GMD FOKUS and
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Combining Transport Layer and Link Layer Mechanisms for Transparent QoS Support of IP based Applications

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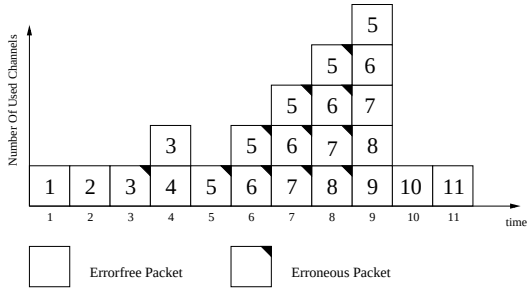
SMPT: Simultaneous MAC-Packet Transmission

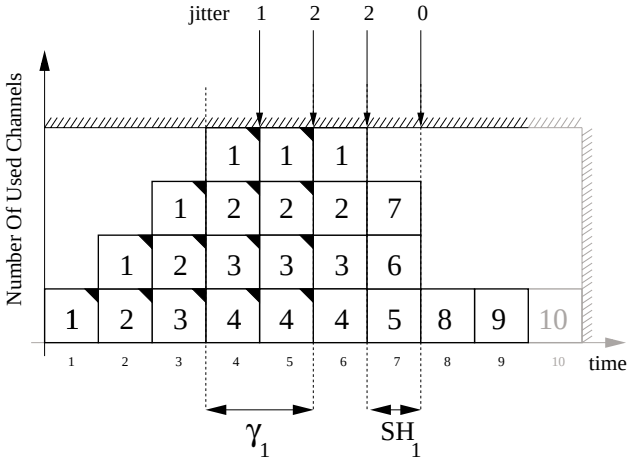
Goal: Stabilisation of QoS in terms of loss rate and jitter

Approach: Usage of multiple codes (CDMA) for dynamic allocation of additional channels for a single wireless terminal



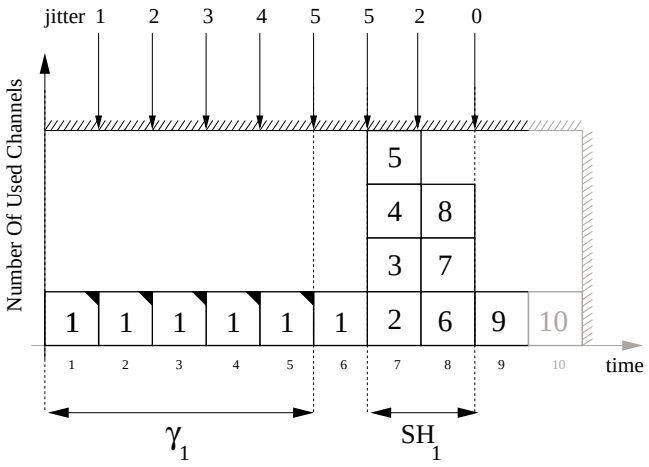
$\Longrightarrow$ Use multiple channels in case of errors $\Longrightarrow$ statistical multiplexing on the wireless link

Jitter Reducation with SMPT: Self Healing



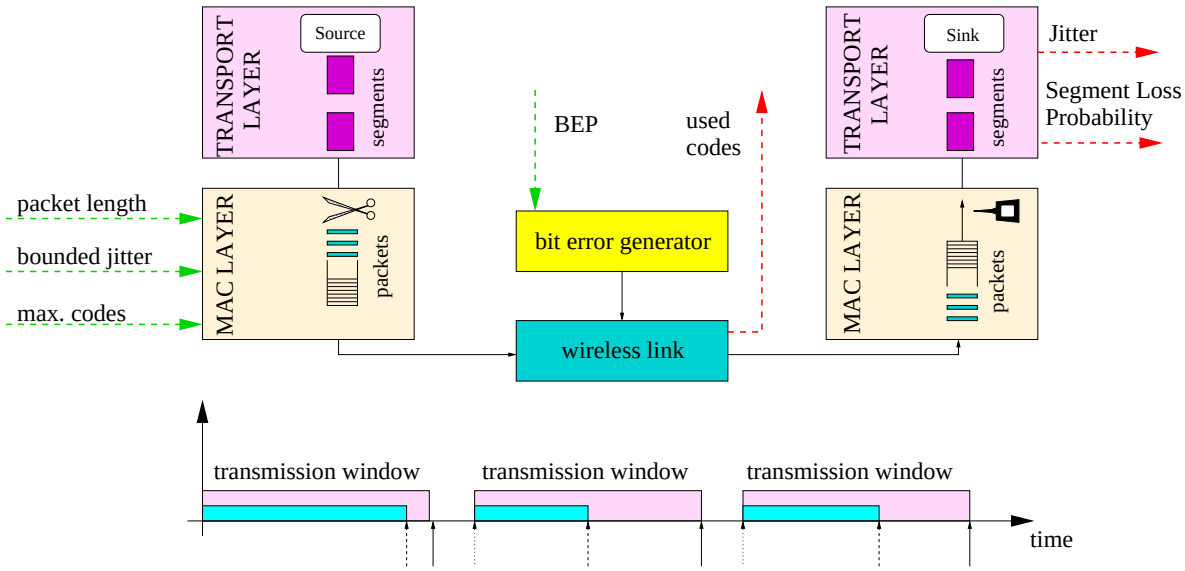
- jitter will be adjusted while transmitting packets
- further use of the spectrum

Probing and Slow Start

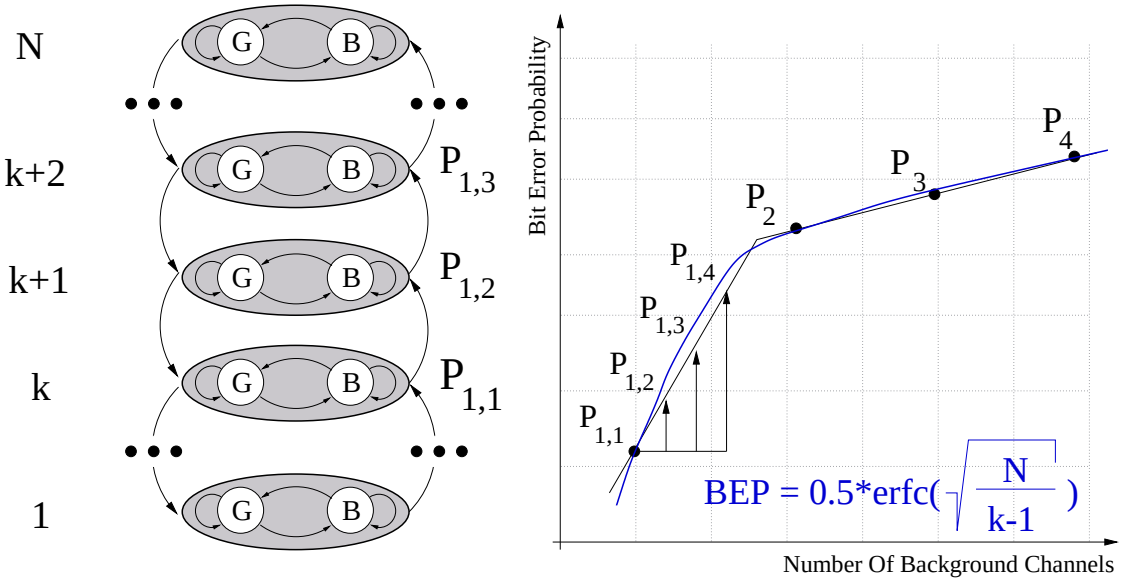


- Duing *bad* channel conditions only the *initial* channel is used - probing
- *Good* channel conditions are used for fast error recovery to reduce jitter - stabilisation
- Well suited for channels with bursty errors

System under Study



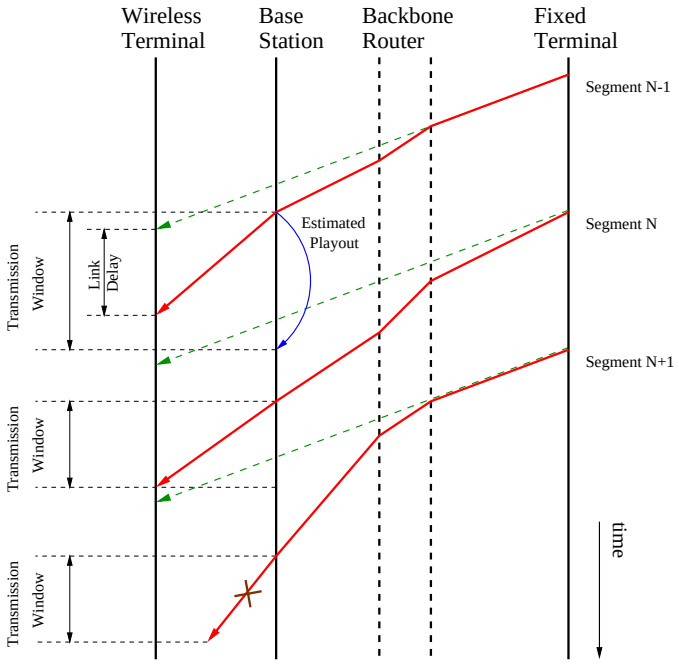
Channel Model



RTP improvements with SMPT

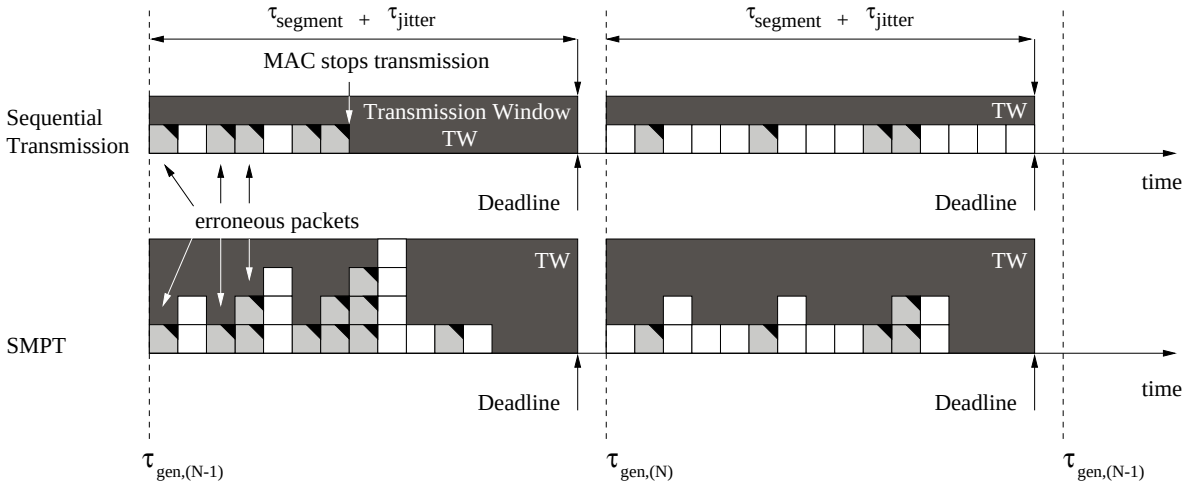
- Mobile source RTP flow (uplink)
  - Fixed TW is used for delay stabilisation over the wireless link.
  - L4 information for scheduling of L2 packets over parallel channels
- Mobile sink RTP flow (downlink)
  - Fixed TW allows stabilisation of delay
  - L4 information for controlling of TW

RTP: Estimating Playout Time



- SMPT allows usage of parallel channels in order to meet allowed jitter
- Number of used channels may be controlled by RTP timestamp and playout delay estimation
- Stopping transmission of **late** RTP packets saves bandwidth and reduces delay of subsequent packets

QoS Enhancement by SMPT



Simulation Results

Transm.	# Codes	Method Window	Loss Prob.	Late Prob.	Total Prob.
Sequential Transmission	1	42	0.0775	0.272	0.3503
		45	0.0116	0.182	0.1943
		40-42	0.2041	0.0	0.2041
		40-45	0.1278	0.0	0.1278
Simultaneous Mac Packet Transmission	2	42	0.0021	0.043	0.0459
		45	0.0002	0.020	0.0206
		40-42	0.0424	0.0	0.0424
		40-45	0.0183	0.0	0.0183

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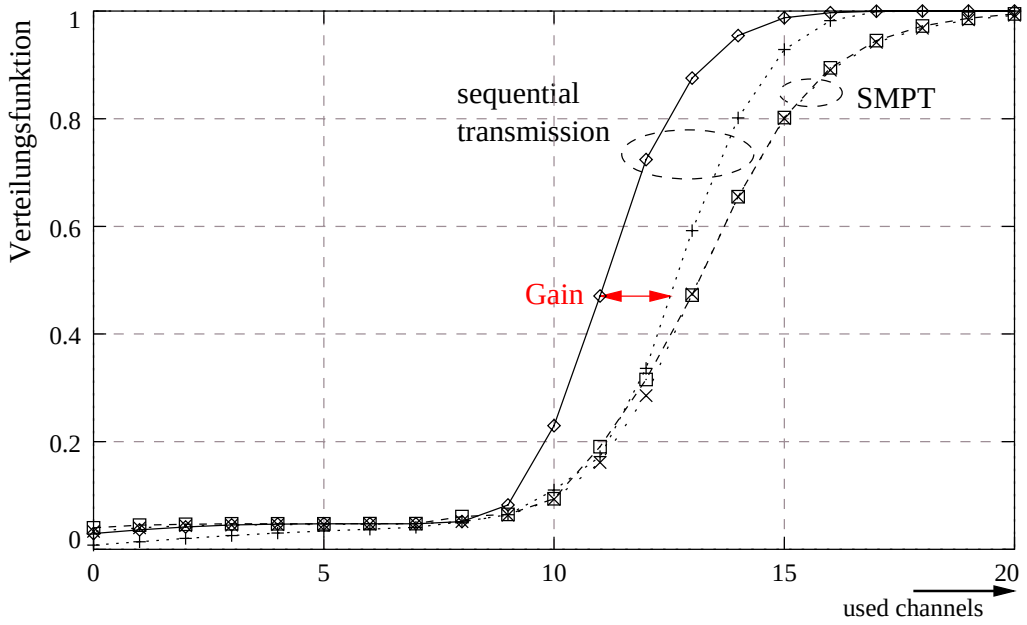
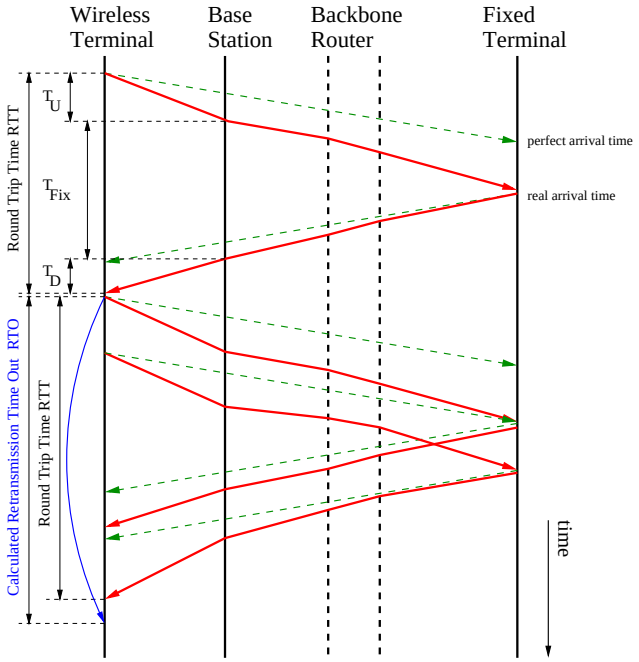
Used Channels



TCP improvements with SMPT

- Mobile source TCP flow (uplink)
  - Dimensioning layer 2 transmission window
- Mobile sink TCP flow (downlink)
  - SMPT with fixed transmission window: small segment delay variation (reduces probability of TCP RTO expiration)
  - dynamically adjusting TW based on an estimation of the RTO timer (in L2 of wireless terminal, or in base station)

Calculation of Retransmission Timeout



- Wireless link may lead to TCP performance degredation due to Retrans mission Timeouts (RTO)
- Usage of multiple channels in SMPT can be controlled based on Retran smission Timeout estimation

Conclusions

- QoS improvements by SMPT
  - SMPT improves the packet loss rate for a given jitter bound
  - Two additional channels lead to a satisfying quality improvement
  - SMPT uses capability of CDMA systems
- Further improvements by using L4 timing information for
  - transmission window TW
  - number of parallel channels
- Simulation result:
  reduction of total errors (loss and late)
  from 35% to 4.2%