Packet Loss Recovery and Control for Voice Transmission over the Internet

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- Motivation: impact of packet losses on voice
- Approach: combined loss recovery and control
- Results:
  - end-to-end loss recovery
  - hop-by-hop loss control
  - combination
- Conclusions

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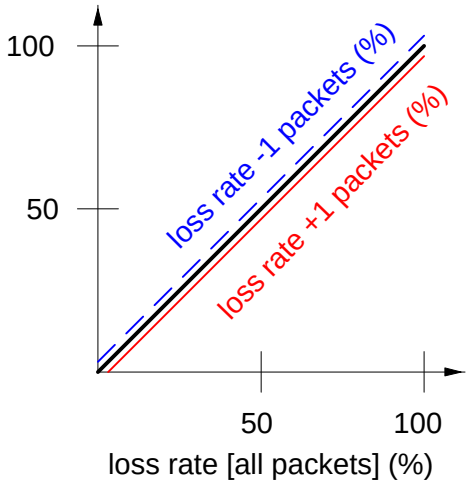
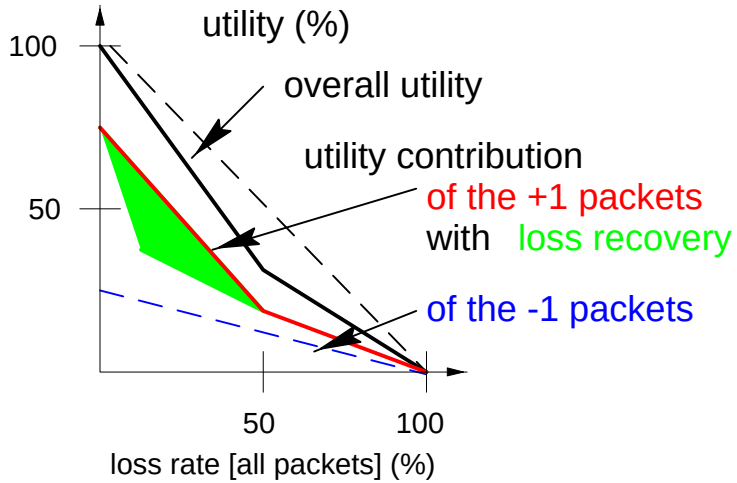
Packet Loss in Voice over IP Networks

- Two major technical evolutions
  - digital voice communication
  - packet-switched networks
- Main advantages over circuit-switched voice:
  - statistical multiplexing gain
  - service integration,
    unified packet-switching infrastructure
- fundamental tradeoff of „best effort“ network:
  statistical multiplexing vs. reliability of transmission
  $\Rightarrow$ *packet loss* $\Rightarrow$ *significant distortions*
- previous approaches to the packet loss problem:
  either end-to-end-only or hop-by-hop-only

Combined Loss Recovery and Control

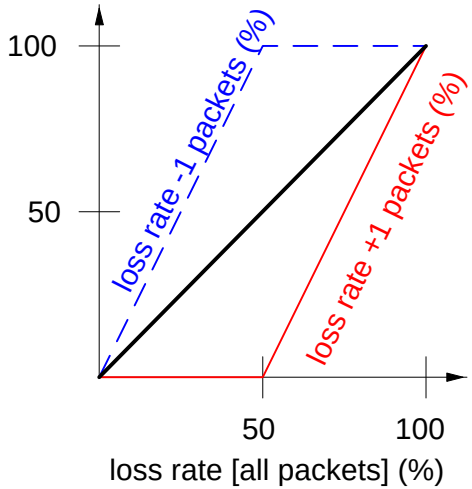
„best effort“

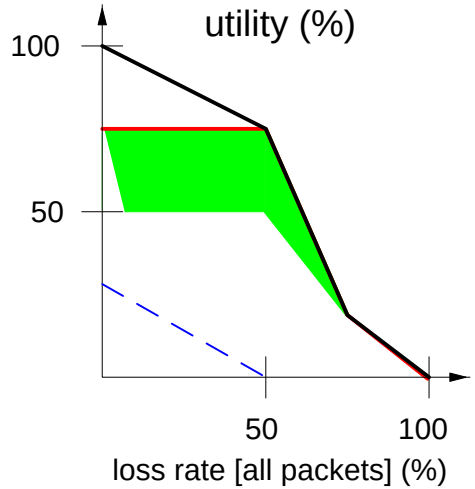




Example:
flow consists of
50% more (**+1**) and
50% less (**-1**)
important packets

intra-flow
loss control





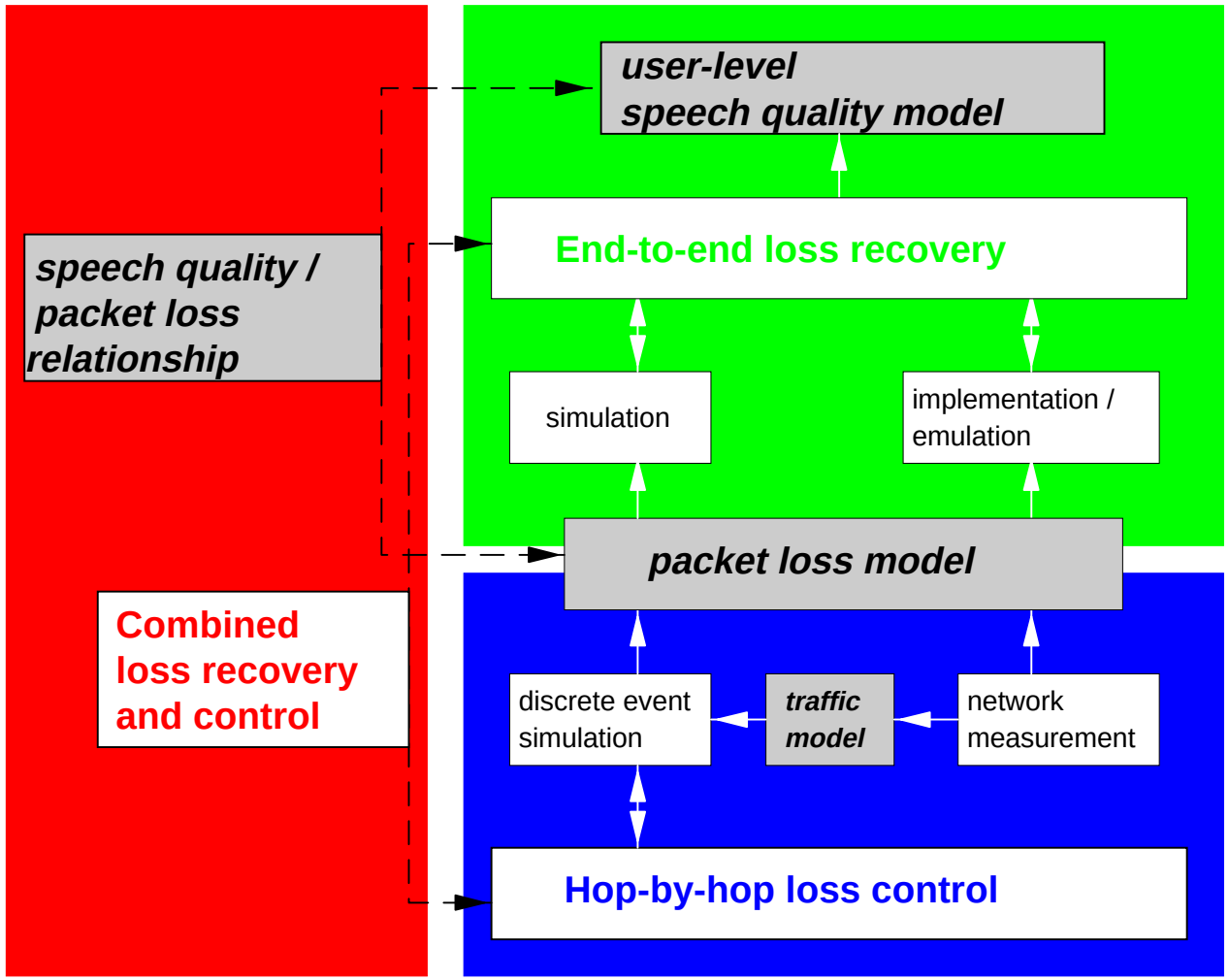
Questions

1 Which packets are *more / less* important for the user perception of voice (utility) ?
 ⇒ *identification / recovery* at the **end-to-end** level

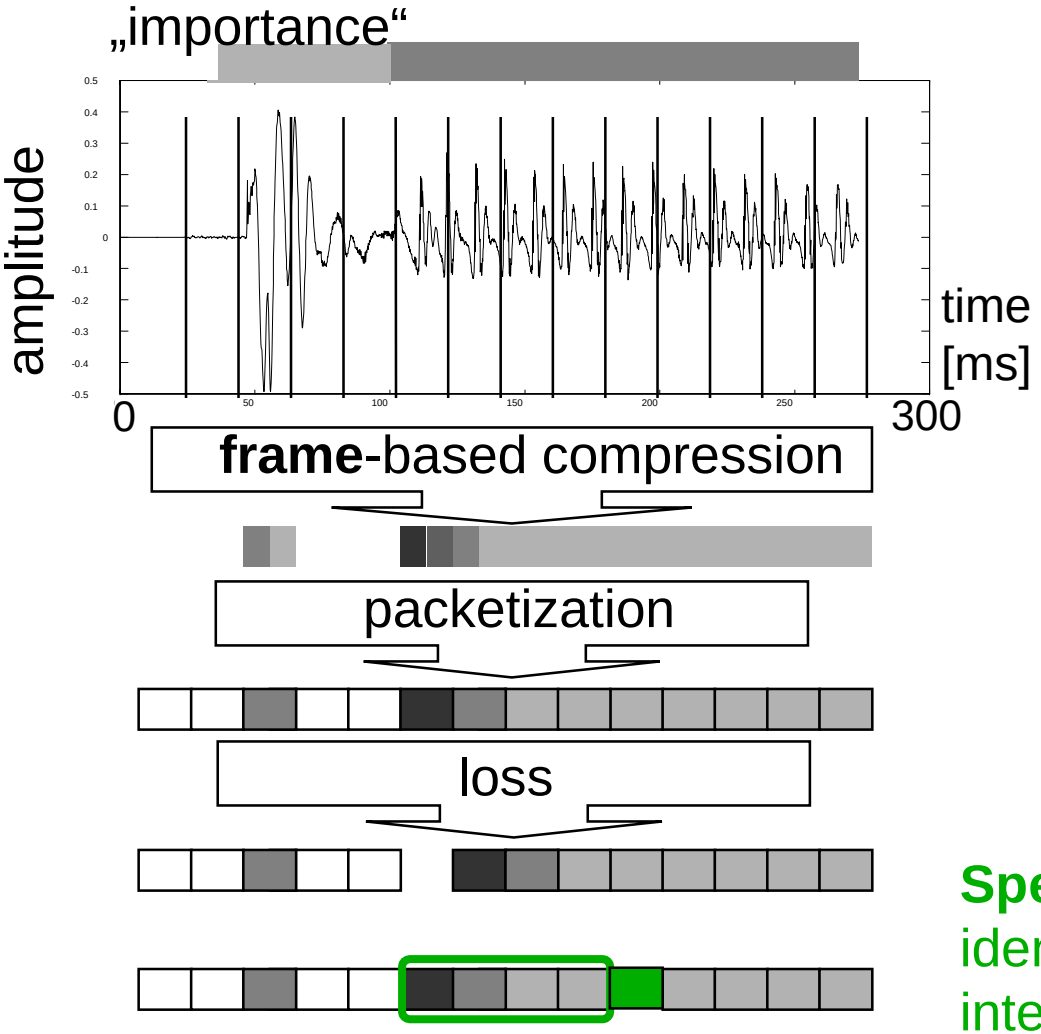
2 How can the loss distribution („+1“, „-1“) rather than the absolute amount of loss be controlled within the network ?
 ⇒ loss control at the **hop-by-hop** level

3 How can the end-to-end and hop-by-hop mechanisms be **combined** ?

Overview


user-level
speech quality model
End-to-end loss recovery
speech quality /
packet loss
relationship
simulation
implementation /
emulation
packet loss model
Combined
loss recovery
and control
discrete event
simulation
traffic
model
network
measurement
Hop-by-hop loss control

End-to-end identification / recovery



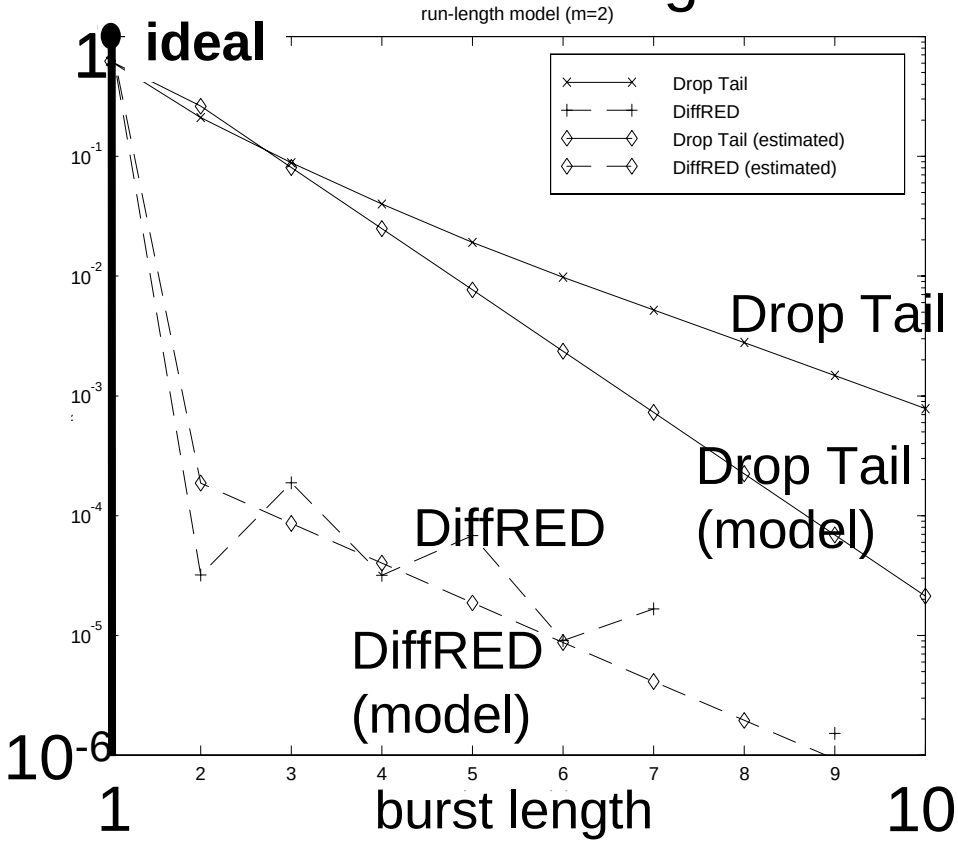
compression	*recoverable loss pattern*
sample	alternating {+1,-1,...}
frame	bursty {+1,+1,-1,-1}

Speech Property Based (SPB)
identification & protection /
internal decoder loss concealment

Hop-by-hop loss control

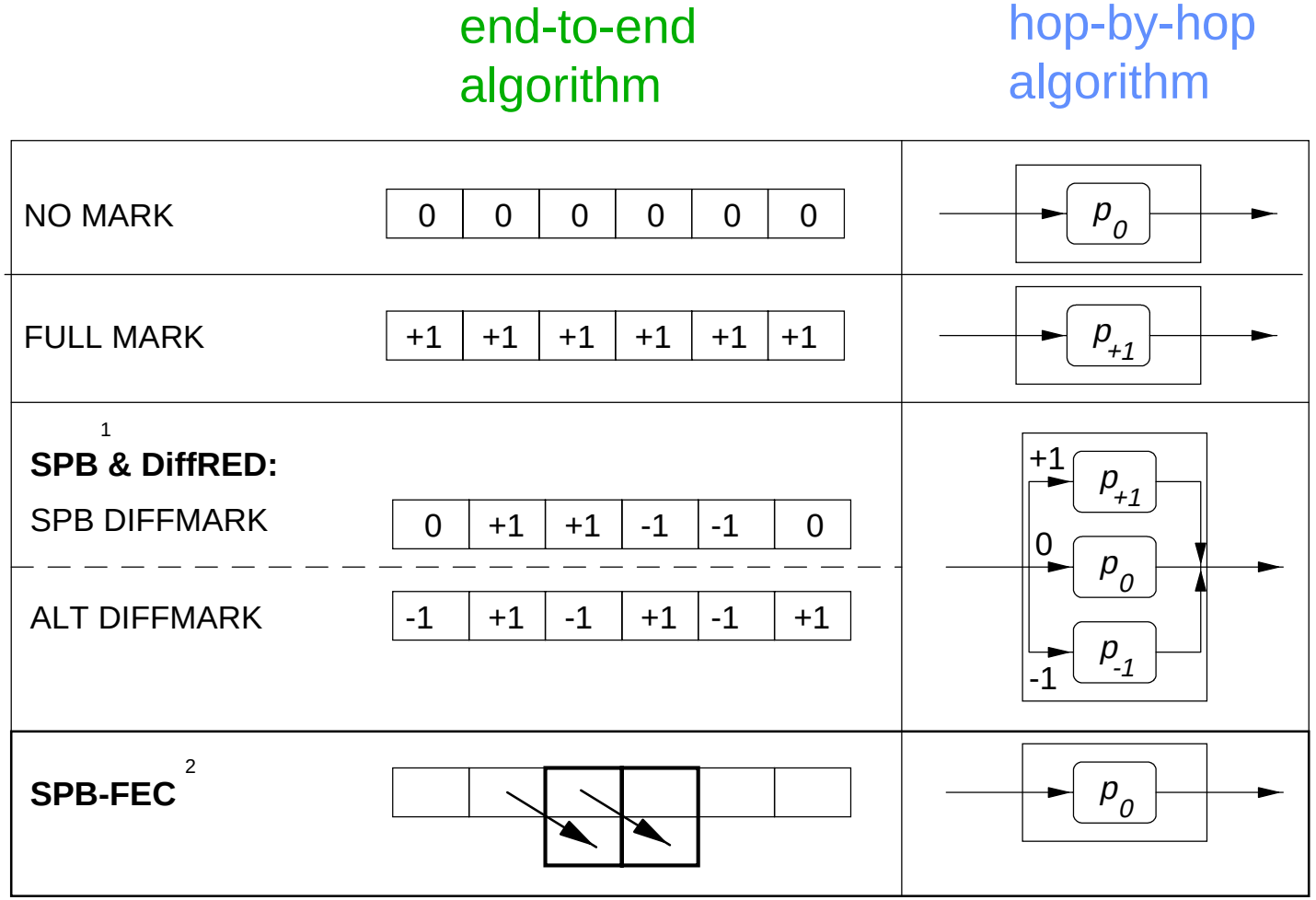
- sender marks packets with recoverable loss pattern
- **Differential Random Early Detection** (DiffRED) enforces the pattern
- well-defined drop probability relationship between +1, -1: still “best effort”
- example: alternating pattern {+1, -1,...}
- problem: simple packet loss models cannot capture algorithm behaviour
  ⇒ new model

PDF[1] of loss burst lengths



[1] Probability Density Function

Combined loss recovery and control



hop-by-hop-only ($p_{+1}=10^{-3}\,p_0$)

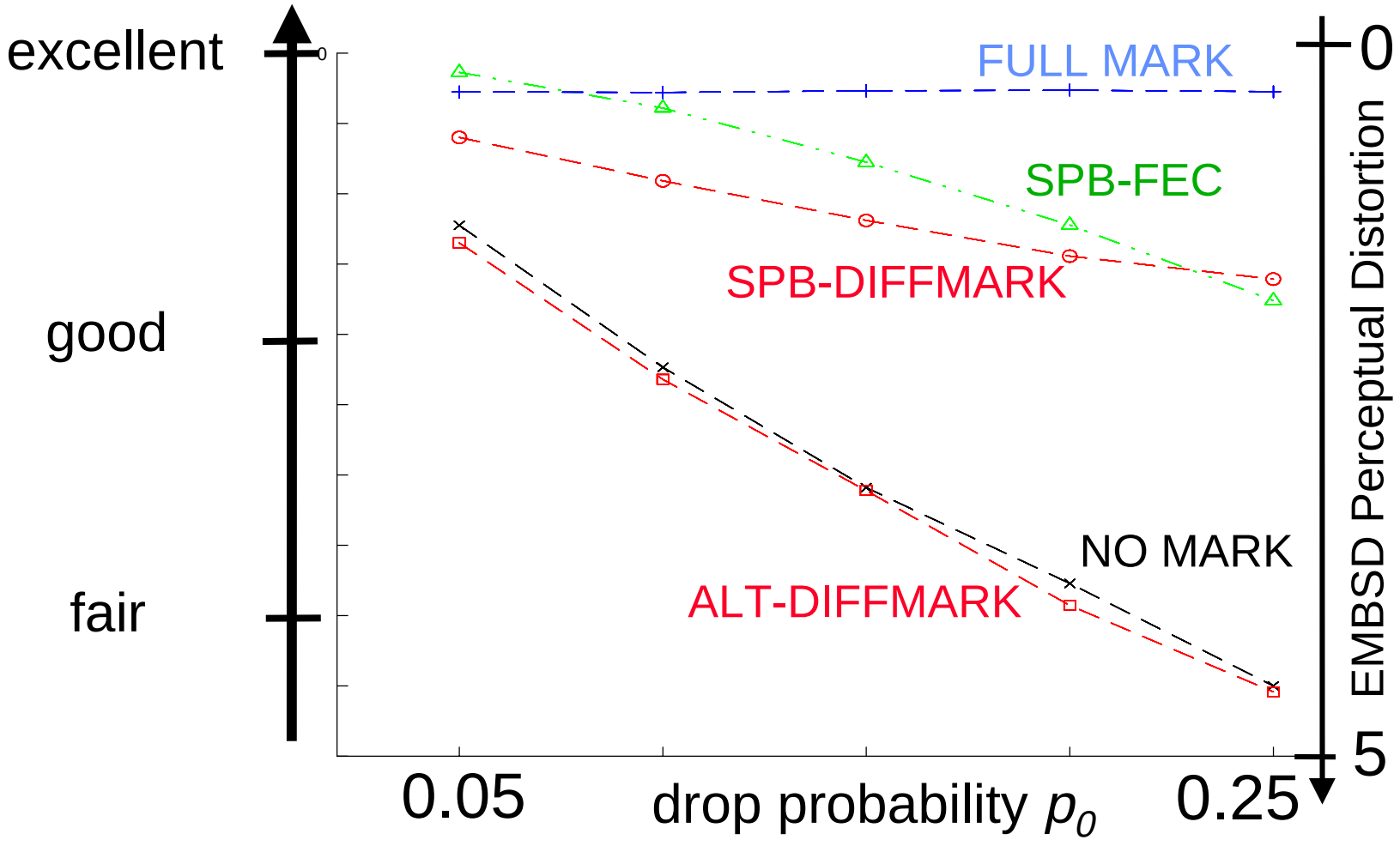
combined („best effort“: $p_{-1} = 2\,p_0 - p_{+1}$)

end-to-end-only

[1] Speech Property Based loss protection [2] Forward Error Correction

Utility (user perception)

(objective speech quality measurement)



Conclusions

- Combined mechanisms:
  performance improvement for „best effort“ networks
  - end-to-end:
    no redundancy / feedback / adaptivity,
    knowledge about the codec, processing needed
  - hop-by-hop:
    no charging architecture (intra-flow QoS),
    deployment in routers necessary
- End-to-end mechanisms:
  - selective (speech property-based) loss protection
    comes close to protection of the entire flow

Conclusions

- Hop-by-hop mechanisms:
  - trading between losses with simple mechanisms in a „best effort“ network
- Measurement of loss process / loss impact:
  - novel packet loss model
  - application of perceptual metrics at the user level
- Applicability validated in real Internet environment
- Future: assessment of large scale deployment costs