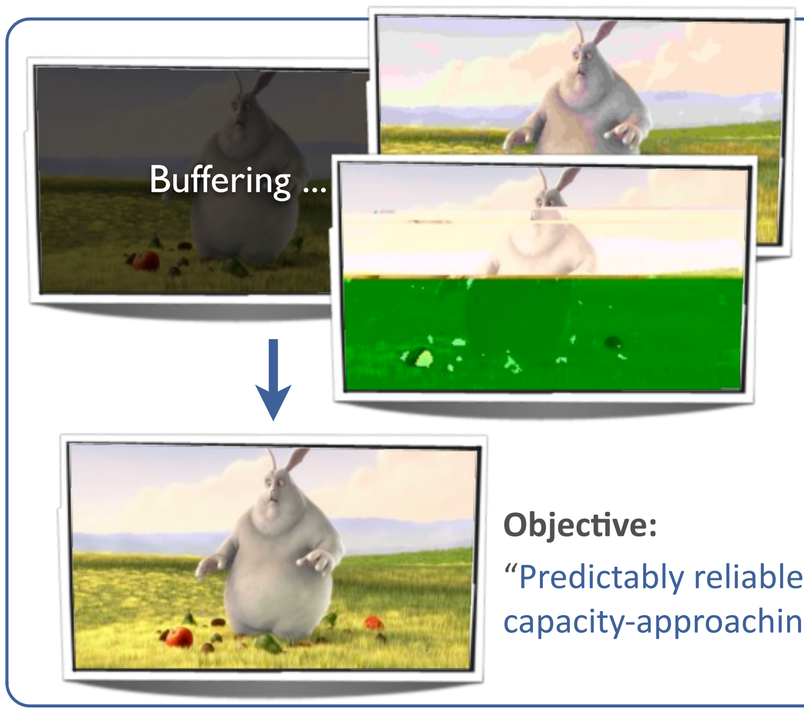
PRRT: Predictably Reliable Real-time Transport

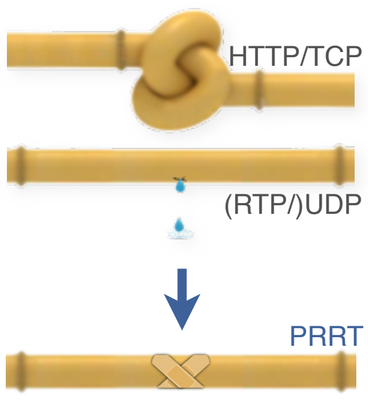
UNIVERSITÄT DES SAARLANDES

Telecommunications Lab

Motivation



State-of-the-art Internet video streaming ...



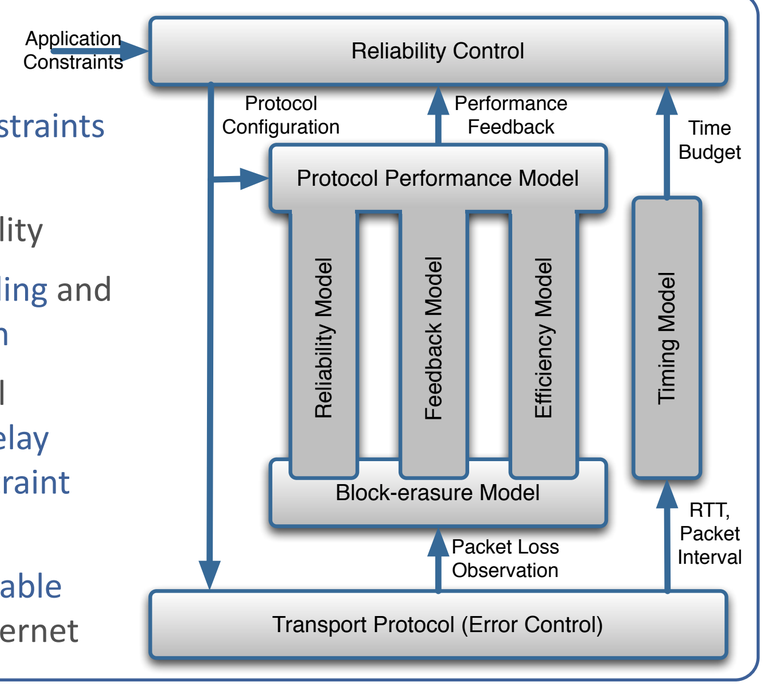
Objective:

"Predictably reliable media transport pipe with capacity-approaching bandwidth utilization"

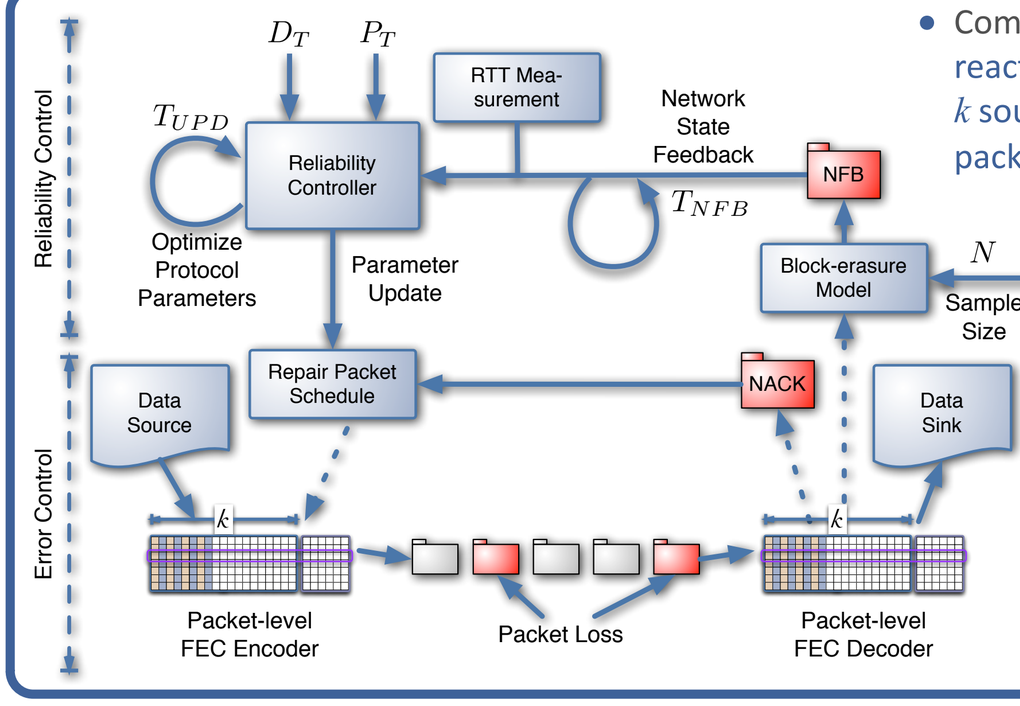
Predictable Reliability

Media- and network-aware error control

- Consider application's constraints on delay and reliability
- Vs. total and partial reliability
- Based on stochastic modeling and combinatorial optimization
- Instantly optimize protocol configuration subject to delay constraint, reliability constraint and bandwidth constraint
- Dynamically approach variable channel capacity in the Internet



Core Architecture: Reliability Control

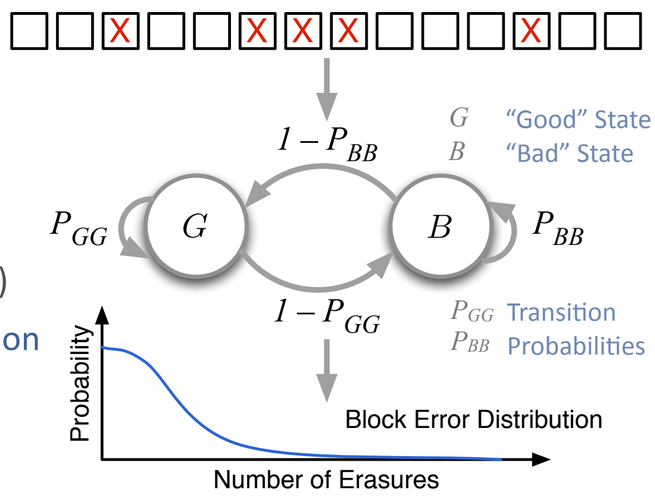


- Combined proactive & reactive error control with k source packets and repair packet schedule N_P
  - Error control captures short-term network dynamics
  - Reliability control optimizes error control in long term

N	Sample Size
T_{NFB}	Feedback Interval
T_{UPD}	Update Interval
D_T	Delay Constraint
P_T	Reliability Constraint
k	# Source Packets
N_P	Repair Packet Schedule

Protocol Performance Model

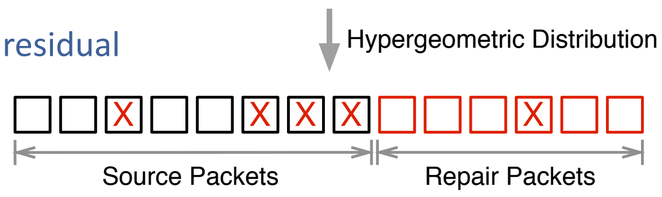
Block Erasure Model



- Observe patterns of packet erasures
- Simulate temporal correlation (e. g. via Gilbert-Elliott model)
- Block error distribution provides general representation

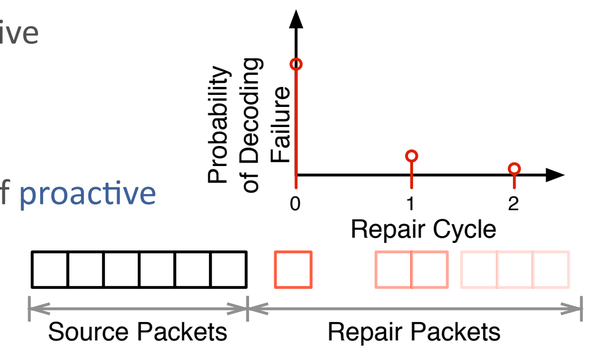
Reliability Model

- Formulate expected residual erasure rate
- Consider all cases of decoding failure
- Simulate erasure patterns via block error distribution and hypergeometric distribution
- Consider unreliable negative receiver feedback



Efficiency Model

- Simulate joint efficiency of proactive and reactive error control
- Exponentially decreasing failure probability

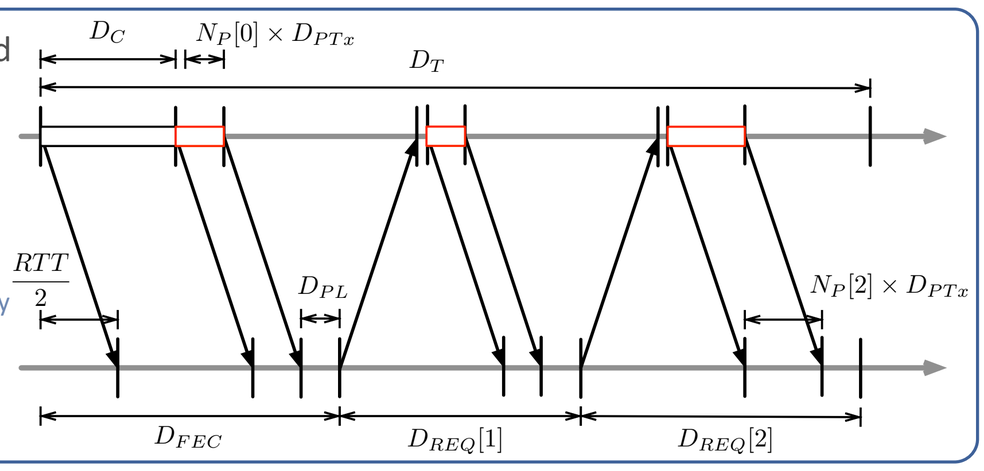


- Formulate packet-level redundancy and protocol overhead

Timing Model

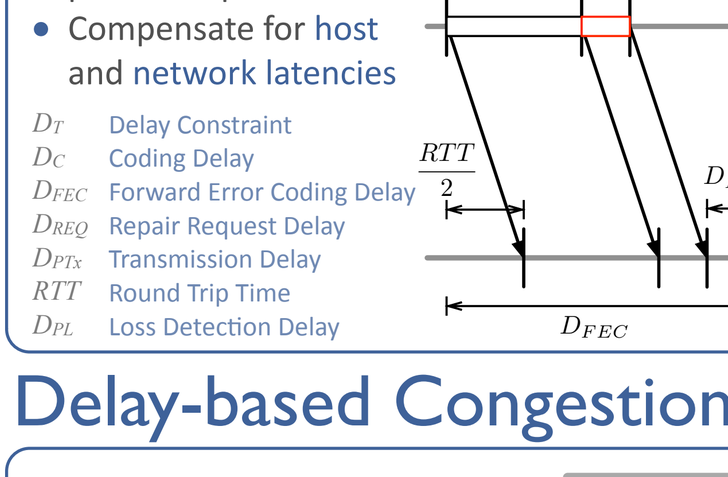
- Synchronize distributed protocol operations
- Compensate for host and network latencies

D_T	Delay Constraint
D_C	Coding Delay
D_{FEC}	Forward Error Coding Delay
D_{REQ}	Repair Request Delay
D_{PTx}	Transmission Delay
RTT	Round Trip Time
D_{PL}	Loss Detection Delay



Delay-based Congestion Control

- Delay- and equation-based congestion control (based on FAST TCP approach)



- Smooth, near-optimum bandwidth estimation via integer congestion signal
- Unaffected by physical packet loss (e. g. on wireless network paths)
- Obtain additional bandwidth in case competing TCP traffic underutilizes the network: Opportunistic TCP-friendliness

Example: Dynamic Video Streaming

- Replace HTTP/TCP in standardized DASH (Dynamic Adaptive Streaming over HTTP)
- Proactively schedule packets under PRRT's goodput estimate
- Transmit at highest quality level as long as bandwidth is underutilized by competing TCP sessions
- Increase throughput by up to 100% compared to HTTP/TCP

Experimental Setup:

- Wide area network + IEEE 802.11n wireless network (RTT 50 ms)
- Dynamic video bit rate 4 - 12 Mbps, chunk size 2s

Manuel Gorius, Jochen Grün, Yongtao Shuai, Thorsten Herfet
{gorius, gruen, shuai, herfet}@cs.uni-saarland.de

Predictably Reliable Real-time Transport
http://www.nt.uni-saarland.de/en/projects/running-projects/prrt.html