Stochastic Packet Loss Model to Evaluate QoE Impairments

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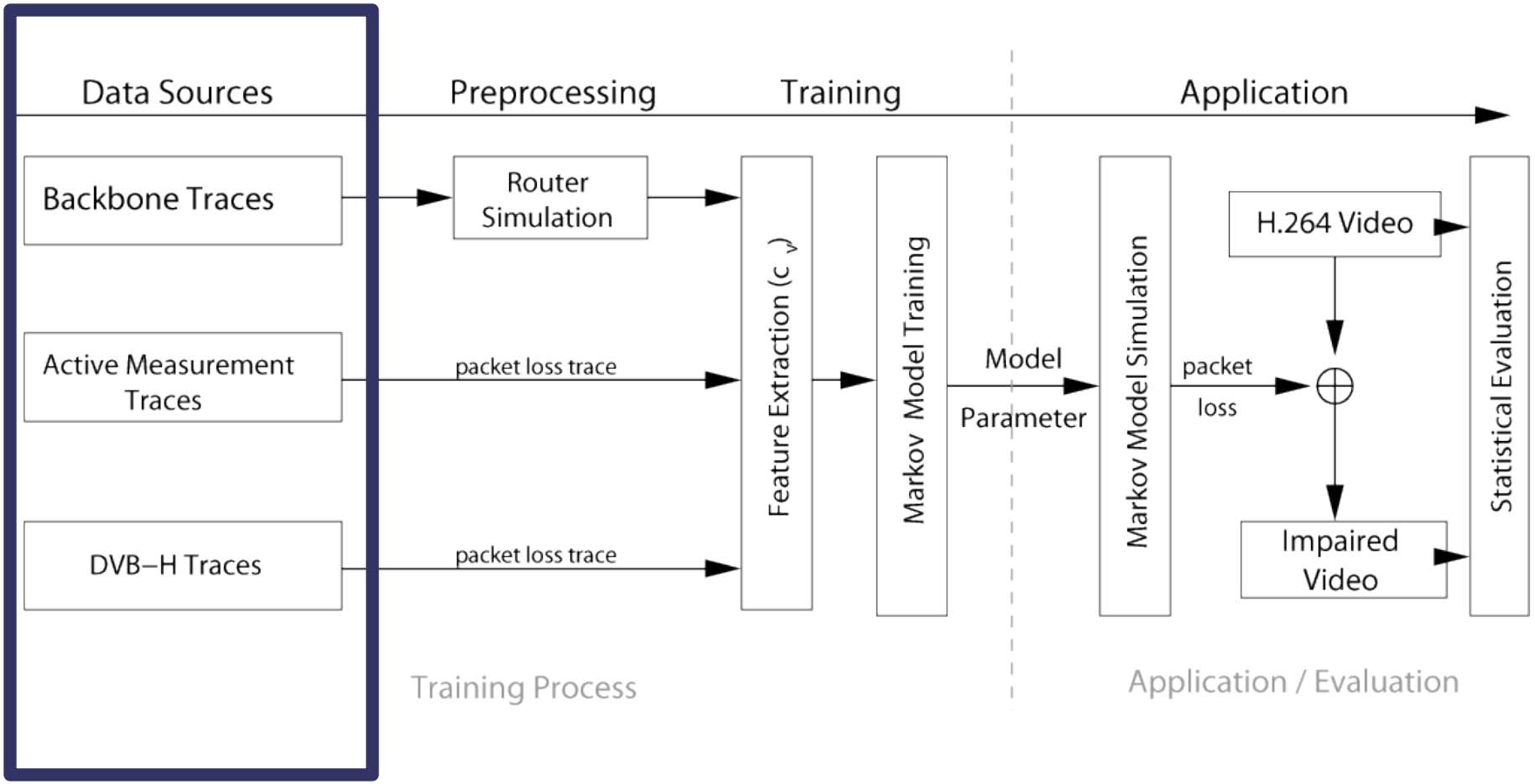
Video Quality of Experience

- Most of Internet bandwidth consumed by video
  - „The Video Tsunami“ [Eubanks, 71st IETF, March 08]
- Amount of streamed video increases
  - Current IPTV deployment at Deutsche Telekom and other ISPs
- Quality of Experience?
  - Subjective quality perceived by user
  - „mature“ for voice (parametric: ITU E-Model)
  - QoE research is exploring new fields
    - Thin Clients [Staehle et al. (2008)]
  - How to model the user's perception of video?
    - Open question

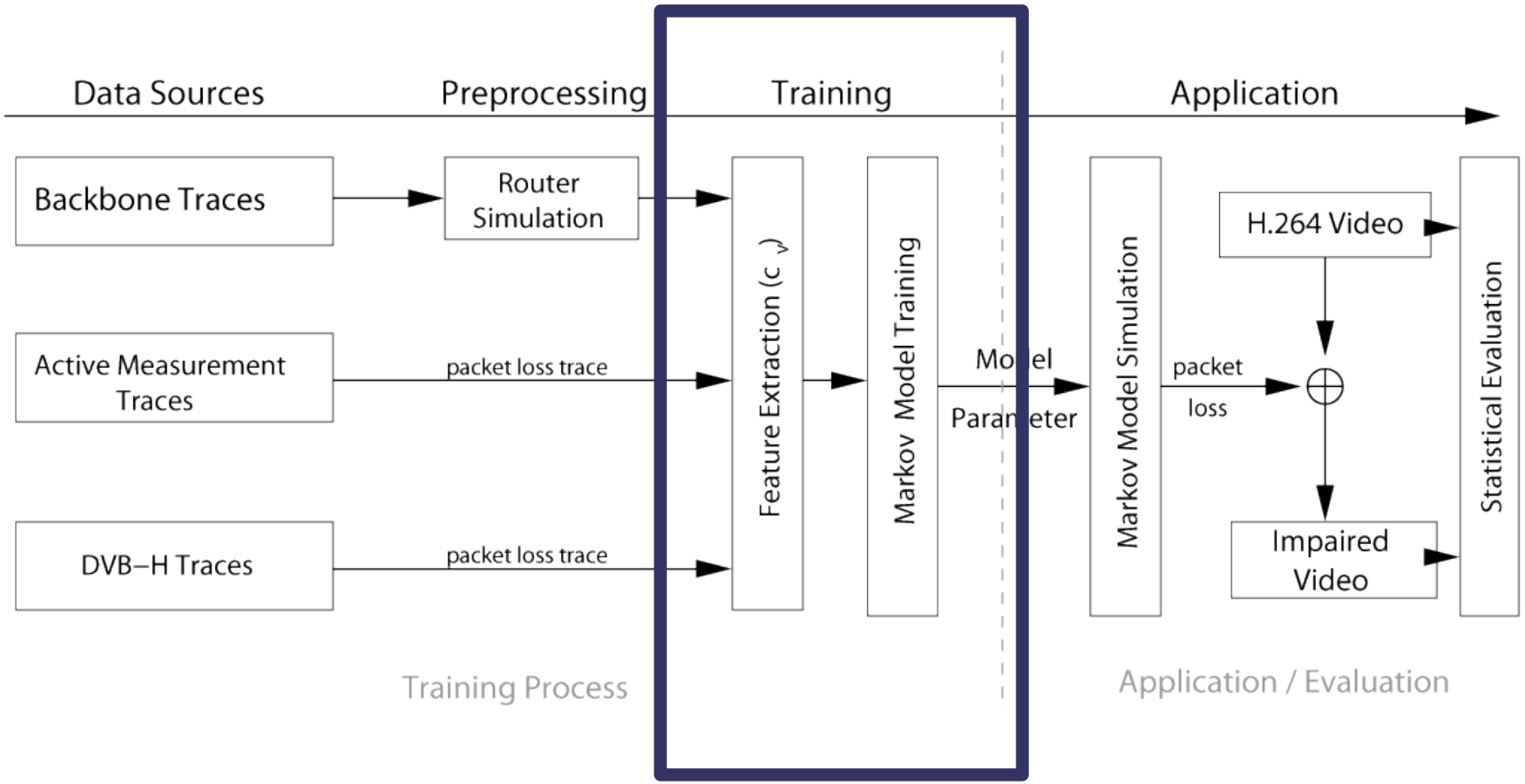
Setup

Data Sources



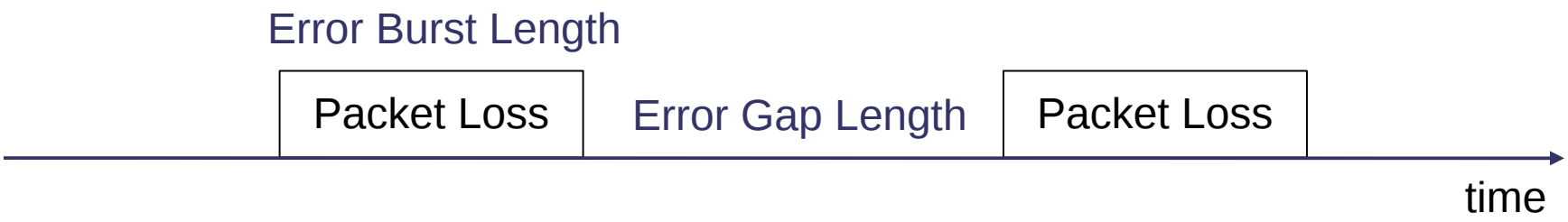
Setup

Markov Modelling



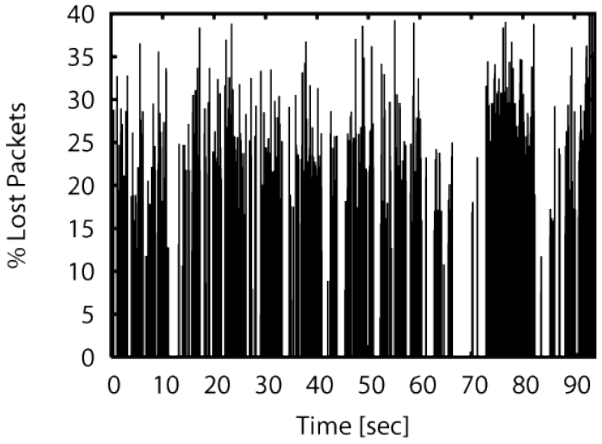
Channel Descriptors

- Typical description method
  - Error Gap & Burst Lengths
  - Useful for evaluating error correction codes

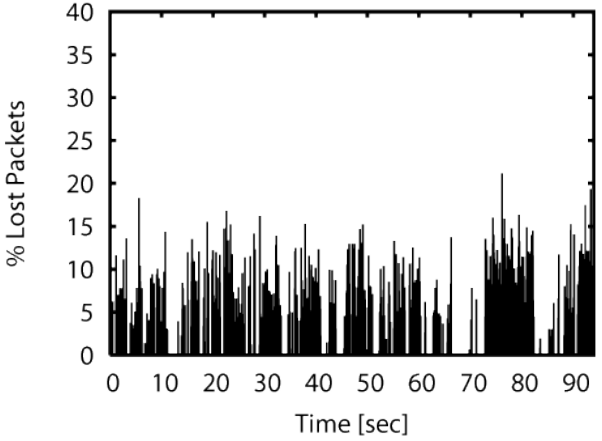


- Our approach
  - Second-order statistics in multiple time-scales
  - Standard description method in teletraffic modelling

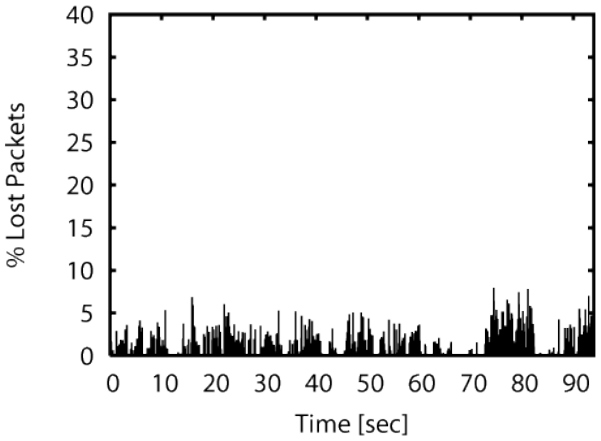
Variability In Multiple Time-Scales



1 ms



10 ms



100 ms

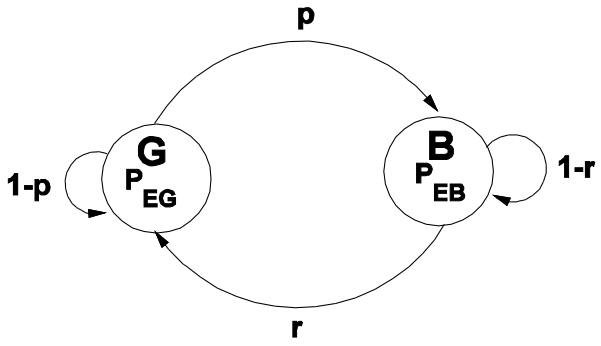
- Variability in multiple time-scales
- Equivalent to autocorrelation

Stochastic Models

- Advantages over traces
  - Less storage capacity necessary
  - Parameters typically have a clear interpretation and can be adapted to application demands
- Typically tradeoff between complexity and accuracy
  - Low complexity models are analytically good traceable
  - Memoryless models inadequate for bursty channels
    - Bad channel conditions persist, e.g. in finite queues
- 2-state Markov models may fit packet dropping process in finite buffer queuing systems [Zorzi (2003)]

Talk Focus:

Gilbert-Elliott



Second-Order Statistics of Gilbert-Elliott Models

- Wanted: Variance for the number of packet losses in a time frame of size N
- Described by Coefficient of Variation $c_v(N) = \sigma/\mu$
  - Comprehensive measure of 2nd order statistics
  - Intuition: variance cannot be interpreted without knowledge of the mean
- Derived by generating functions
  - Explicit expression for Gilbert-Elliott:

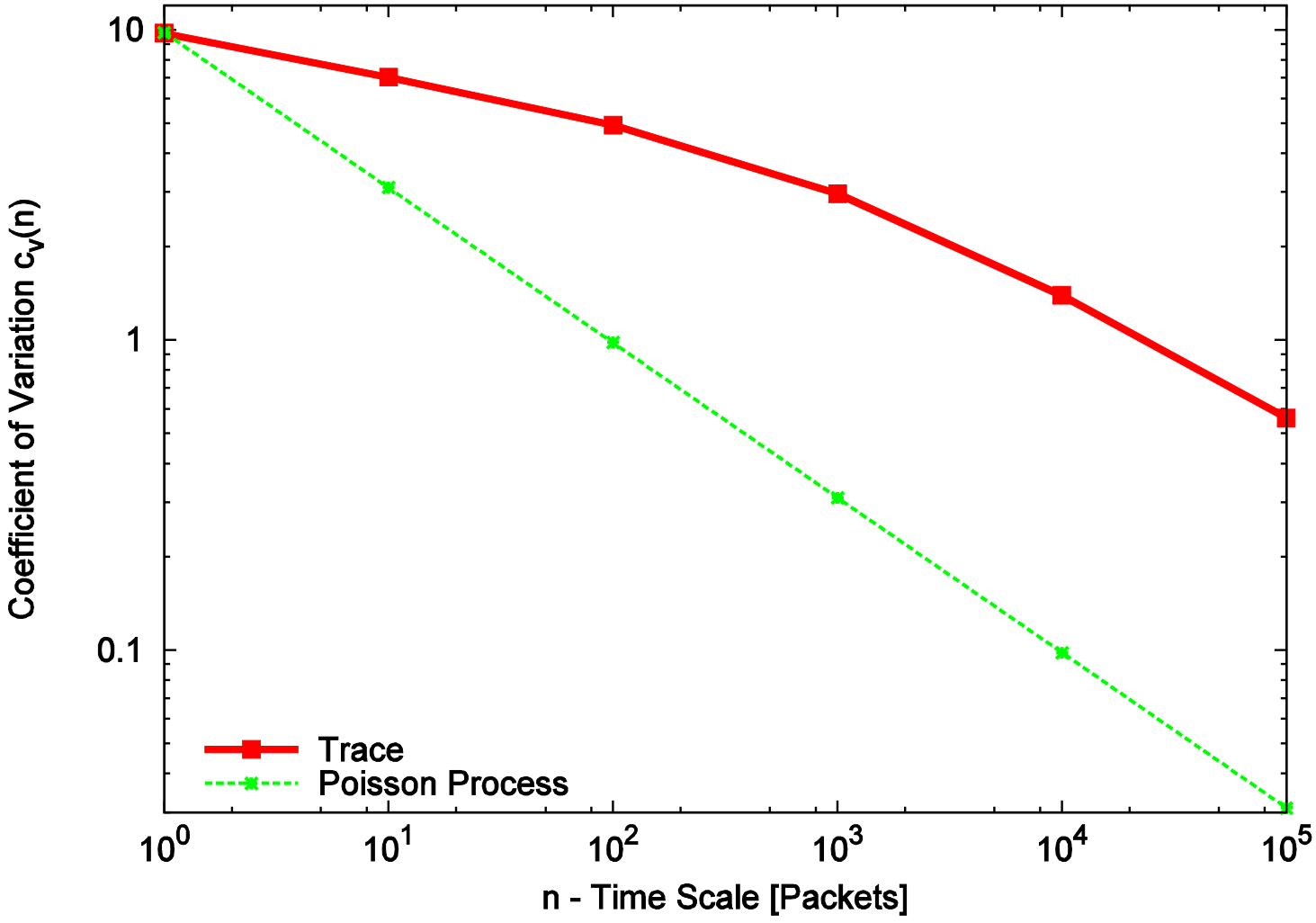
$$c_v(N) = \frac{1}{\sqrt{N}} \sqrt{\frac{hp + kr}{\omega} + \frac{2pr(1-p-r)(h-k)^2}{\omega^2(p+r)} \left(1 - \frac{1-(1-p-r)^N}{N(p+r)}\right)}$$

$$\omega := (1-h)p + (1-k)r$$

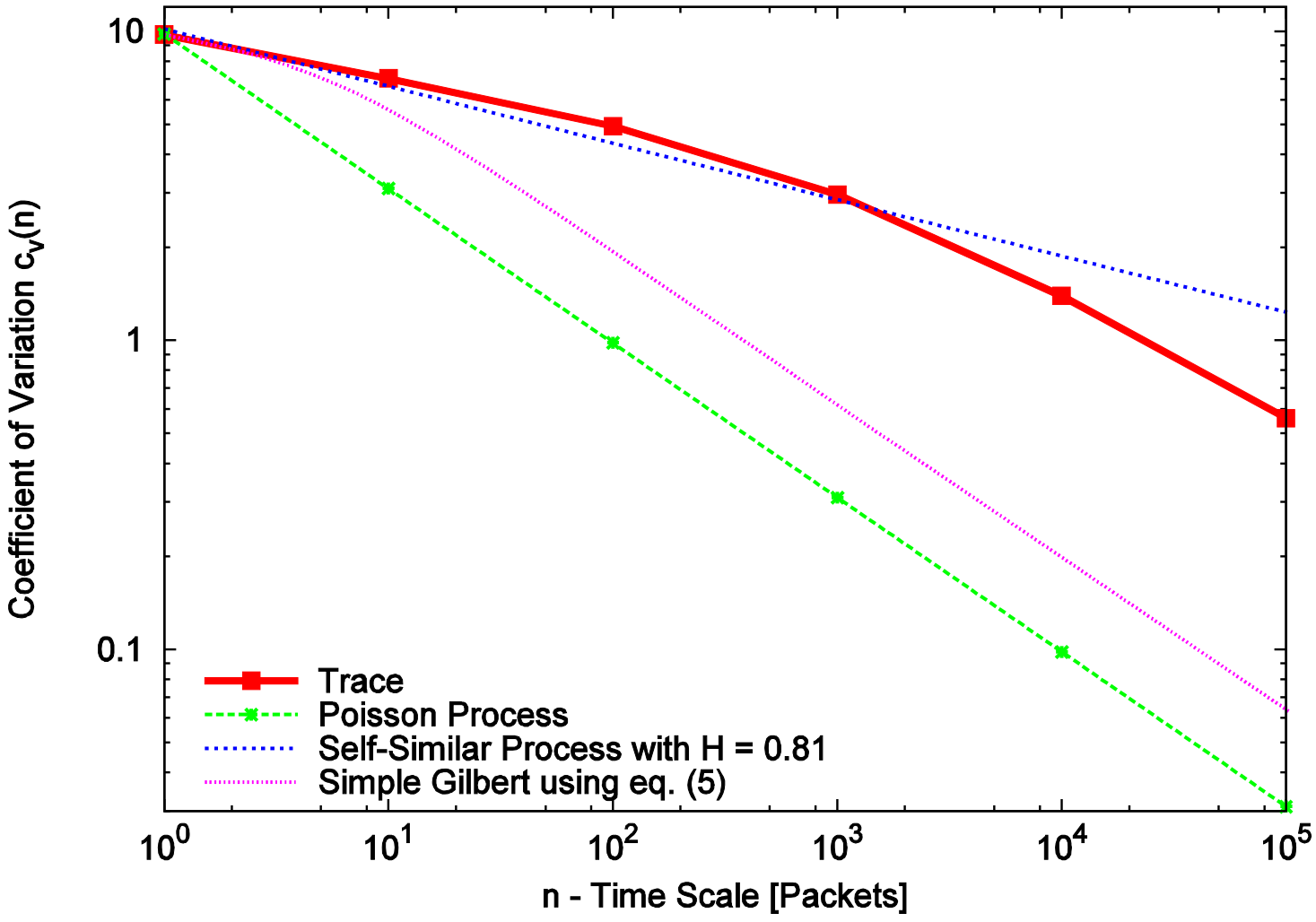
Evaluation

How accurate did we model?

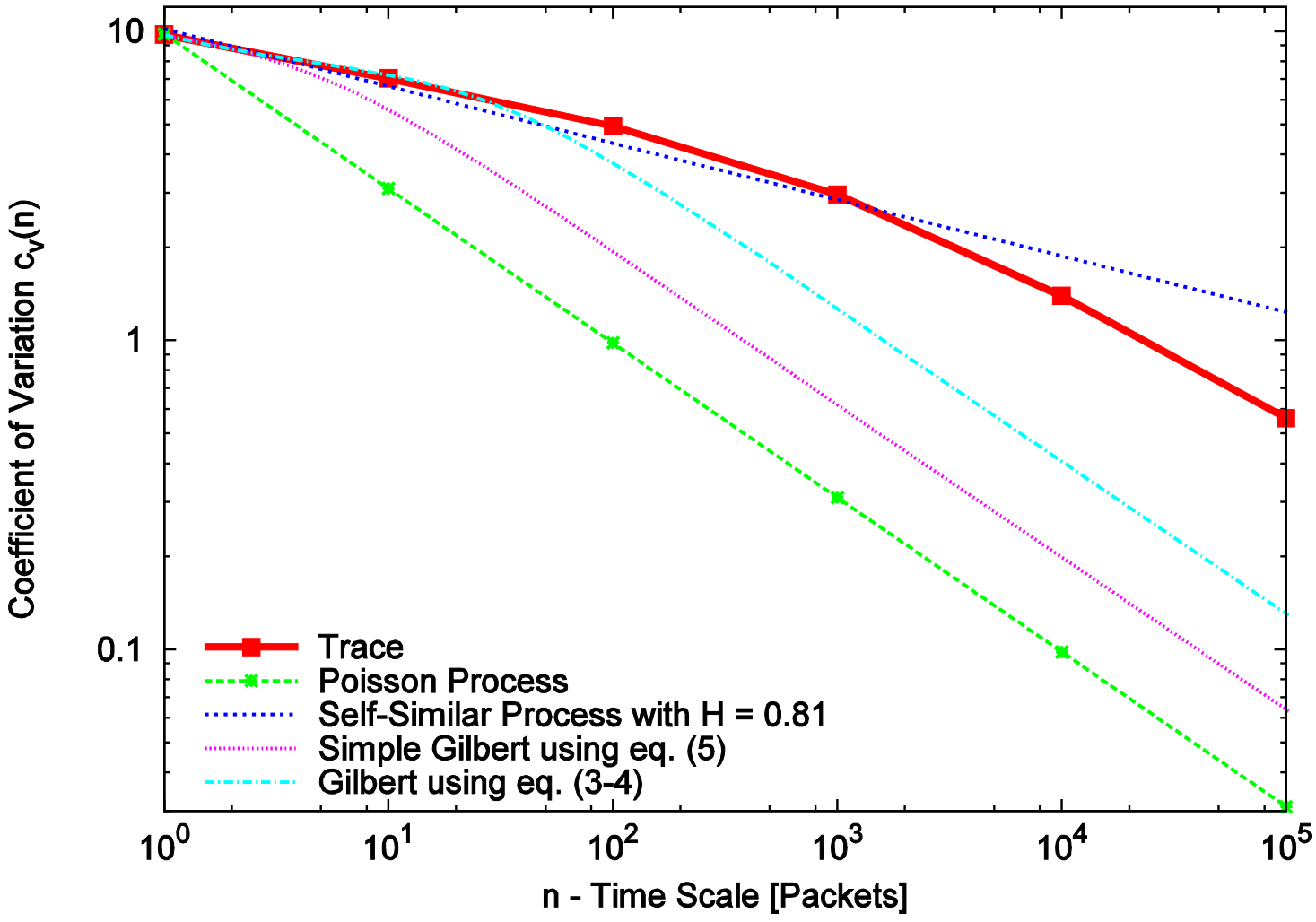
Backbone Trace



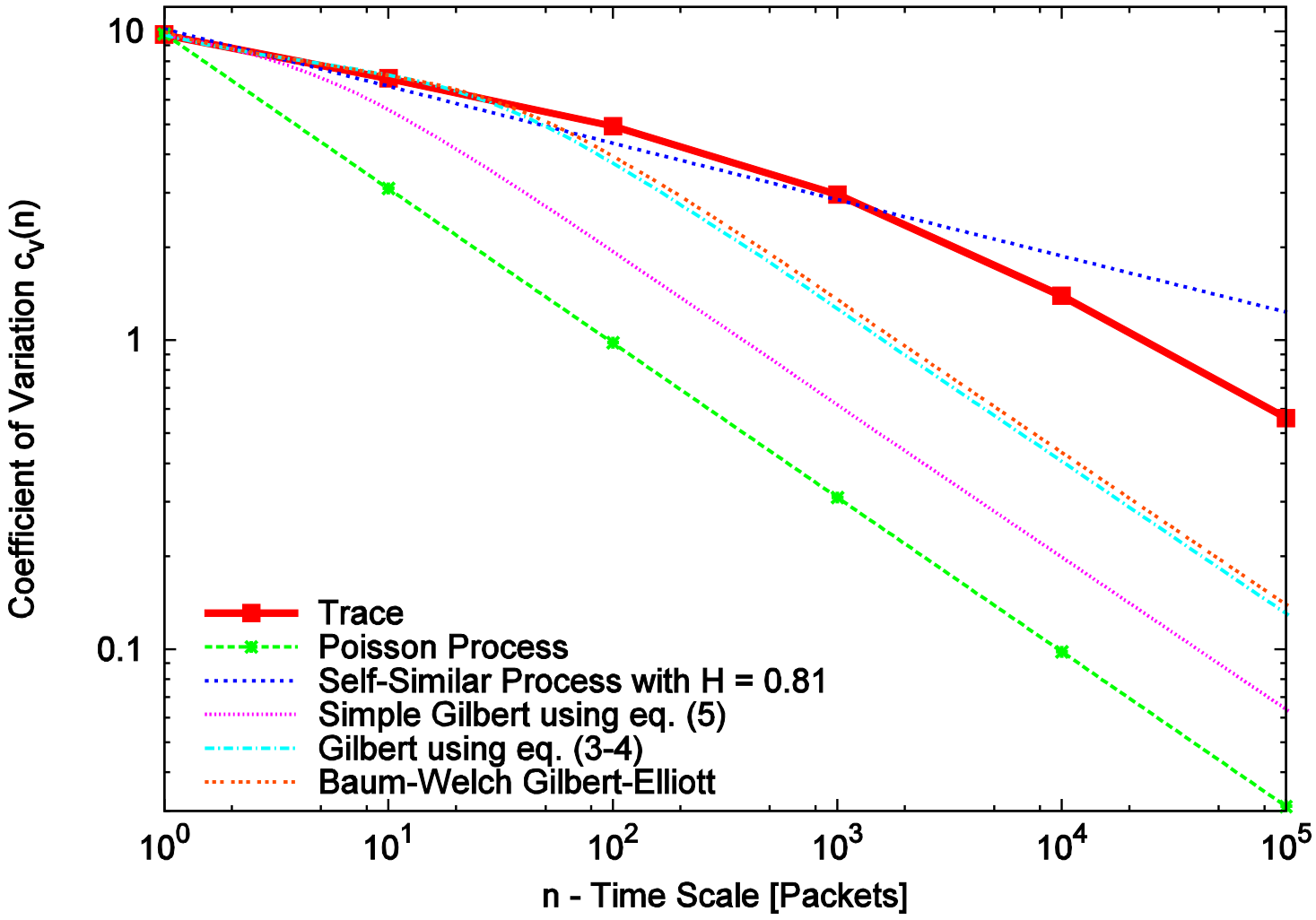
Backbone Trace



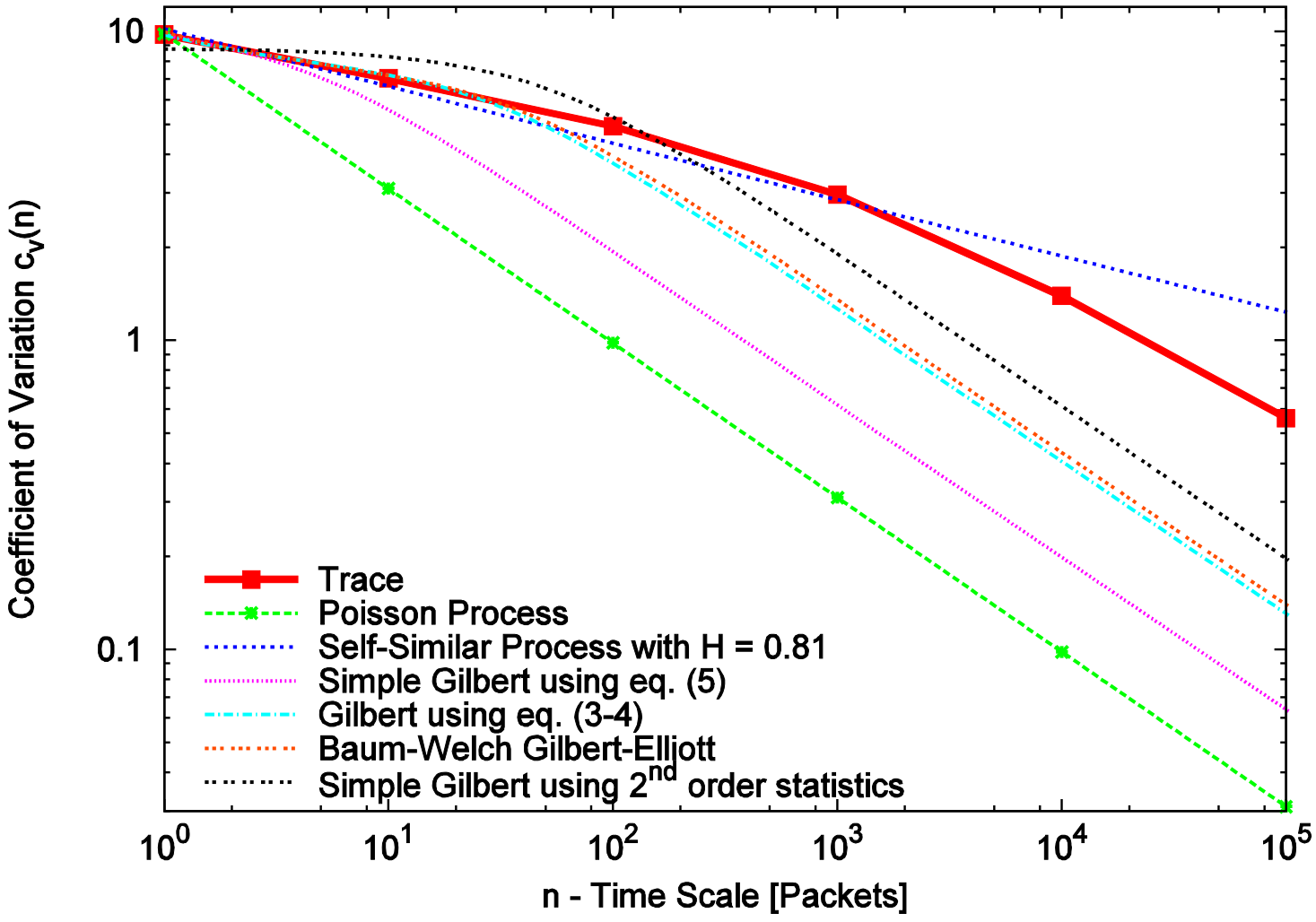
Backbone Trace



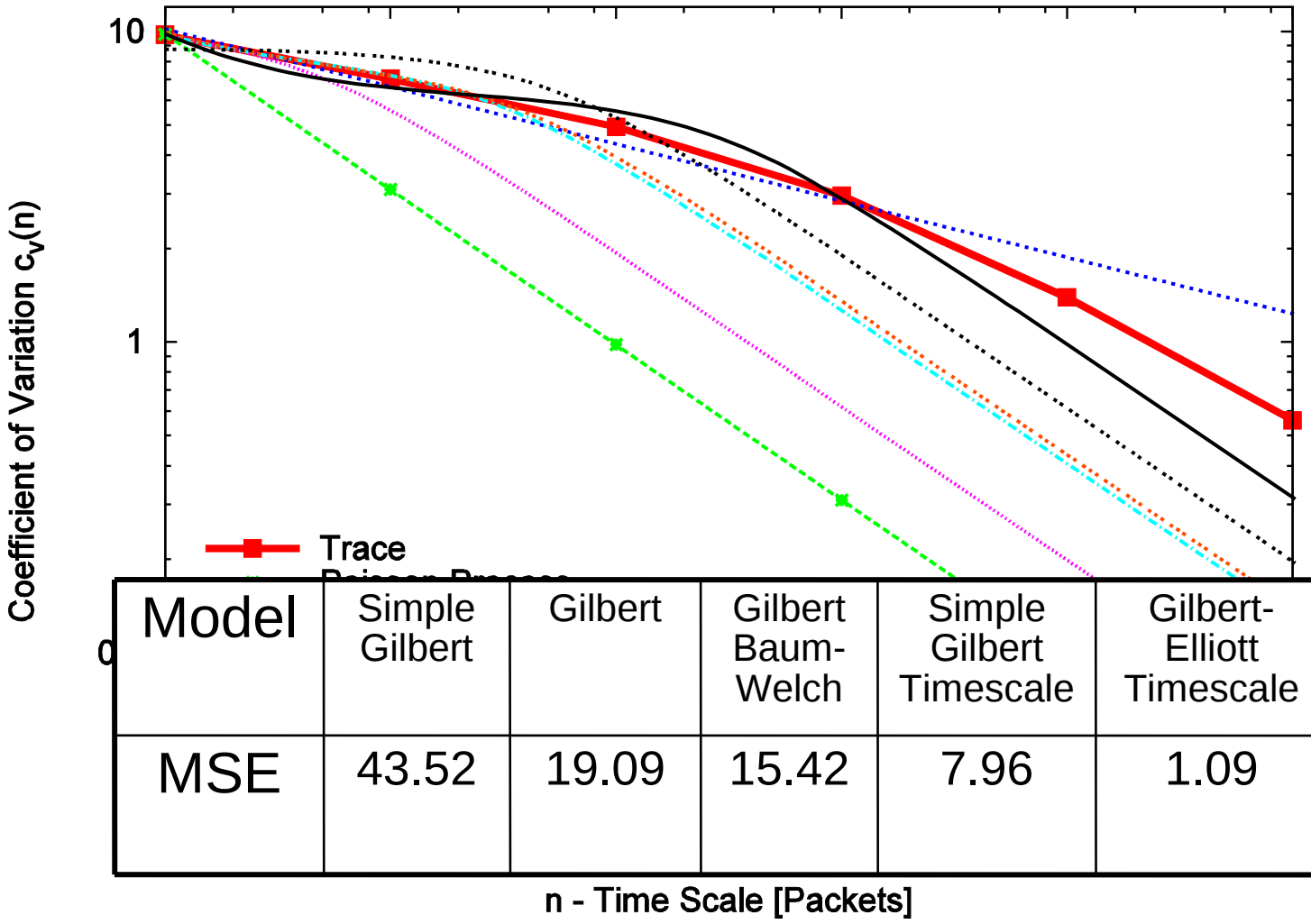
Backbone Trace



Backbone Trace



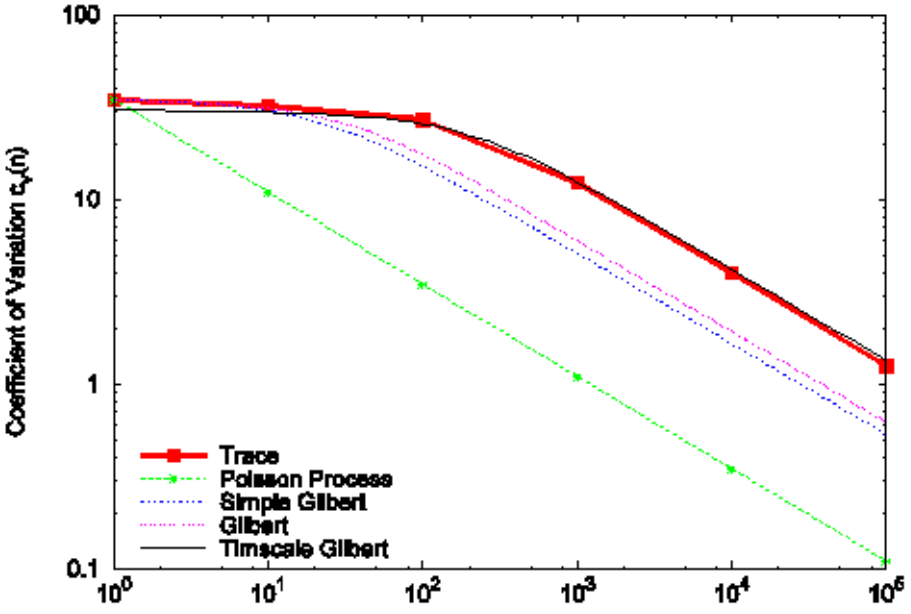
Backbone Trace



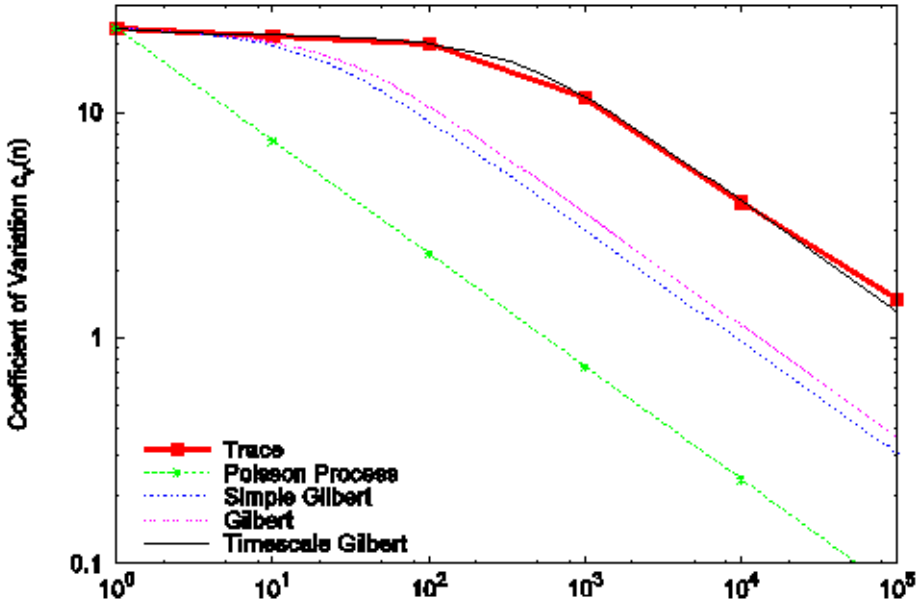
Model	Simple Gilbert	Gilbert	Gilbert Baum-Welch	Simple Gilbert Timescale	Gilbert-Elliott Timescale
MSE	43.52	19.09	15.42	7.96	1.09

DVB-H Packet-Error Traces

Traces from Jussi Poikonen, University of Turku (Finland)



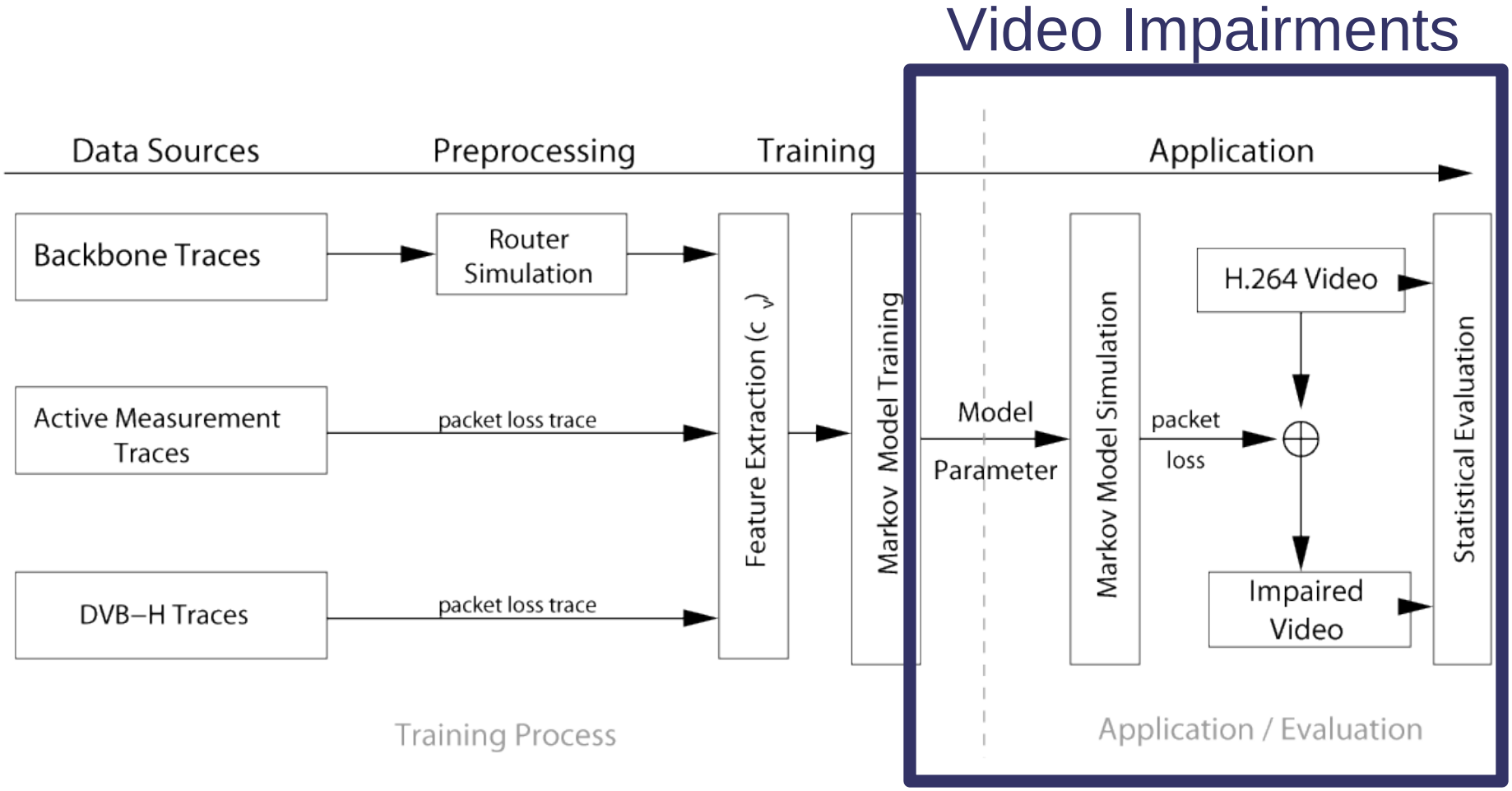
Trace 1



Trace 2

MSE/Trace	Loss Rate	Simple Gilbert	Gilbert	Timescale Gilbert-Elliott
1	0.08 %	32.93	22.19	4.29
2	1.8 %	34.54	27.08	0.008
3	6.7 %	0.372	/	0.017

Setup


Video Impairments
Data Sources
Preprocessing
Training
Application
Backbone Traces
Router Simulation
Active Measurement Traces
packet loss trace
DVB–H Traces
packet loss trace
Feature Extraction (c_v)
Markov Model Training
Model Parameter
Markov Model Simulation
packet loss
H.264 Video
Impaired Video
Statistical Evaluation
Training Process
Application / Evaluation

Video Samples

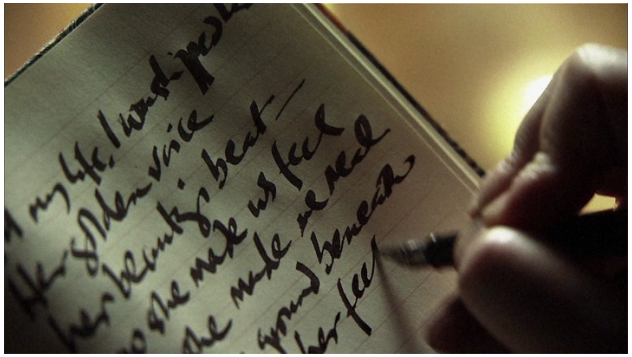
Movie Trailer

Interview

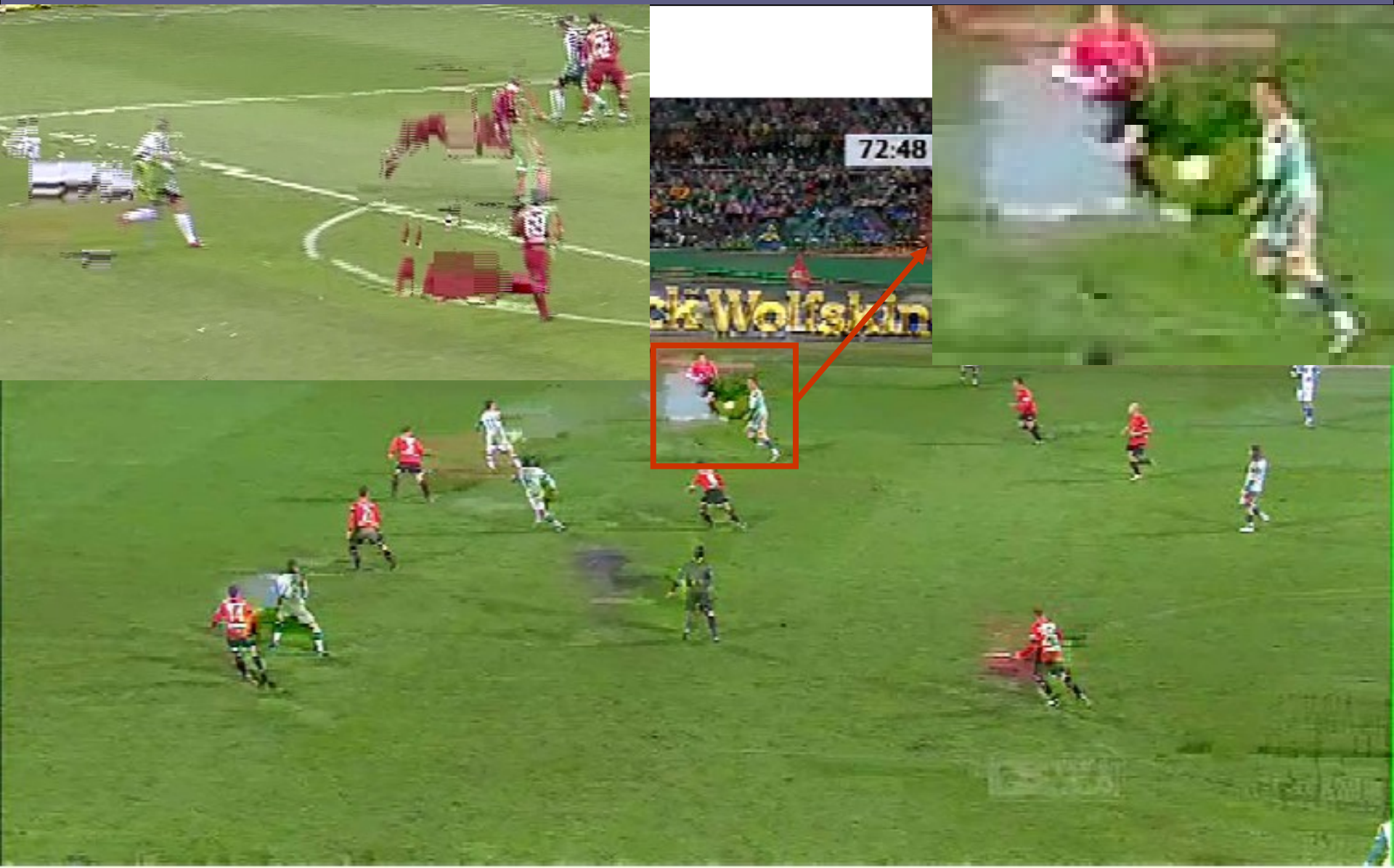
Soccer Match

Movie Sequence

U2 Music Clip



Visual Impairments caused by Packet Loss



Summary

- Analysed loss processes are not exactly self-similar
  - Suggests that Markov models are appropriate
  - Packet loss process can be modeled using simple models
- New fitting procedure leads to a closer match in multiple time-scales than classical methods
  - Flexibility to include information from relevant time-scales
- Model used as impairment generator for video quality of experience studies

Publications

- Hohlfeld, Oliver; Geib, Rüdiger; Hasslinger, Gerhard: **Packet Loss in Real-Time Services: Markovian Models Generating QoE Impairments**
  - In: 16th International Workshop on Quality of Service (**IWQoS**), pp. 261-270, 2008.
- Hasslinger, Gerhard; Hohlfeld, Oliver: **The Gilbert-Elliott Model for Packet Loss in Real Time Services on the Internet**
  - In: 14th GI/ITG Conference on Measurement, Modeling, and Evaluation of Computer and Communication Systems (**MMB**), 2008.

Thanks!

Questions

www.ohohlfeld.com