Universität Stuttgart

INSTITUT FÜR
KOMMUNIKATIONSNETZE
UND RECHNERSYSTEME
Prof. Dr.-Ing. Dr. h. c. mult. P. J. Kühn

Network-driven Adaptive Video Streaming in Wireless Environments

2nd Seminar on Service Quality Evaluation in Wireless Networks

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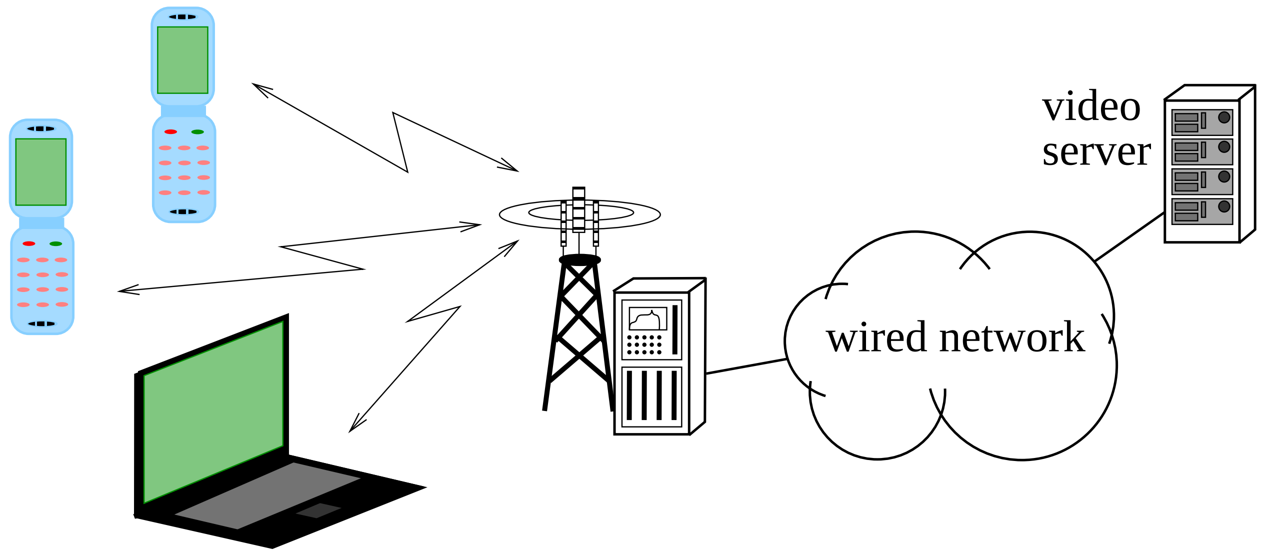
Zigmund Orlov
Institute of Communication Networks and Computer Engineering
University of Stuttgart
zigmund.orlov@ikr.uni-stuttgart.de

Wireless Channel



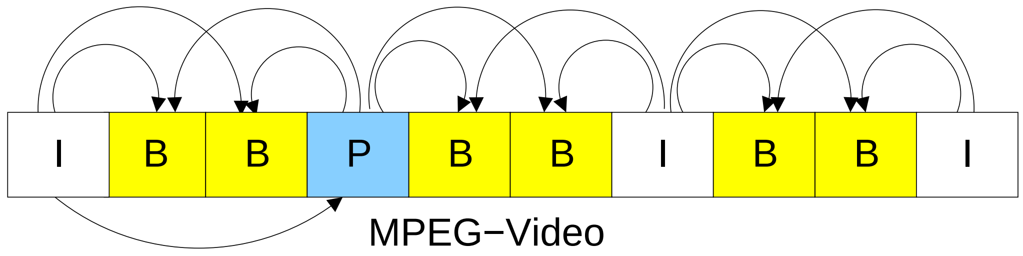
Wireless channels

- **Narrow and strongly time-varying bandwidth**
- **Large and time-varying delay**
- **Link-layer losses**

-> Challenge for a video streaming application is to overcome the highly time-variance of wireless-channel characteristics.

Video,Video Streaming, Video Losses

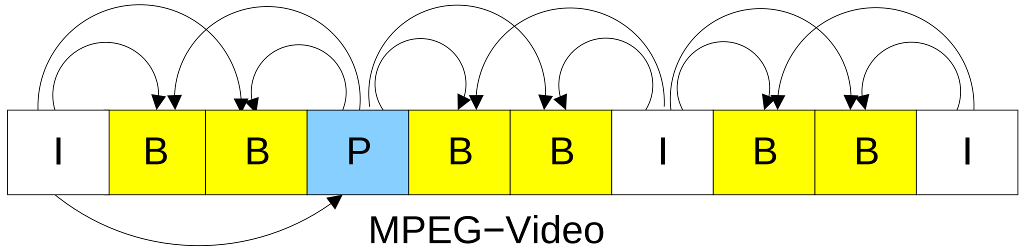
Video



- **Intra-coded (independent decoding) frames:** I-frames
- **Inter-coded (decoding dependencies):** P-frames**,** B-frames

Video,Video Streaming, Video Losses

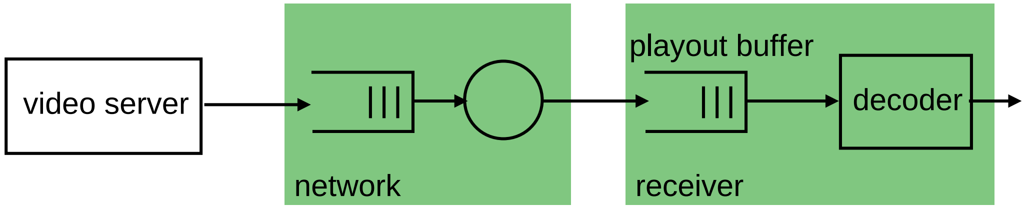
Video



- **Intra-coded (independent decoding) frames:** I-frames
- **Inter-coded (decoding dependencies):** P-frames, B-frames

Video Streaming

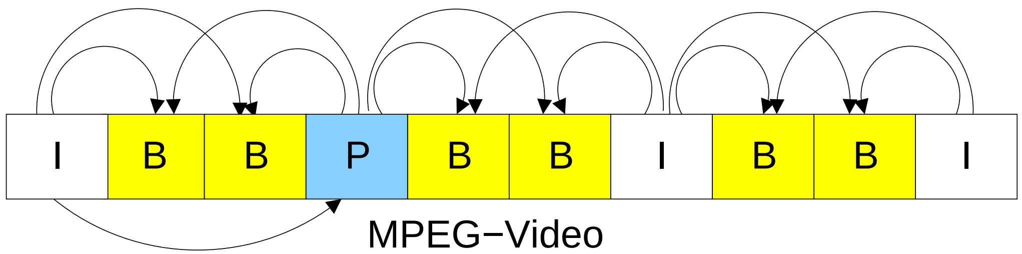
- **Transmission path:**



Video,Video Streaming, Video Losses

Video

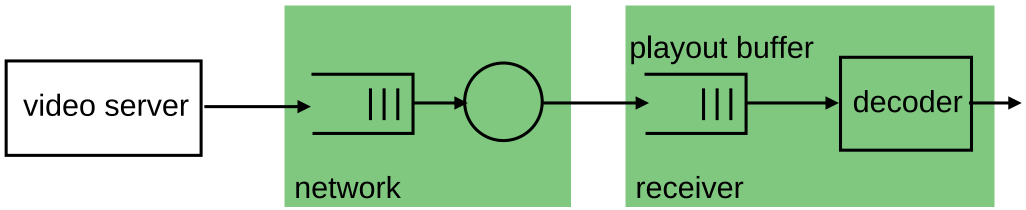
- **Intra-coded (independent decoding) frames:** I-frames



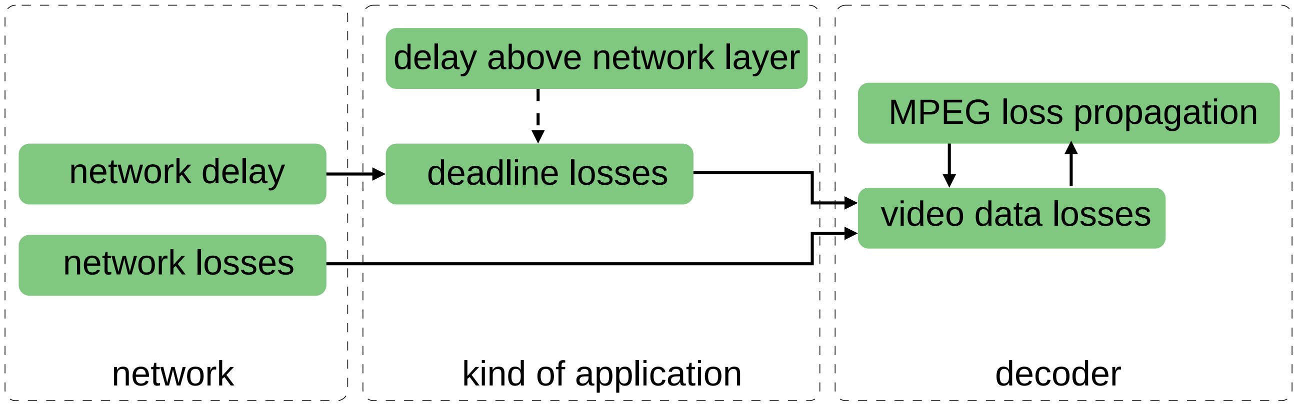
- **Inter-coded (decoding dependencies):** P-frames**,** B-frames

Video Streaming

- **Transmission path:**



- **Losses:**



Video Stream Adaptation

Network layer

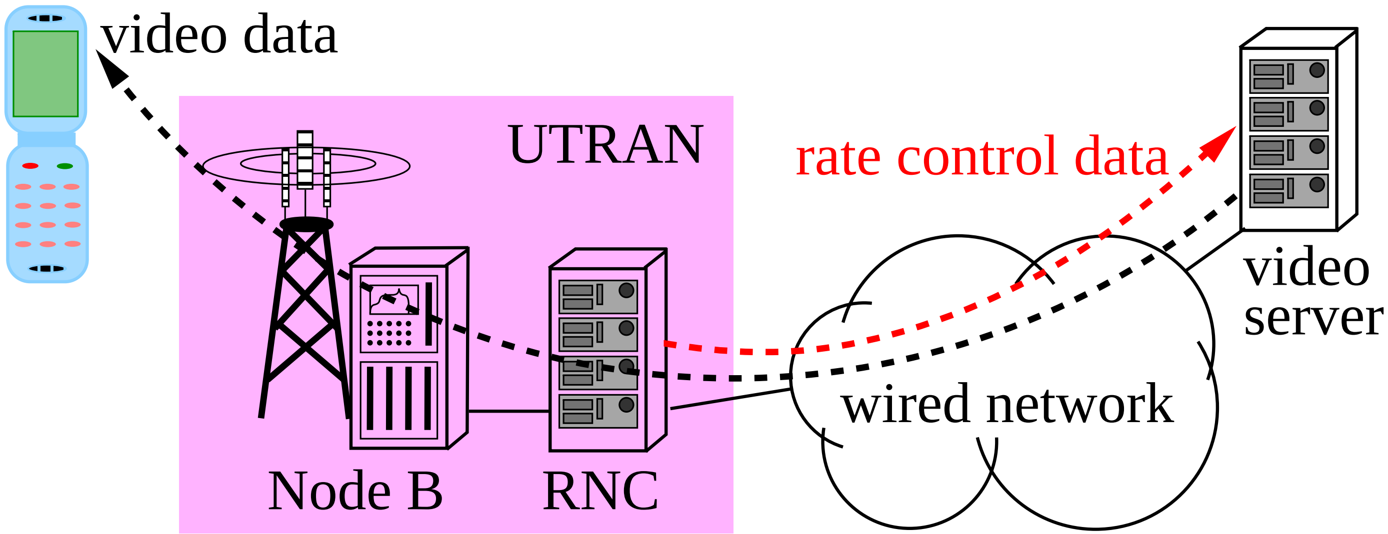
Application-aware buffer management.

Z. Orlov, M. Necker, "Enhancement of Video Streaming QoS with Active Buffer Management in Wireless Environments", European Wireless 2007

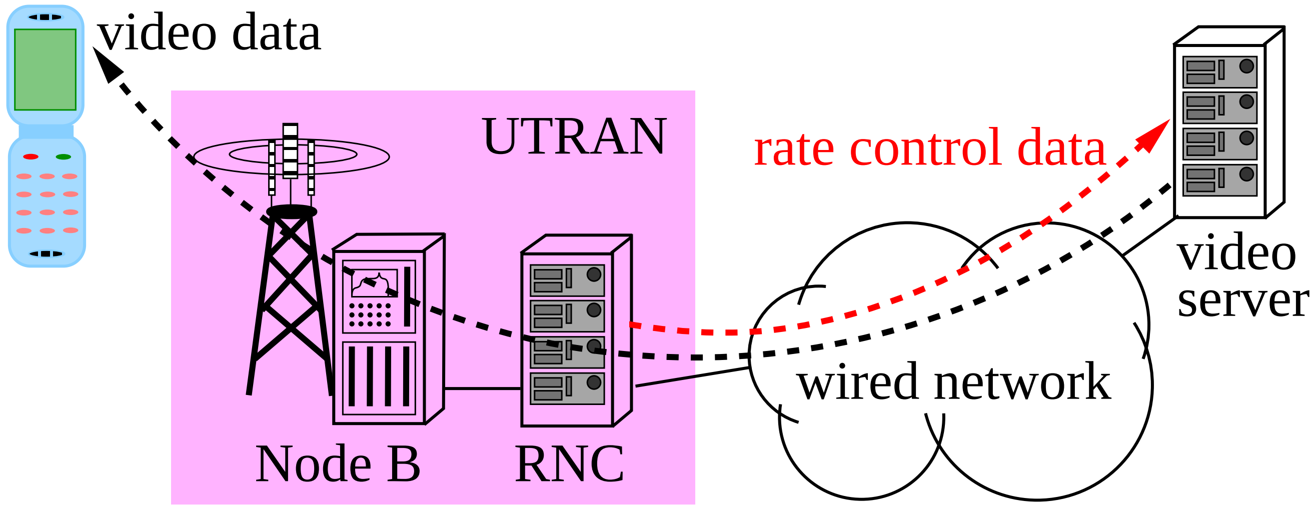
Compression layer

- **Transcoding points/proxies**
- **End-to-end(E2E) rate control(RC)**

  E2E RTP-based RC
- **Network-driven rate control**



Network-Driven Rate Control



Advantages (compared to E2E RTP-based RC)

- **Faster reaction to changes of channel state**
- **Preciser decisions due to direct access to link layer**
- **Simpler up-switch algorithm**
- **Global sight of the cell (optimization point of view)**
- **Possibility to adjust the channel data rate (transmission power)**

Disadvantages

- **Radio link is supposed to be the only bottle-neck.**
- **Implementation efforts**

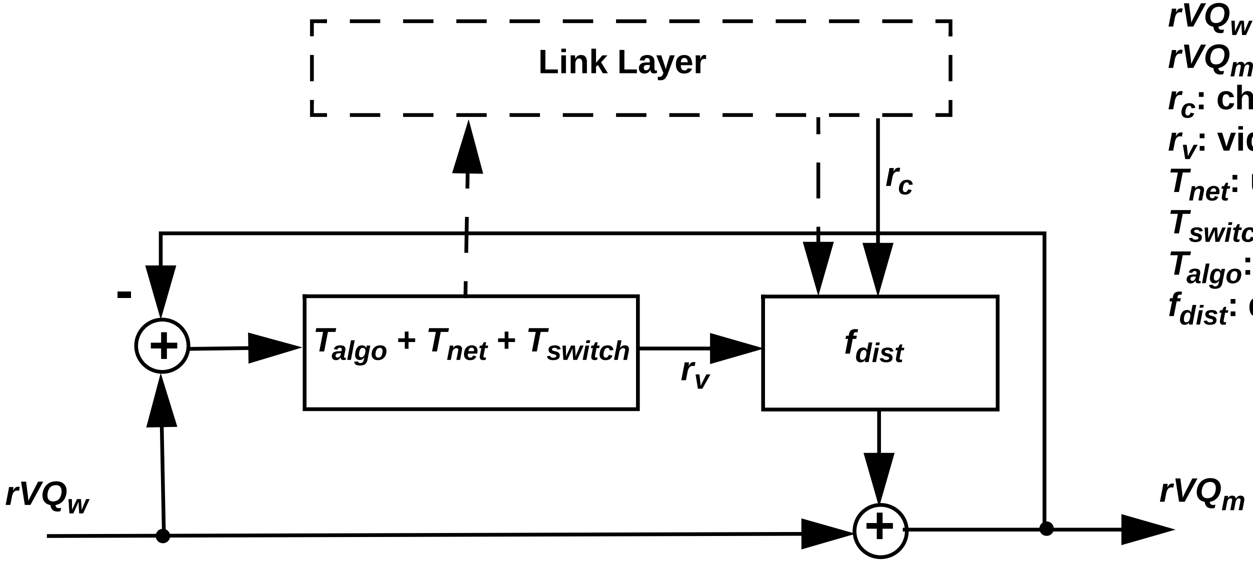
Control loop for video streaming adaptation

Metric

- **relative (<u>best possible</u>) video quality *rVQ* = [0, 1.0]**
- $rVQ(t) := f(r_c(t), r_v(t))$

Subject

rVQ at receiver should be 1.0

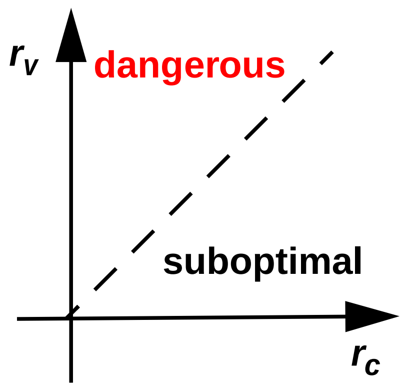


- rVQ_w: relative wished video quality
- rVQ_m: relative measured video quality
- r_c: channel data rate
- r_v: video data rate
- T_{net}: uplink network delay
- T_{switch}: video switching delay
- T_{algo}: switching-decision algorithm delay
- f_{dist}: distortion function

Optimal Adaptation

Adaptation

- minimise *diff* = r_c - r_v
- *diff* must be nonnegative
- maximise r_v



Constraints

- video data rates are discret in bit-stream switching approach
- delays in the control loop can become large
- frequent alternate up-down switching can be annoying

Possible metrics

- $r_v(t)$ / $r_c(t)$
- video data throughput

UTRAN Model and Investigated Scenario

Model

- detailed model of a single-cell HSDPA-system
- emulation (IKR EmuLib based on IKR SimLib)
- IKR video streaming testbed

Scenario

- urban channel trace (mean transport format bandwidth 1.055 Mbps)
- smallest transport format bandwidth 343 kbps
- one user (video)

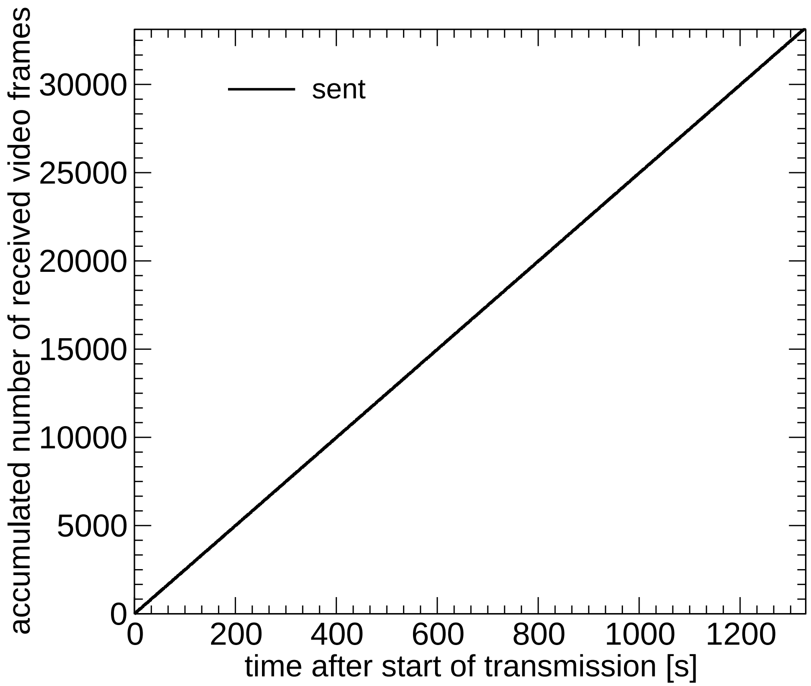
Video

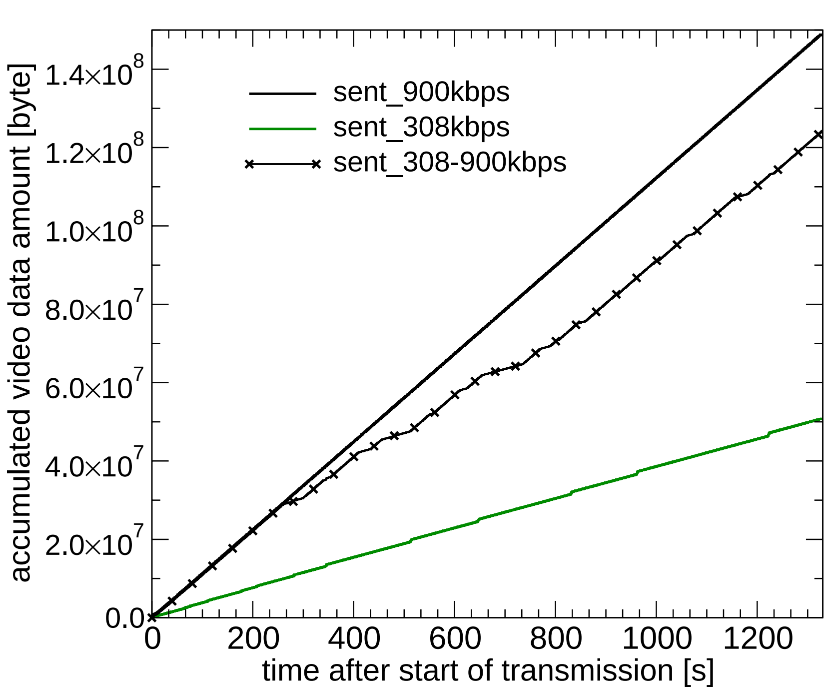
- two versions (308 kbps and 900 kbps)
- CIF, 33120 frames, 25 Frames/s

Factors influencing Video Quality

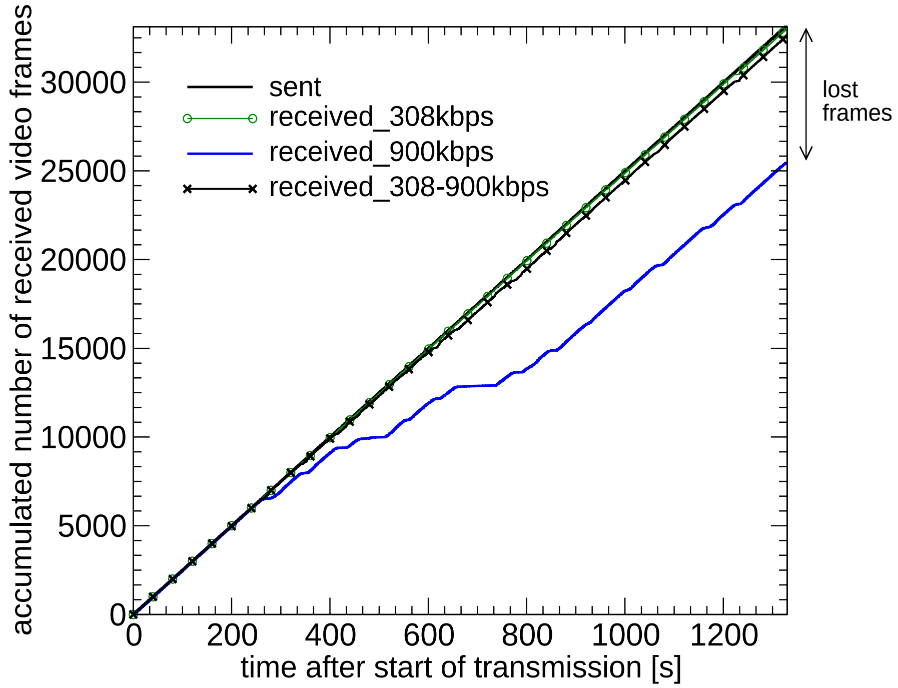
Factors influencing VQ

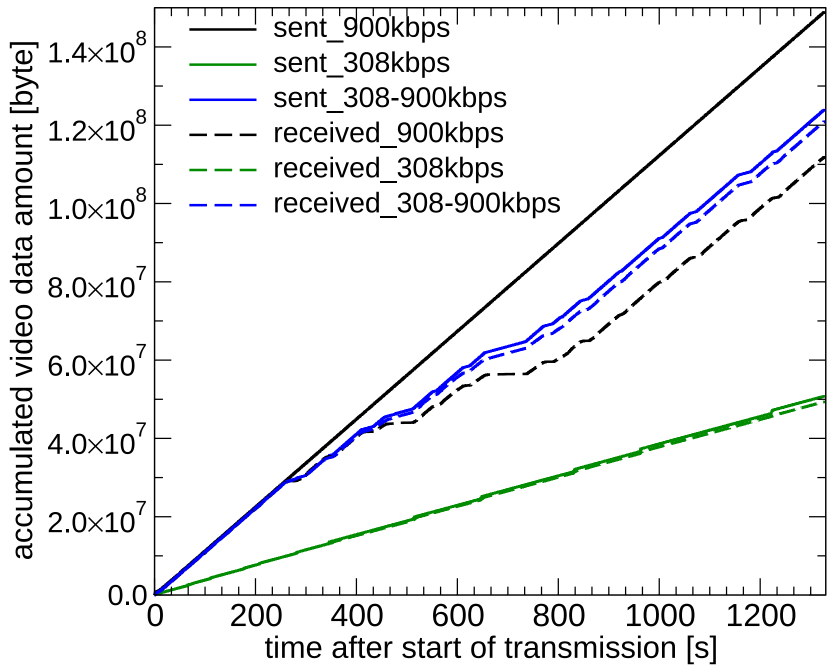
- **data amount (Mapping to PSNR/MOS later)**
- **video information continuity (Trial of mapping to subjective quality later)**





Continuity and Data Amount





- **continuity and FER (Frame Error Rate) in adaptation case are very good**
- **received data amount in the adaptation case is higher than in the case without adaptation (900kbps) due to IP-packet dependencies (video frames).**

Video Quality Evaluation: PSNR And MOS

Objective metric: PSNR (Peak Signal-to-Noise Ratio)

- **ITU-T Recommendation P.930**
- **the noise part is represented by mean squared error of luminance component between the video under test and the reference video. Peak signal energy is represented by maximal possible luminance value.**

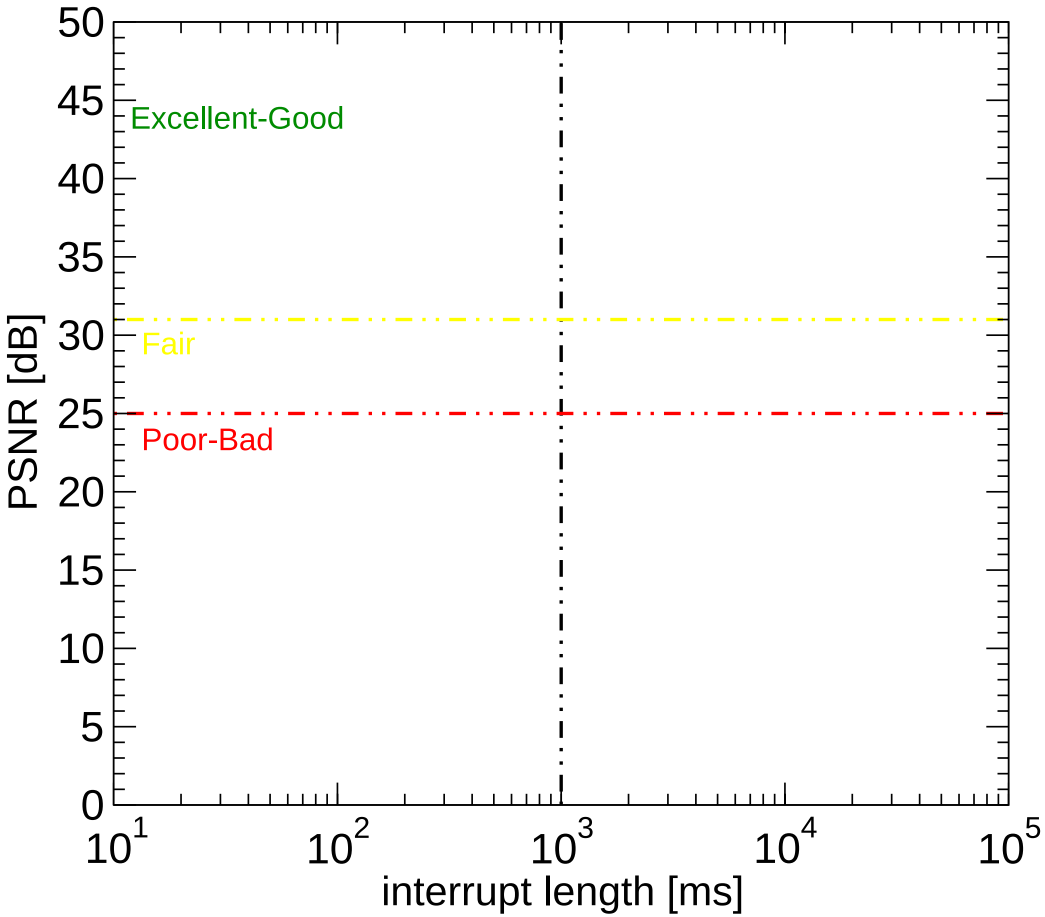
Subjective metric: MOS (Mean Opinion Score)

- **ITU-T Recommendation P.800**

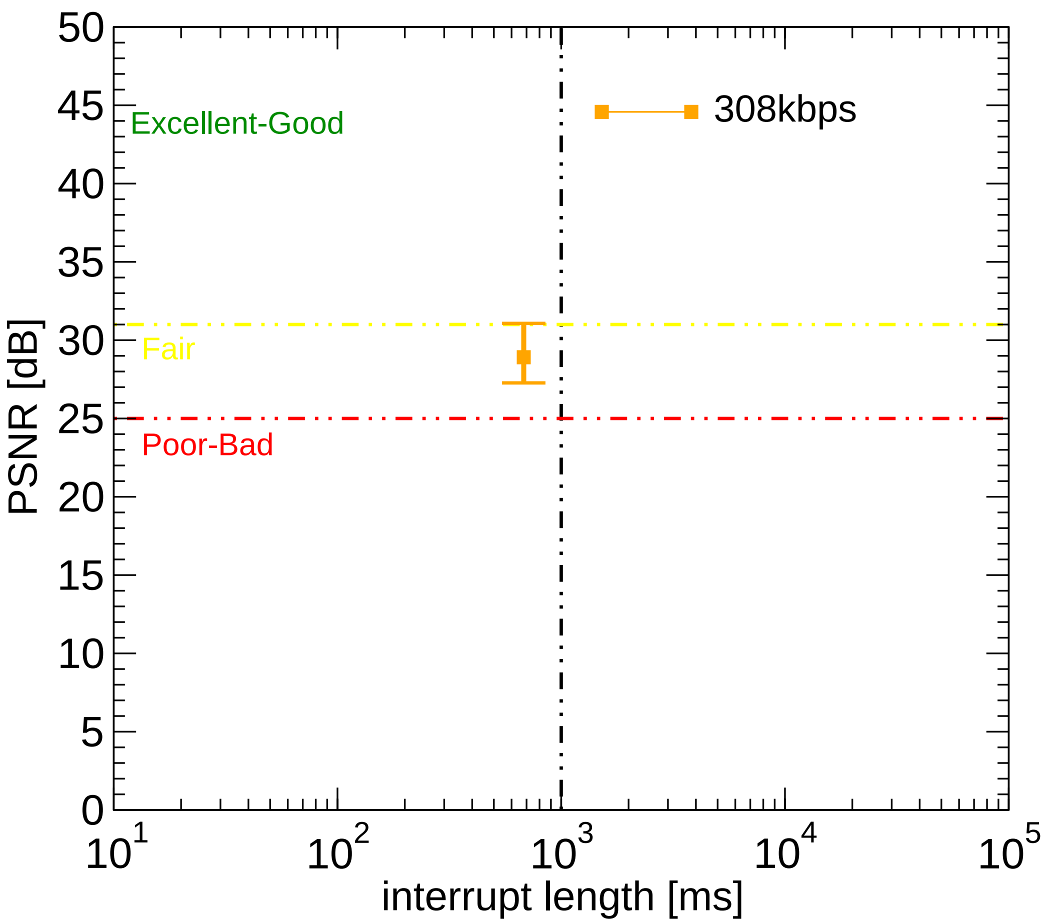
Scale	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

PSNR [dB]	MOS
> 37	5 (Excellent)
31 - 37	4 (Good)
25 - 31	3 (Fair)
20 - 25	2 (Poor)
< 20	1 (Bad)

Video Quality of Received Content

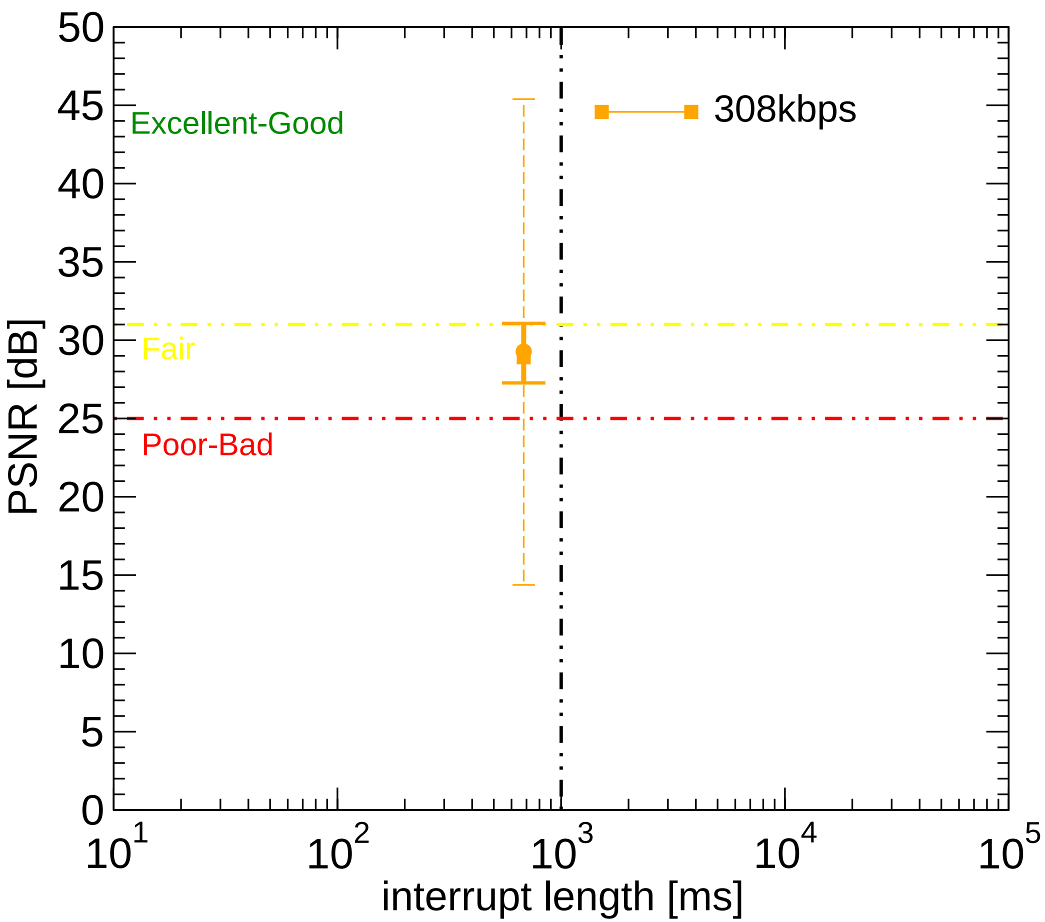


Video Quality Of Received Content



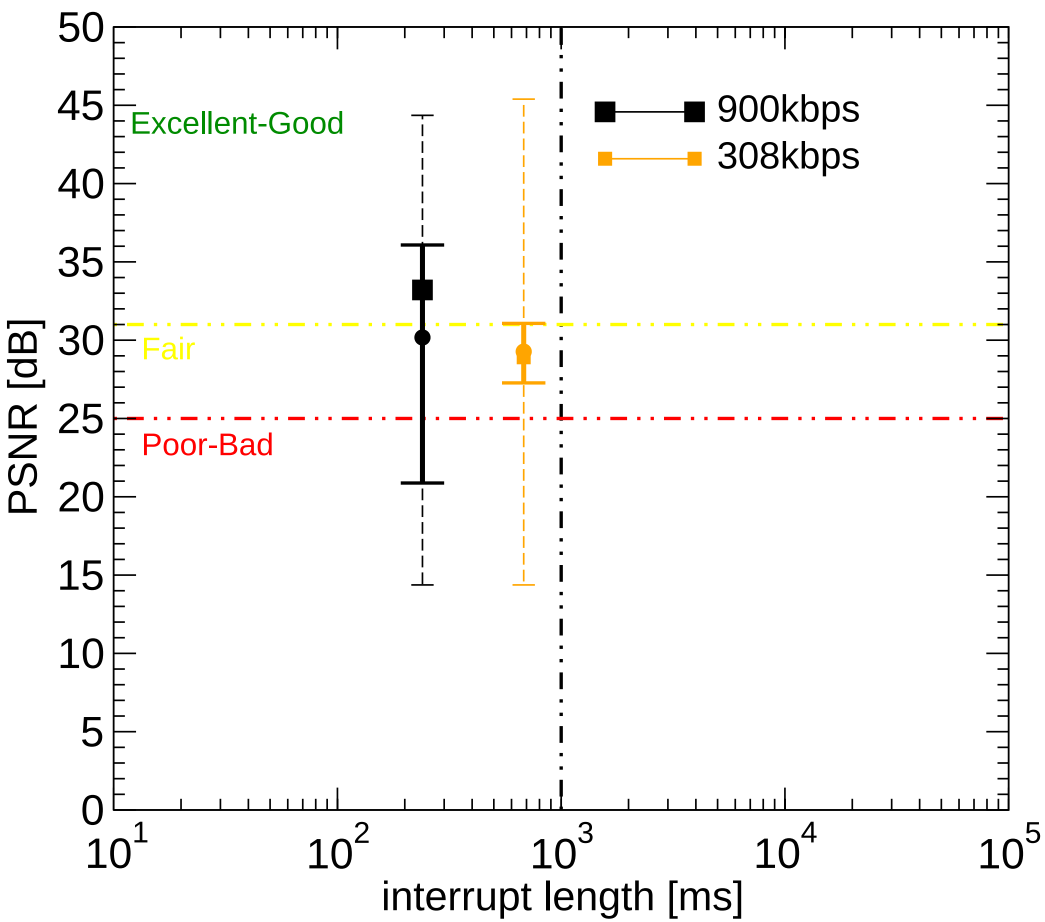
video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	
900		
308-900		

Video Quality Of Received Content



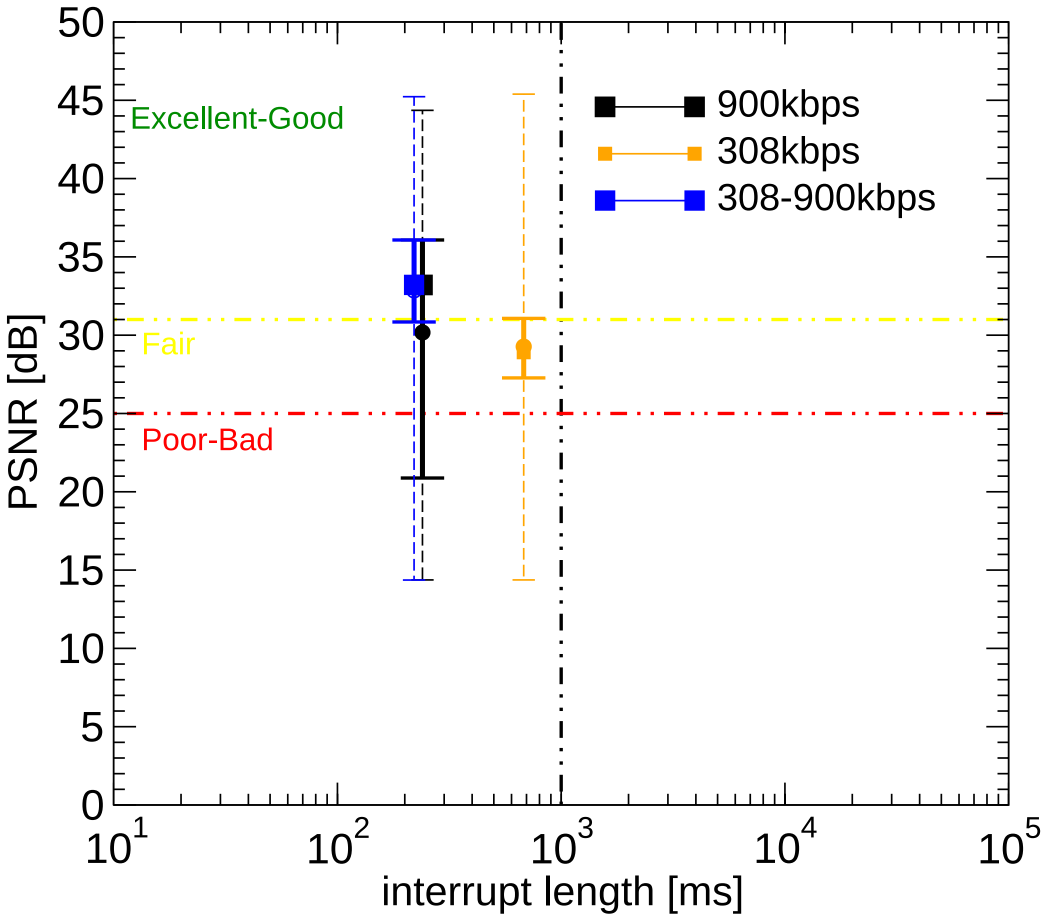
video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	
900		
308-900		

Video Quality Of Received Content



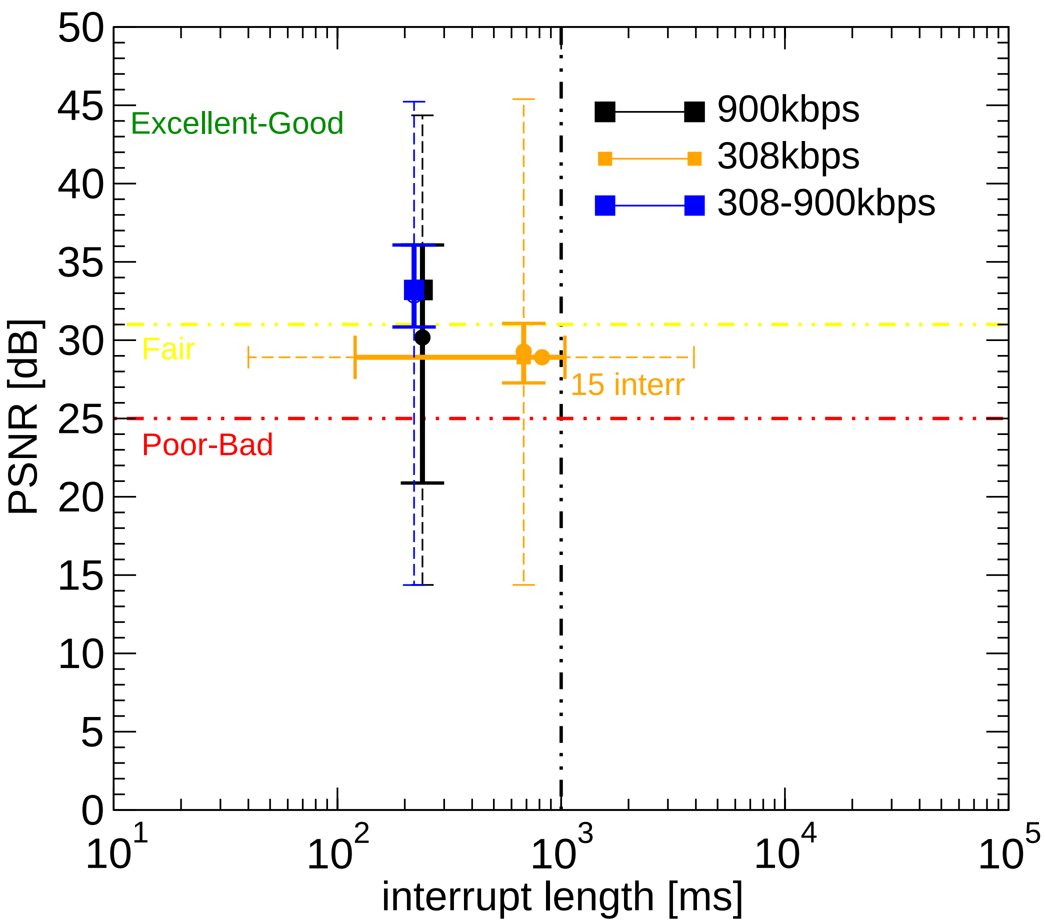
video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	
900	0.270	
308-900		

Video Quality Of Received Content



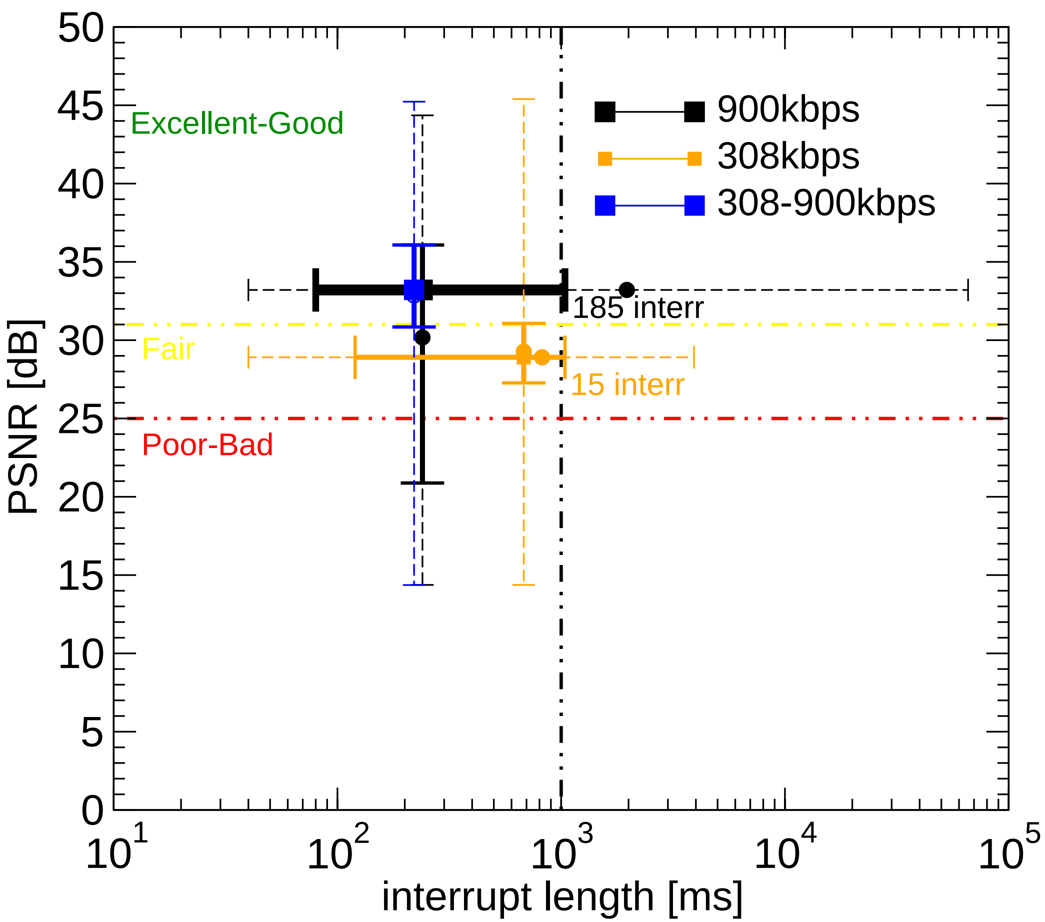
video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	
900	0.270	
308-900	0.039	

Video Quality Of Received Content



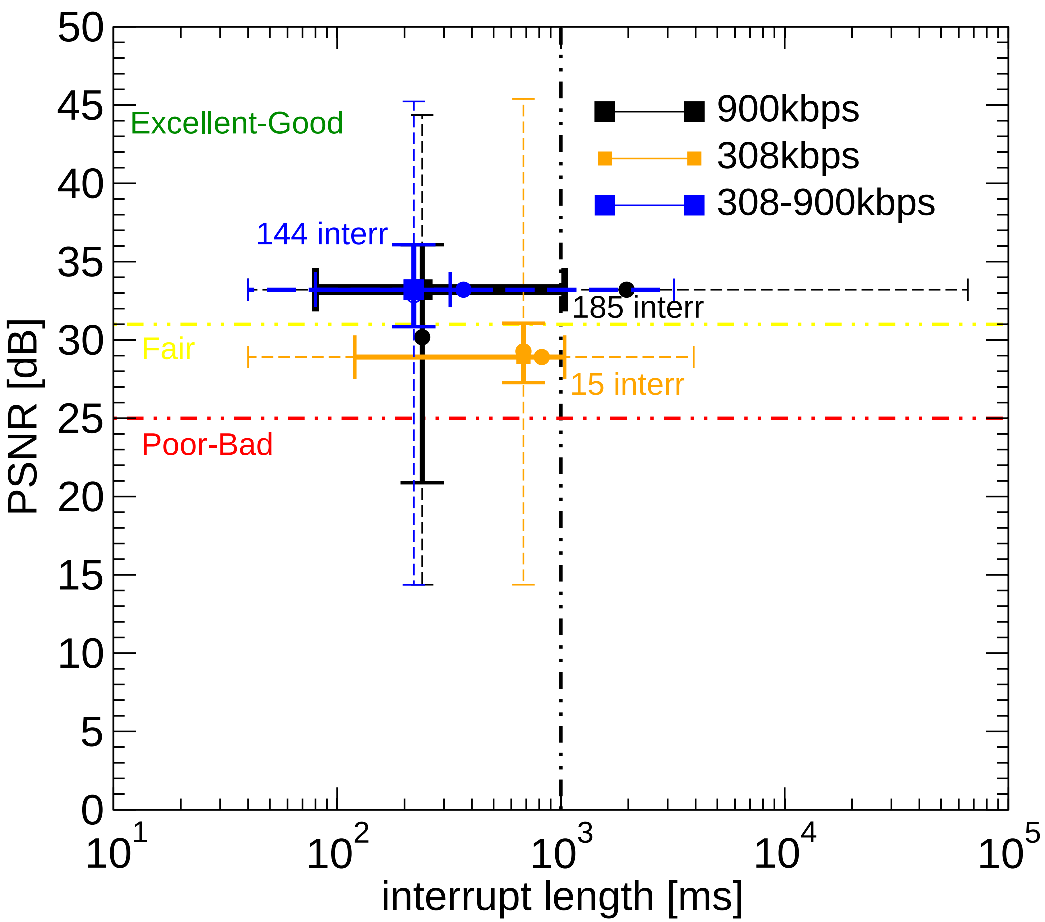
video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	0.266
900	0.270	
308-900	0.039	

Video Quality Of Received Content



video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	0.266
900	0.270	0.356
308-900	0.039	

Video Quality Of Received Content



video	p (psnr <= 25dB)	p(interr>1s)
308	0.009	0.266
900	0.270	0.356
308-900	0.039	0.138

- **Adaptation case achivied best results**
- **p(psnr <= 25 db) = 0.039 is the price for the better overall quality**

Conclusion and Outlook

- **Network-driven rate control has functional advantages compared to E2E RTP-based rate control, if the radio link is the bottle-neck**
  - faster
  - preciser
  - simpler
- **There is a possibility to optimise the whole cell**
- **Adjust of channel rate (power) can be performed for a short period**
- **Investigations with several competing users are planed**