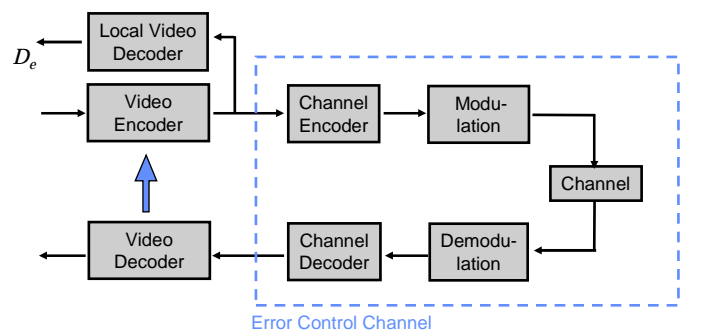

Video Transmission

- Transmission of Hybrid Coded Video
- Error Control Channel
- Motion-compensated Video Coding
- Error Mitigation
- Scalable Approaches
- Intra Coding
- Distortion-Distortion Functions
- Feedback-based Error Control

Transmission of Hybrid Coded Video



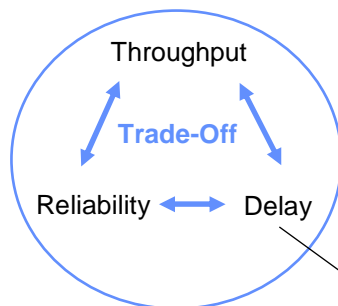
$$D_d = D_e + \Delta D$$

$$PSNR_d = PSNR_e - \Delta PSNR \quad (PSNR = 10 \log(255^2/D) \text{ [dB]})$$

How do system components interact?

Error Control Channel

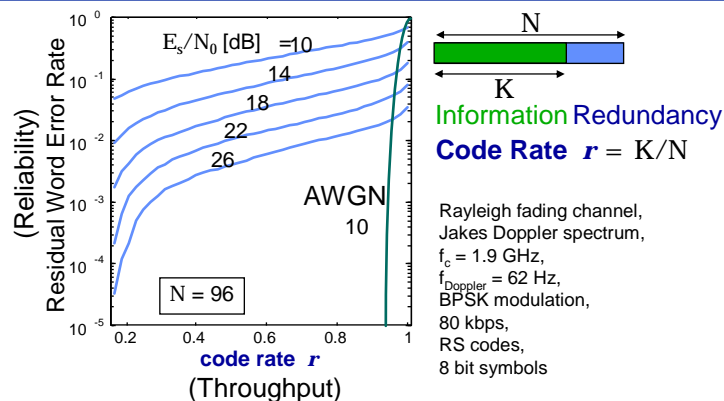
- Combination of
 - Channel codec
 - Modulation
 - Channel
- Interface to video codec



From: Färber

Low (RTD < 250 ms) for conversational services

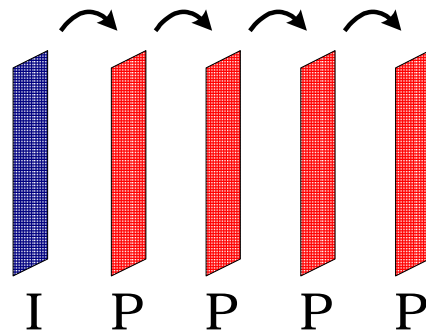
AWGN and Rayleigh Channel



- Code rate r** controls bit allocation between source and channel coding
- Trade-off reliability vs. throughput depends on ECC

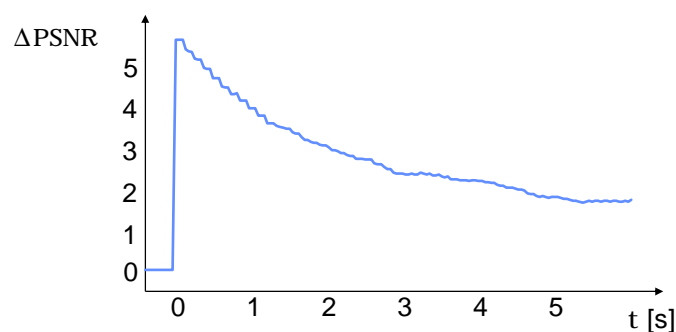
From: Färber

Motion-Compensated Coding of Video



- If just one frame is missing → reference pictures at coder and decoder differ → error propagation
- Error decays slowly → mitigate error propagation

Recovery from Single Burst



- Single burst covering 1/3 of a frame
- Previous frame concealment
- Average over many trials
- No Intra

Temporal Error Propagation

- 1 picture = 1 packet
- 10 % packet loss probability



Sources of Bad Video at the Decoder

- Source coding distortions
 - Not enough bit-rate available for targeted spatio-temporal resolution
 - Large activity in the video signal
 - Many scene cuts
- Transmission errors and throughput variation
 - Channel noise
 - Fading
 - Cell overload and variations

Set source coding and transmission system parameters for best decoder video quality given the application constraints

Applications and Constraints

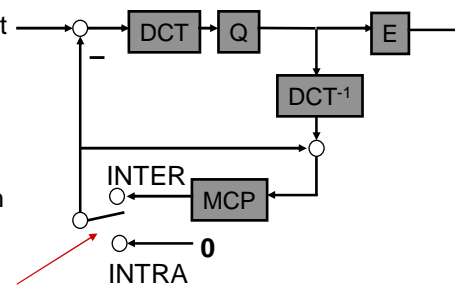
- Conversational vs. non-conversational services
- Unicast vs. multicast: single vs. multiple possibly heterogeneous transmission conditions
- Delay constraints:
 - 250 ms RTT for conversational services
 - $\approx 2\text{-}3$ s or more play-out delay for unicast streaming
 - ≈ 0.5 s for multicast streaming
- High vs. low bit-rate coding: source coding performance
- Off-line vs. on-line encoding: adaptation possibilities
- Feedback: with or w/o per picture or statistical feedback

Videoconferencing: On-line Encoding, Low Delay

- Conversational services:
 - Low bit-rates (< 100 kbit/s): QCIF/CIF pictures @ 10/15 Hz
 - Low RTT < 250 ms corresponding to 2-3 picture intervals
- Methods for improvement
 - Reduce number of errors
 - ♦ **Increased FEC**: decreases source bit-rate/quality
 - ♦ No retransmissions possible
 - Mitigate impact of errors
 - ♦ **Concealment** of lost pictures
 - ♦ **Intra** block coding: stop temporal error propagation
 - ♦ **Multi-frame prediction** from acknowledged references
 - ♦ Intra-picture **scalability: syntax** (spatial, SNR)

Video Encoder

- Hybrid video coding is the most successful compression scheme and used in all current standards (MPEG-1/2/4, H.261, H.263, H.264/AVC...)
- Motion-compensated prediction provides efficiency
- Transform coding of prediction error
- INTRA/INTER mode decision on block basis (INTRA rate β)

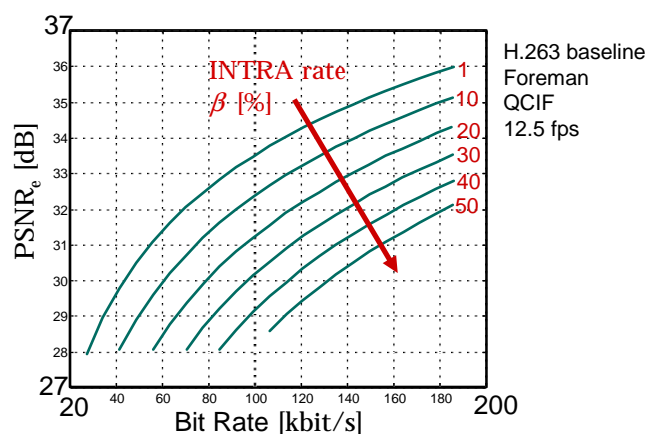


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Thomas Wiegand: Digital Image Communication

Video Transmission 11

Rate-Distortion Performance



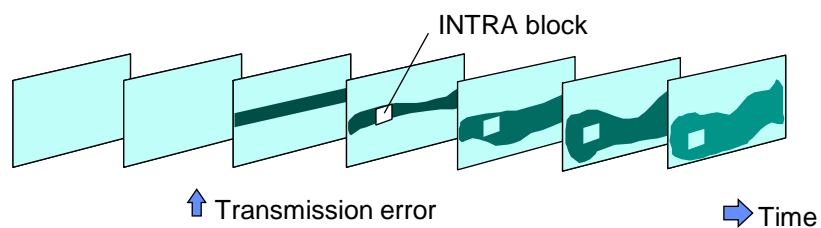
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Video Transmission 12

Video Decoder

- MCP causes spatio-temporal error propagation in case of a transmission error
- Resynch. and error concealment of limited help
- INTRA coding helps but reduces coding efficiency
- Loop filter introduces leakage



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Video Transmission 13

Error Resilience: MPEG-4 vs. H.264/AVC

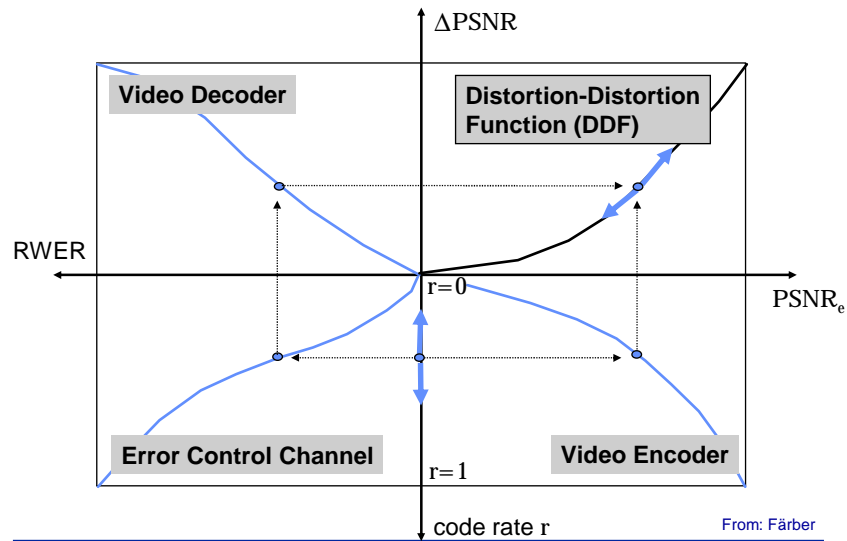
10 % Packet loss, 20 % of each picture Intra coded

MPEG-4 ASP @ 64 kbit/s
10 Hz, QCIF

H.264/AVC @ 64 kbit/s
10 Hz, QCIF



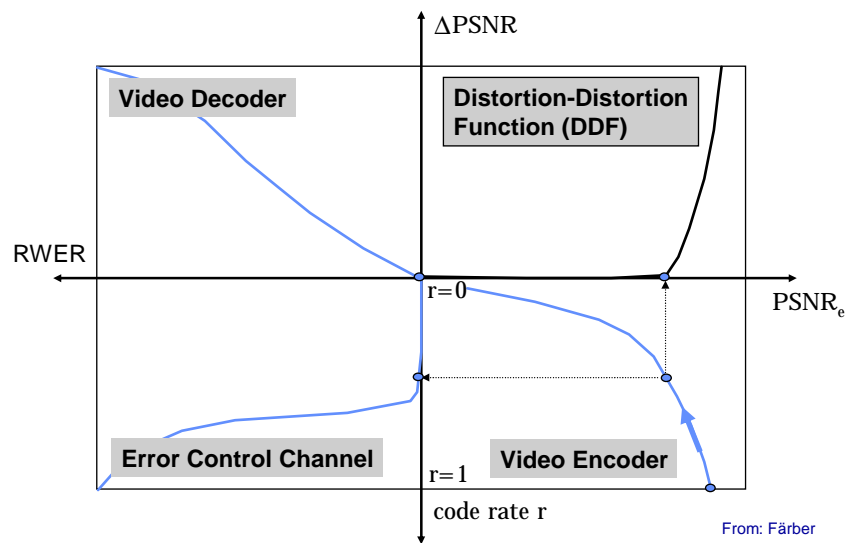
Interaction of System Components



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Video Transmission 15

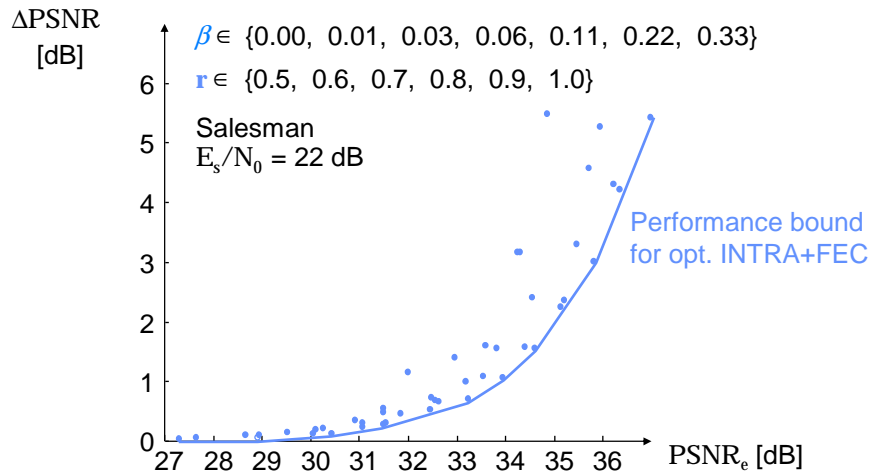
When Channel Coding Does the Job



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Video Transmission 16

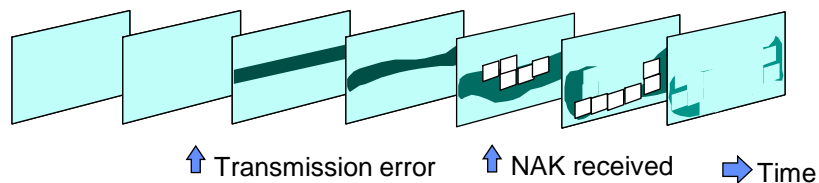
Performance Bound for INTRA+FEC



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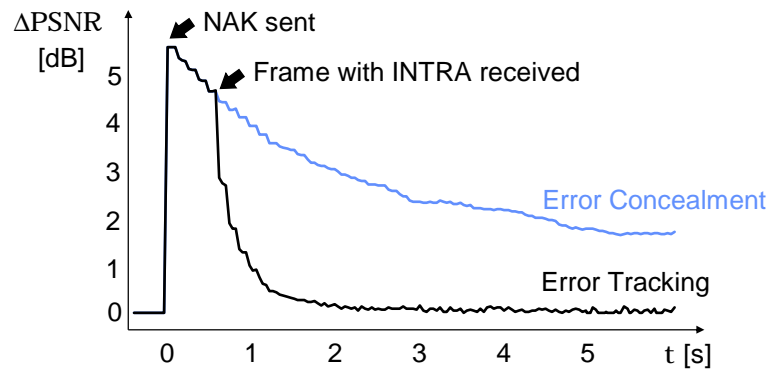
Feedback-Based Error Control

- Spatio-temporal error propagation can be reconstructed at the encoder using an Error Tracking algorithm and **feedback** from the decoder
- Feedback consists of sending Negative Acknowledgements (NAKs) for lost image parts
- Use INTRA-mode for macroblocks affected by transmission errors to stop error propagation



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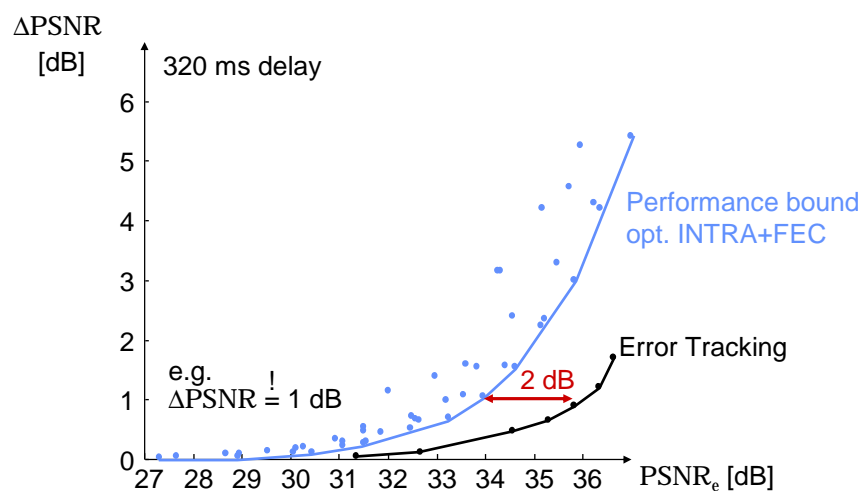
Recovery from Single Burst



- Same conditions as above
- 700 ms RTD

From: Färber

Comparison of DDFs



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Demo

- Sequence: Salesman, frames 0-300, 15 fps
- Rayleigh Fading, $E_S/N_0 = 22$ dB, $f_D = 62$ Hz
- FEC block size: 88 byte (1 GOB)
- BPSK, $f_c = 1900$ MHz, 80 kbps

<p>High error resilience Low coding efficiency</p> <p>$\beta = 33/99$ $r = 48/88$ $PSNR_e = 26.8$ $PSNR_d = 26.7$ $\Delta PSNR = 0.1$</p>	<p>High coding efficiency Low error resilience</p> <p>$\beta = 1/99$ $r = 88/88$ $PSNR_e = 37.2$ $PSNR_d = 28.8$ $\Delta PSNR = 8.4$</p>
<p>Max PSNR at decoder (Good compromise)</p> <p>$\beta = 6/99$ $r = 72/88$ $PSNR_e = 34.3$ $PSNR_d = 32.7$ $\Delta PSNR = 1.6$</p>	<p>Error Tracking</p> <p>$\tau = 3$ $r = 72/88$ $PSNR_e = 35.6$ $PSNR_d = 34.5$ $\Delta PSNR = 1.1$</p>

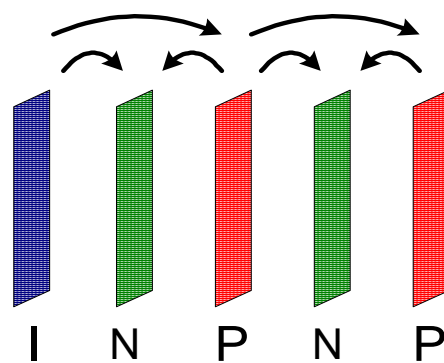
From: Färber



Video Streaming: Off-line Encoding, High Delay

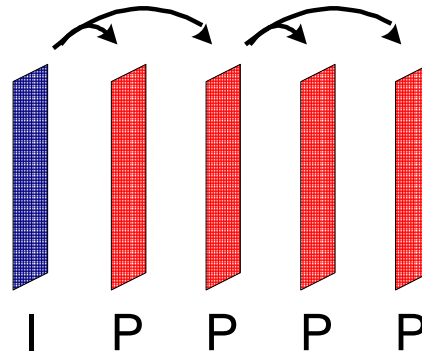
- Wireless streaming services
 - Medium bit-rates (100-300 kbit/s):
QCIF/CIF pictures @ 15/30 Hz
 - High delay $\approx 2\text{-}3$ s corresponding to 30/60 – 45/90 pictures
- Methods for improvement
 - Reduce number of errors
 - ♦ Retransmissions
 - ♦ Inc. FEC (Multicast)
 - ♦ Adjust source bit-rate to average throughput
 - Mitigate impact of errors
 - ♦ Inter-picture scalability: insertion of **non reference pictures**
 - ♦ Concealment and intra-picture methods of less importance

Temporal Scalability with B-Pictures



- non-reference pictures (N) maybe discarded
- Requires large delay
- Unequal protection

P-Picture with Switched Reference



- Every other P picture maybe discarded
- Rate-Distortion performance problems
- Unequal protection

Summary: Video Transmission

- Transmission of video requires consideration of source coding and transmission channel
- Transmission channel is often lumped into unit called: Error Control Channel
- In videoconferencing, transmission errors are often not avoidable
- Motion-compensated prediction leads to spatio-temporal error propagation if error concealment is applied at decoder
- Video encoder can be controlled to stop spatio-temporal error propagation
- Trade-off must be balanced considering the complete system
- Distortion-distortion functions evaluate trade-off
- Feedback provides improved performance
- In video streaming, channel coding (i.e. re-transmissions) and temporal scalability can do the job