wavelet,...)

ViTooKi - The Video ToolKit in C++

- Support for MPEG-1/2/4 video codecs (ffmpeg+xvid)
- runs on Win,Linux,Linux-iPAQ, winCE-iPAQ
- MPEG-21 terminal capabilities + live transcoding
- Immediate and fast adaptation and stream switching
- Smoothed streamout for client buffers
- Flow control (TCP-friendliness)
- Transport via RTP
  - extensions: immediate RTCP and NACK+retransmission
- --> avail as open source via CVS (44 kLOC, 1.6MB)
  - The Video ToolKit @ ITEC http://vitooki.sourceforge.net