

Adaptive Loss Concealment for Internet Telephony Applications

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Overview

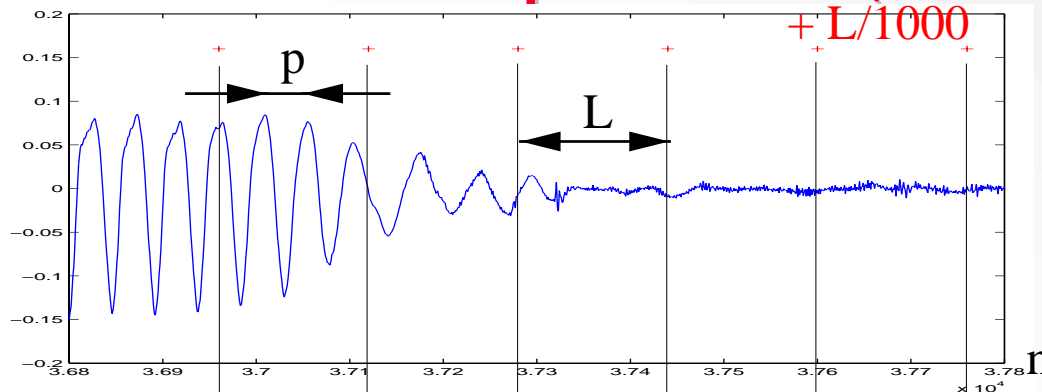
- Motivation
- Receiver-Based Concealment
- **Adaptive Packetization / Concealment**
(Sender/Receiver operation)
- Properties (packet sizes / header overhead, delay)
- Subjective Test
- Conclusions

Motivation: Loss of Speech Packets

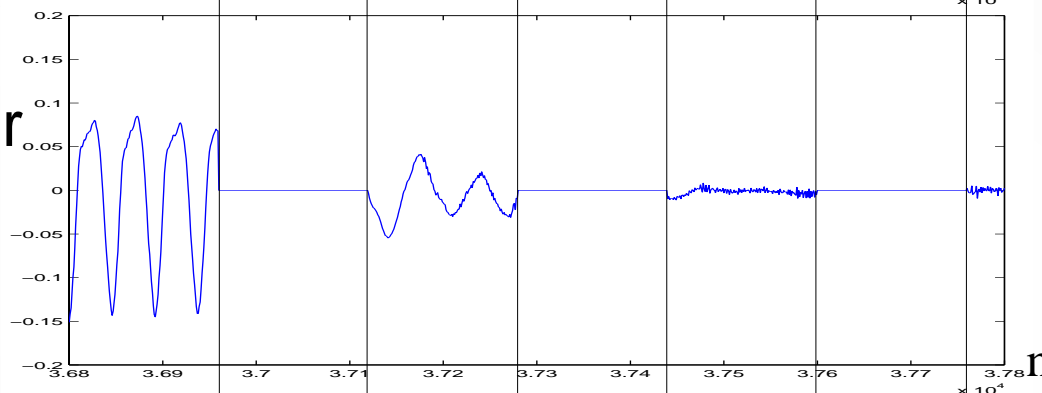
- Congestion in the Internet / Mbone
 - ⇒ Packet Loss
 - ⇒ speech signal dropouts
 - ⇒ need to enhance speech quality
- Solutions:
 - bandwidth adaptation, resource reservation,
 - differential services, redundancy/FEC,
 - interleaving, ***receiver-based concealment***

Packet Repetition (Receiver-Based)

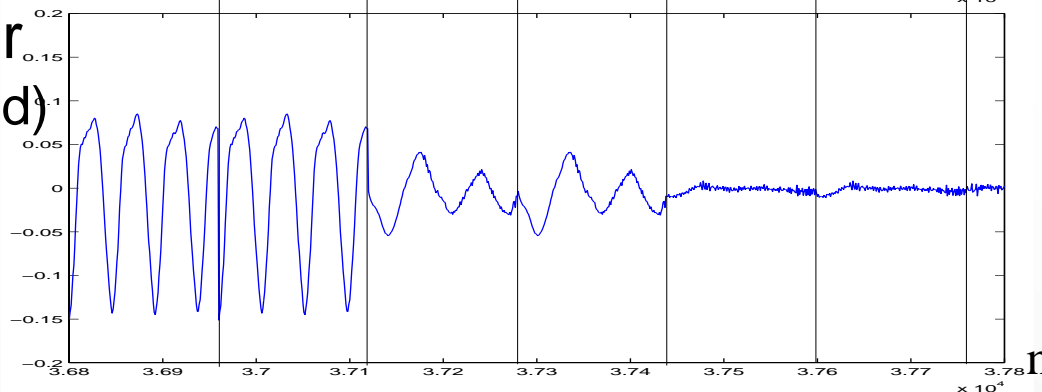
Sender
 $s(n)$



Receiver
 $\tilde{s}(n)$



Receiver
(concealed)
 $\hat{s}(n)$

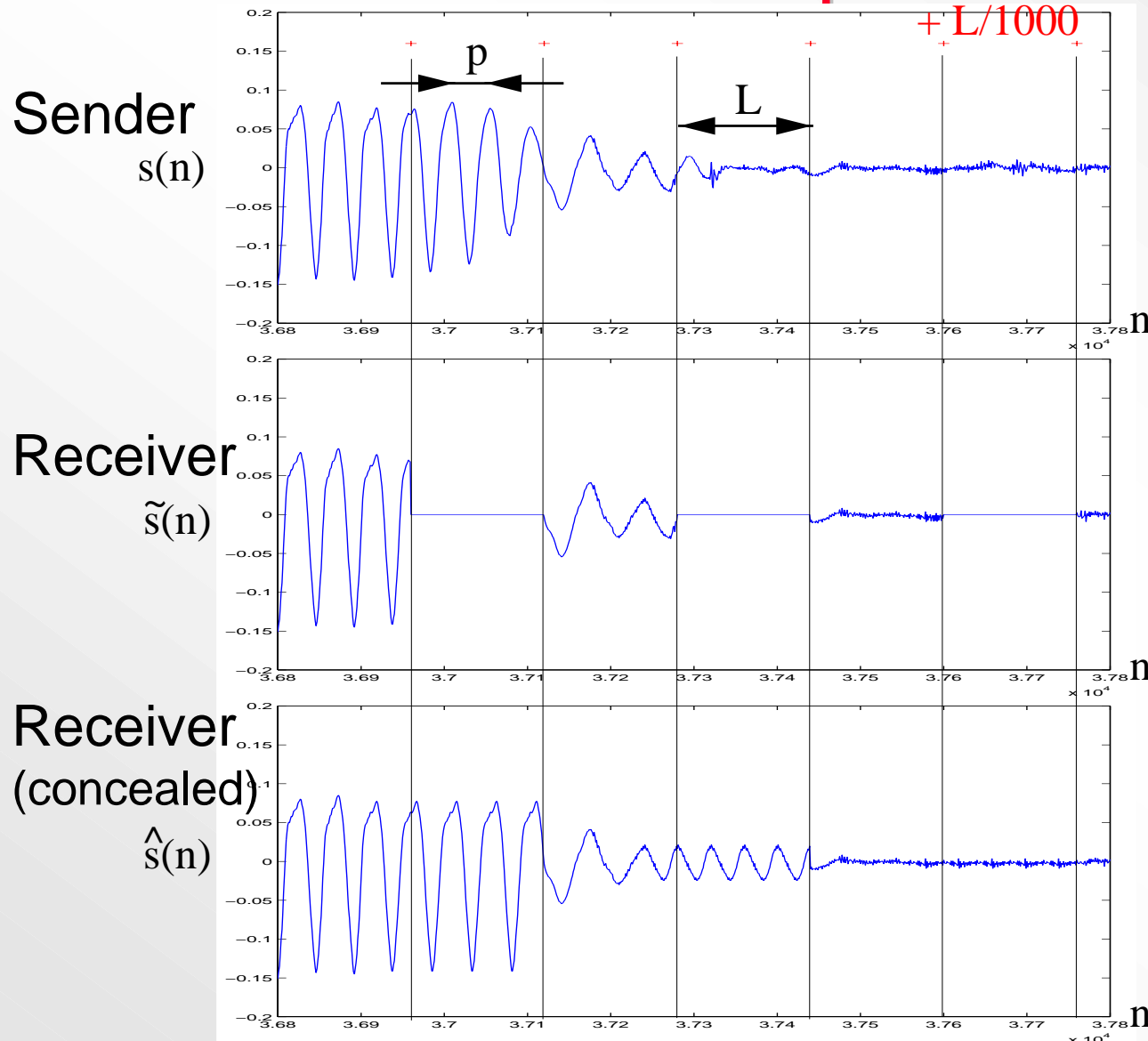


n : sample number

$p(n)$: pitch period

L : packet size

Pitch Waveform Replication (Receiver-Based)

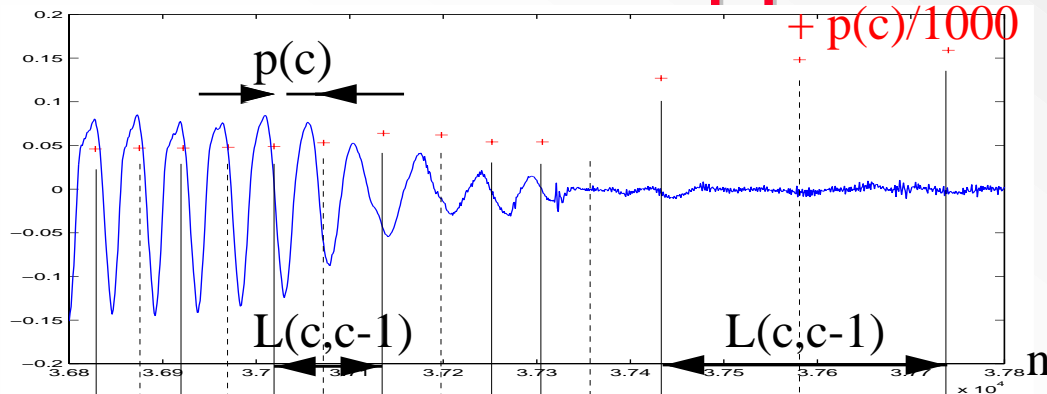


$p(n)$: pitch period

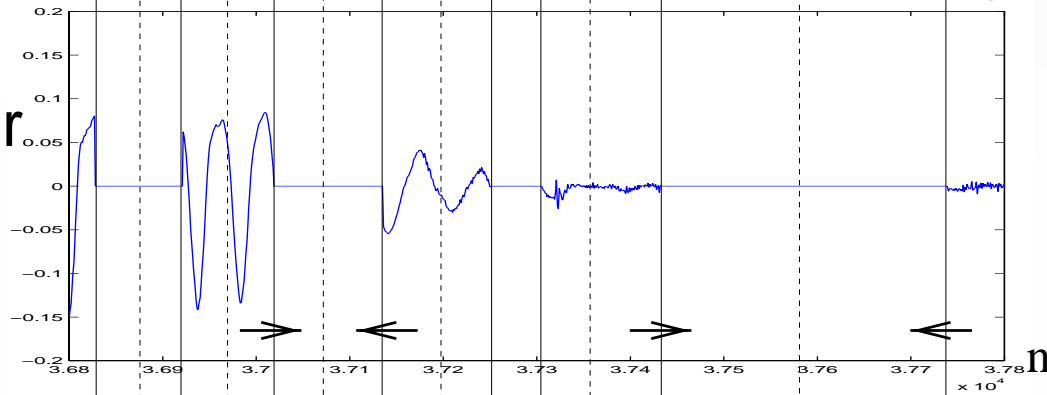
L : packet size

New approach

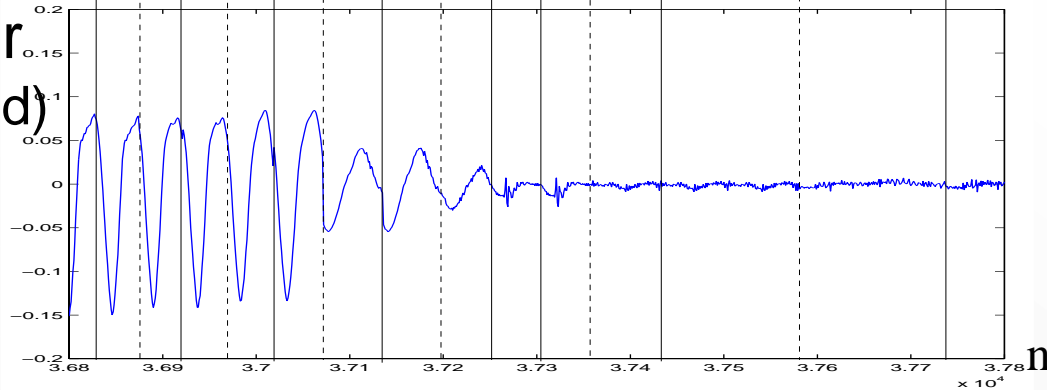
Sender
 $s(n)$



Receiver
 $\tilde{s}(n)$



Receiver
(concealed)
 $\hat{s}(n)$



c : „chunk“ number

$p(c)$: pitch period

$L(c, c-1)$:

packet size



Adaptive Packetization / Concealment

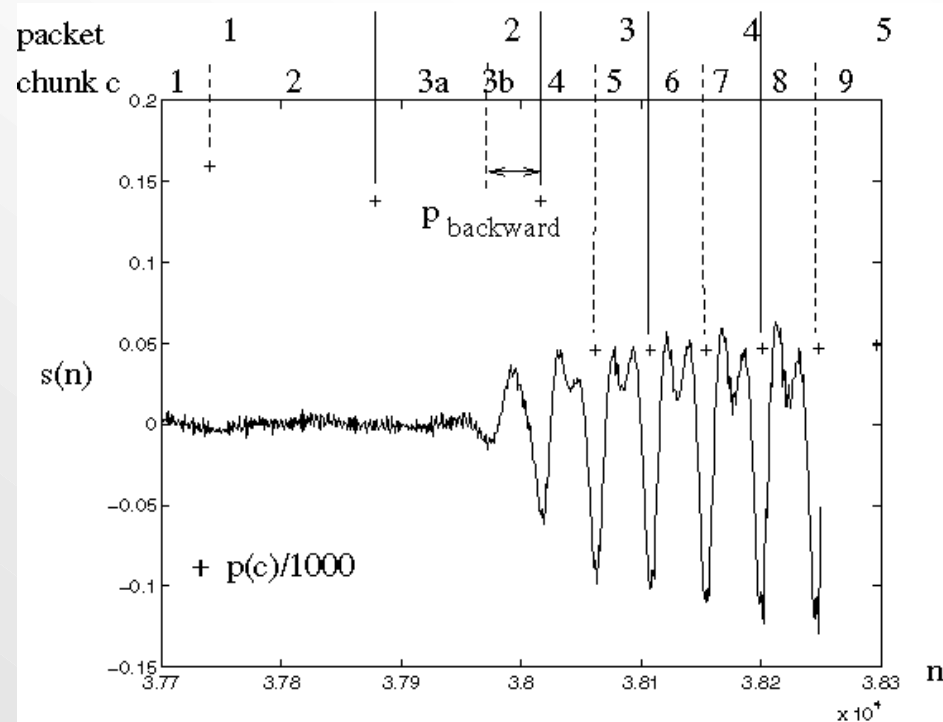
Sender-supported concealment:

choose packetization interval adaptively

- packet size (size of lost segment) relates to „importance“ of packet content
- pre-processing of the *undistorted* signal
- enables *simple* concealment operation at the receiver (high probability that adjacent packets contents resemble each other)

Sender: Adaptive Packetization

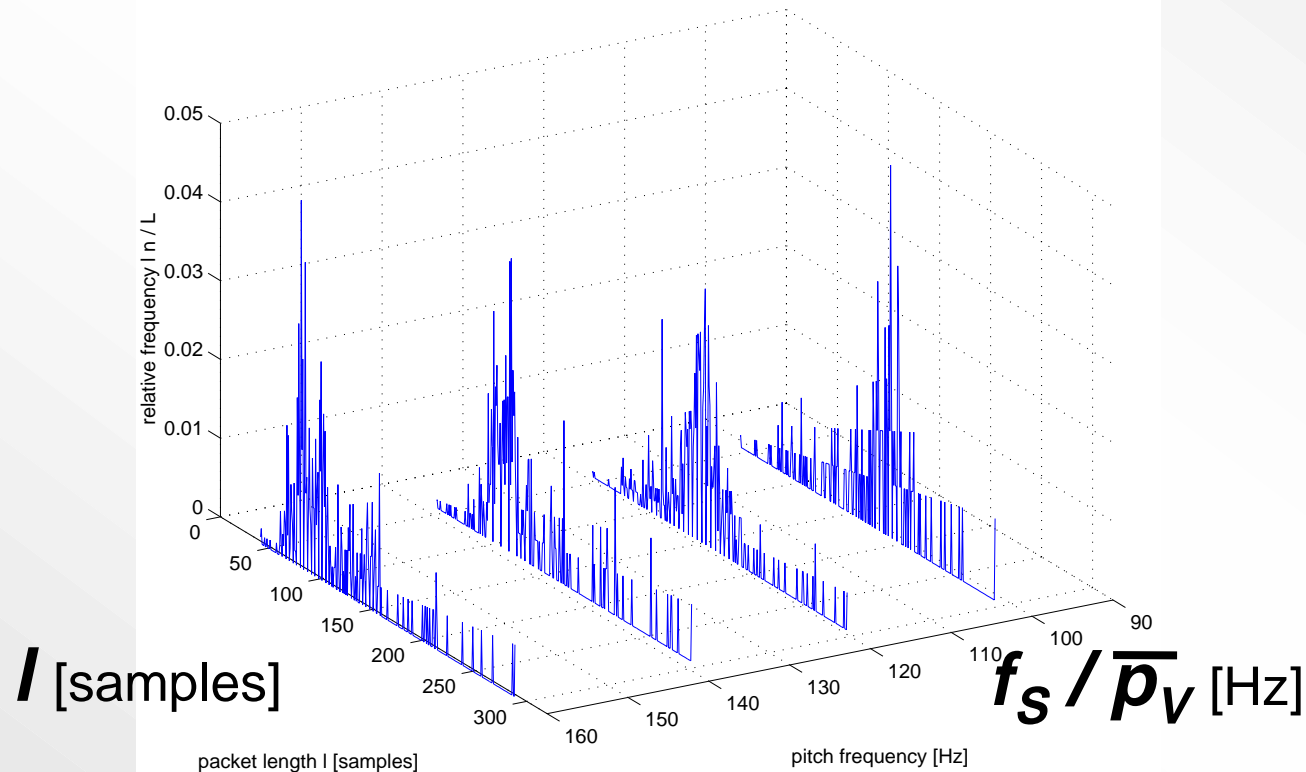
- Auto-correlation of signal \Rightarrow partitioning („chunks“)
- speech content transition check: voiced/unvoiced
- packetization: 2 chunks/package (header overhead)



(110 ms speech)

Packet Size Frequency Distribution

- Packet size is now dependent on speaker's pitch (range: $p_{min}=30$, $2p_{max}=320$ samples; 4...40ms)



(Relative frequency n weighted with size l)

Relative Packet Header Overhead

Typical value for IP Telephony: $O = 20\%$

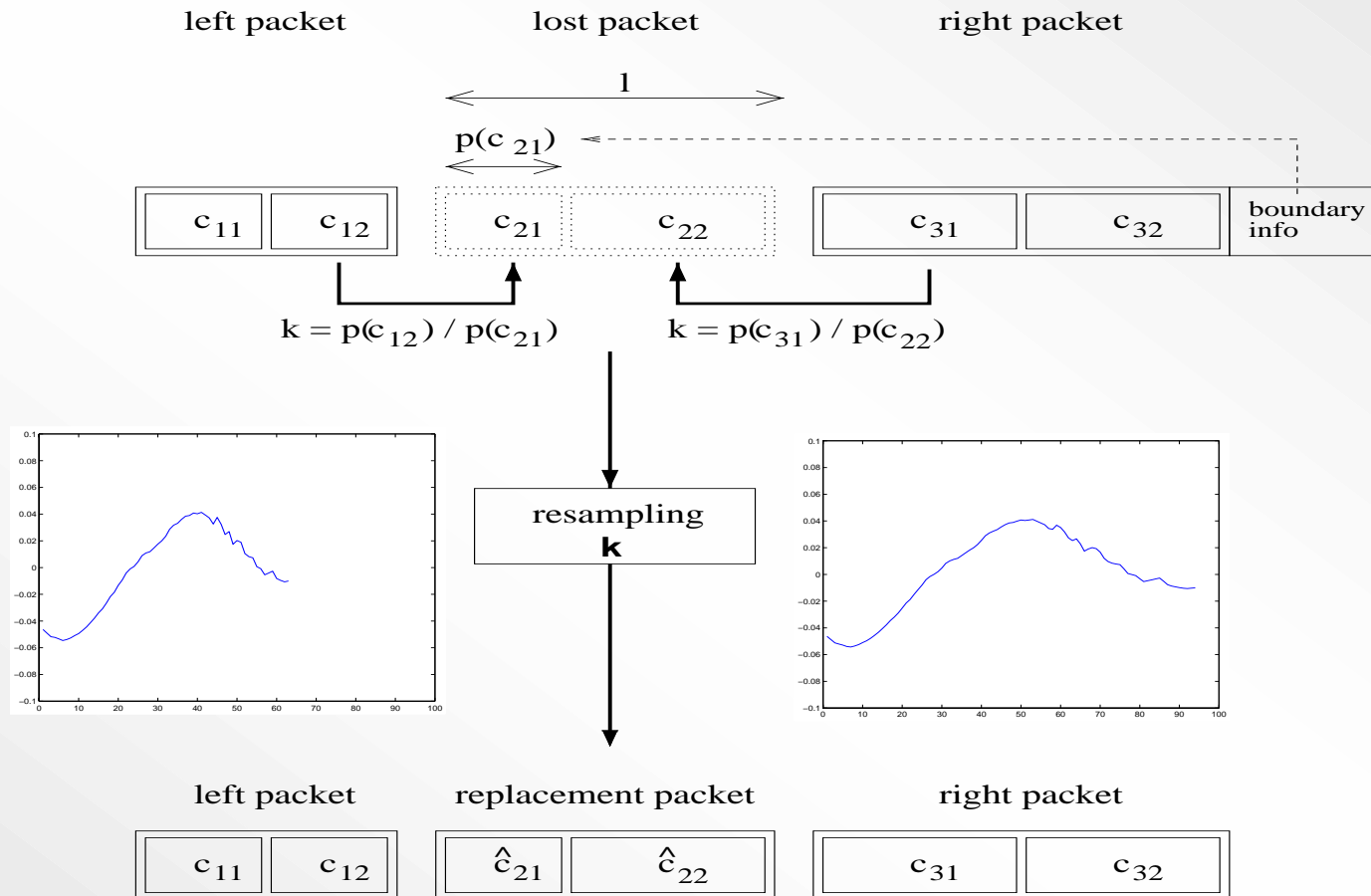
- fixed packetization interval: 160 samples [20ms],
- RTP/UDP/IP per packet overhead: $o = 40$ octets

AP/C:

Speaker	Estimated overhead $o/(o+2p_v)$	Measured overhead O [%]
Male low	20.16	20.14
Male high	22.97	22.83
Female low	25.72	24.84
Female high	28.62	27.98

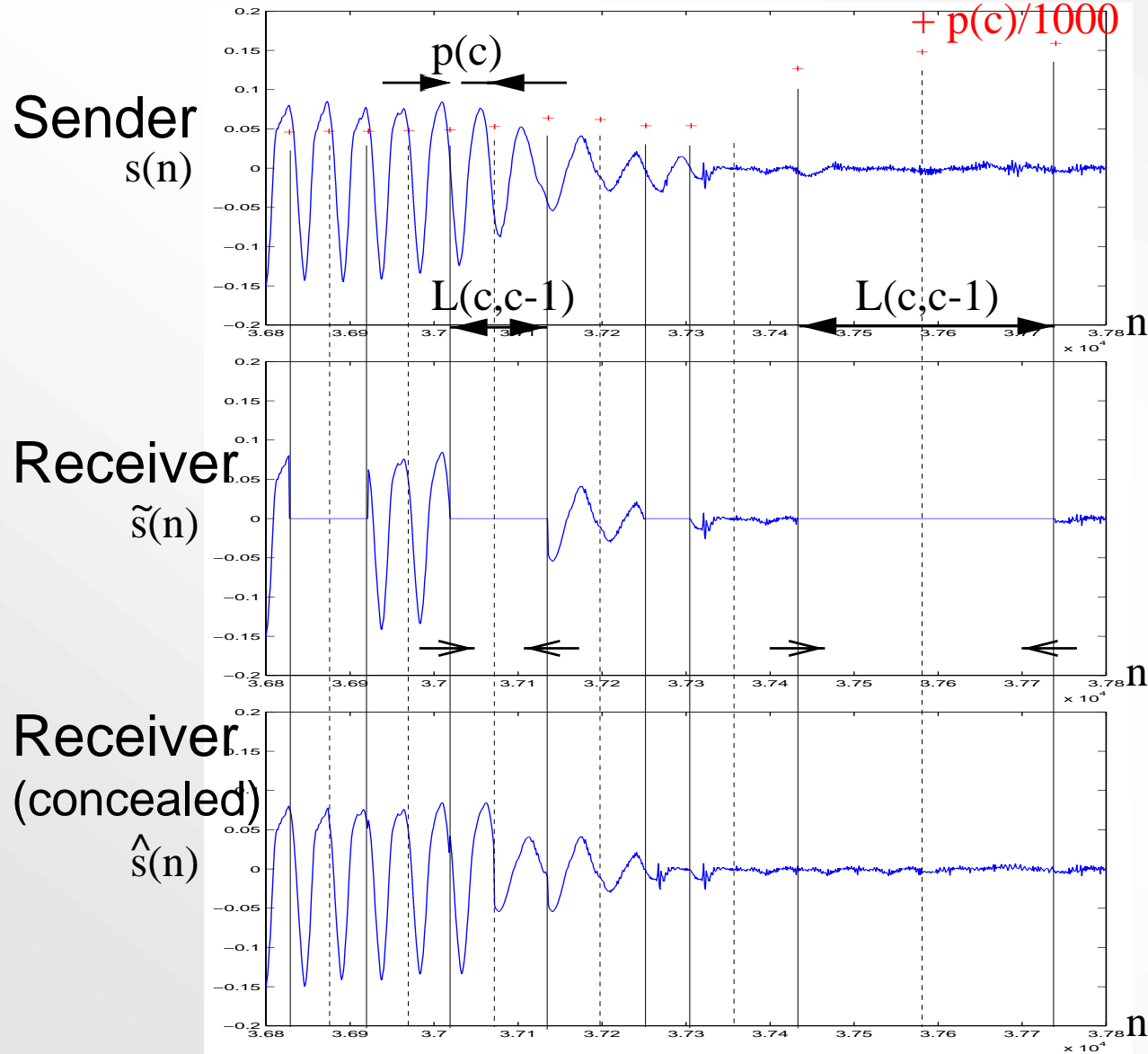
(mean pitch period: p_v)

Receiver: Concealment



resampling: no specific distortions introduced
(like e.g. with PWR)

Receiver: Concealment (contd.)



c : „chunk“ number

$p(c)$: pitch period

$L(c,c-1)$:
packet size

Discussion

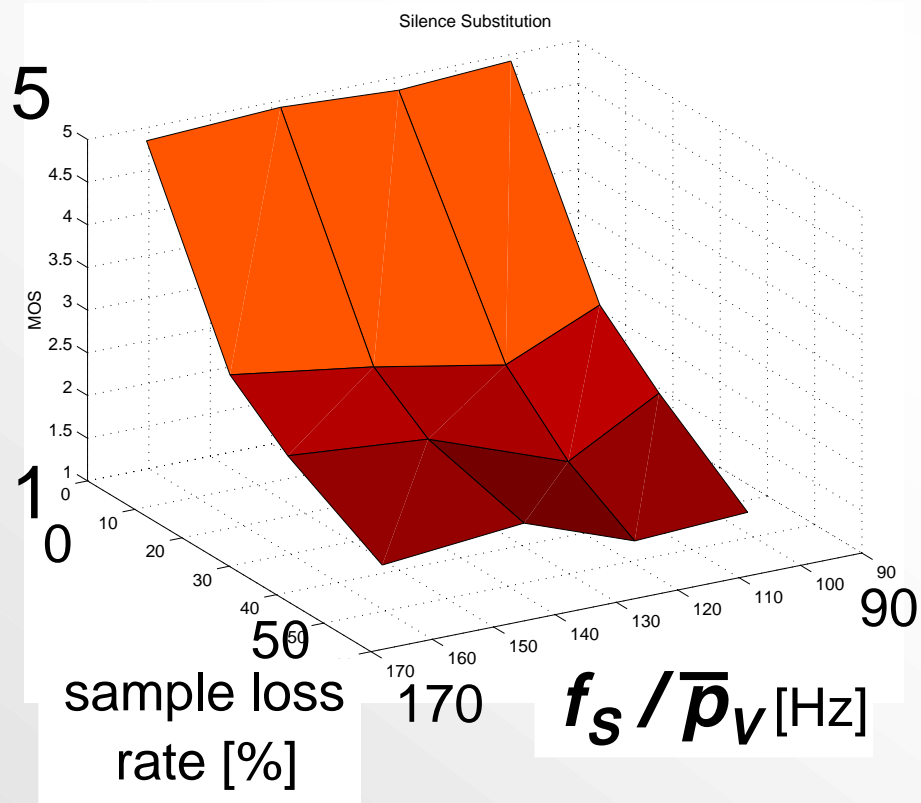
- characteristic“ information: 2 octets
(own and following intra-packet boundary)
- additional **delay** (buffering):
sender: $[p_{max}, 2p_{max} - p_{min}] = 20...36ms$
receiver: $[p_{min}, 2p_{max}] = 4...40ms$ (on loss only)
- computational complexity/processing delay: low
- backwards compatible with existing tools

Subjective Test: Test Procedure

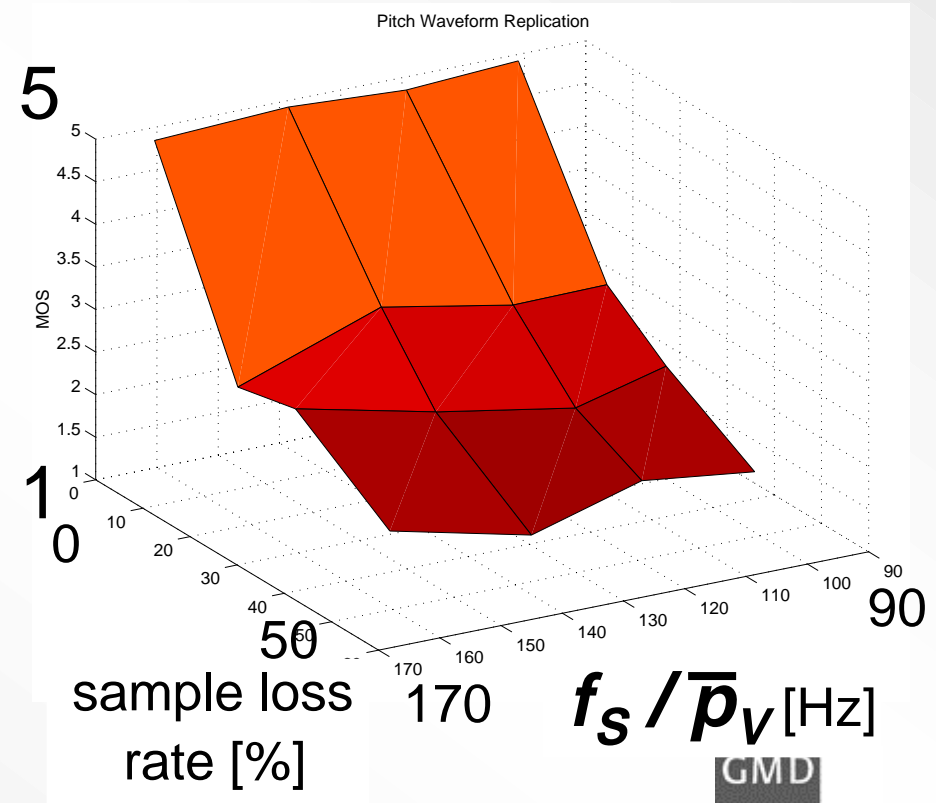
- Four signals (different speakers), PCM 16 bit linear, 8 kHz
- comparison with „silence substitution“ and PWR
- random, yet *isolated* packet losses
- 40 test conditions: 4 speakers x (3 algorithms x 3 loss rates + original)
- thirteen non-expert listeners judged on MOS scale
- Anchoring: Original=5, „Worst Case“=1 (50% loss)
- test conditions in rapid, random sequence

Subjective Test: Results

MOS: Silence Substitution



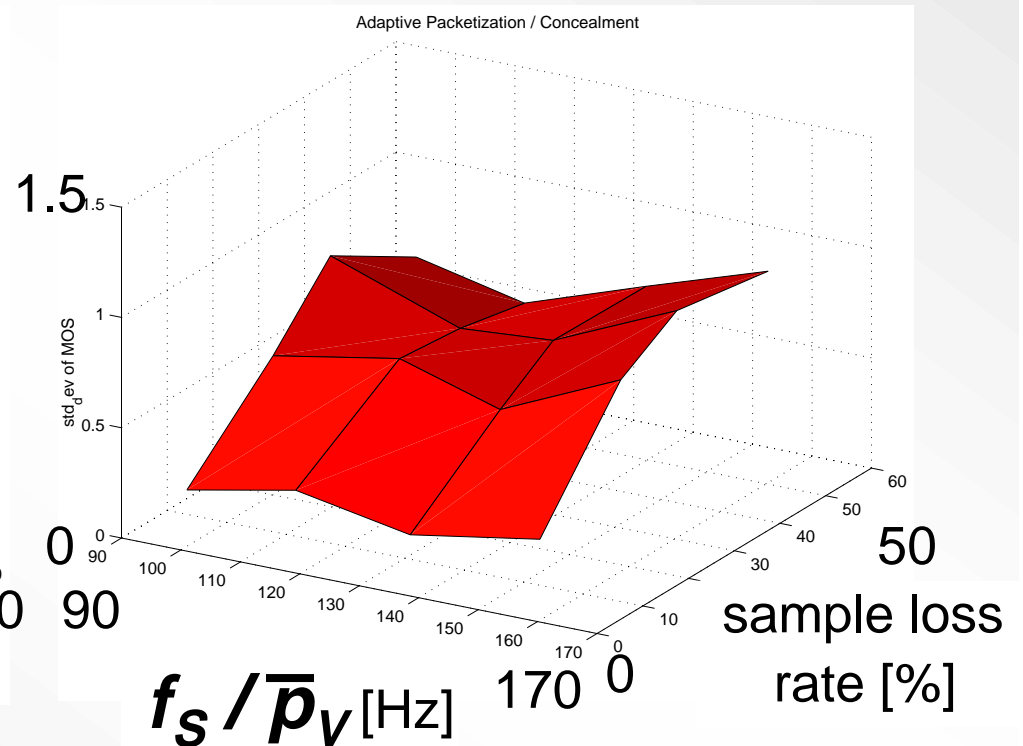
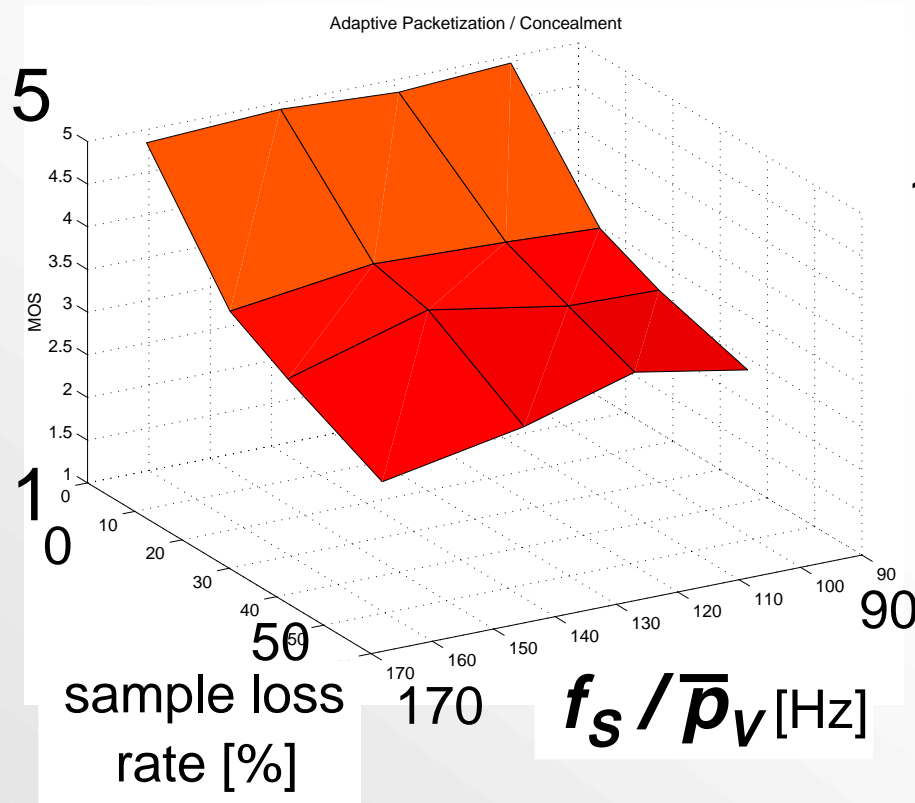
MOS: Pitch Waveform Replication



Subjective Test: Results (contd.)

MOS: Adaptive Packetization/
Concealment

Standard deviation of MOS (AP/C)



Conclusions

- Sender preprocessing (*Adaptive Packetization*)
 - ⇒ pre-defined parts of the signal are dropped
 - ⇒ less perceptible distortion, simple concealment
- low overhead
(data, delay, processing, deployment)
- Future/ongoing work:
frame-based codec support / integration
complement end2end mechanism with queue
management at routers (loss burstiness !)
- <http://www.fokus.gmd.de/research/cc/g1one/products/voice/apc>