# ANALYSIS OF PACKET LOSS IN VIDEO TRANSFERS OVER UDP

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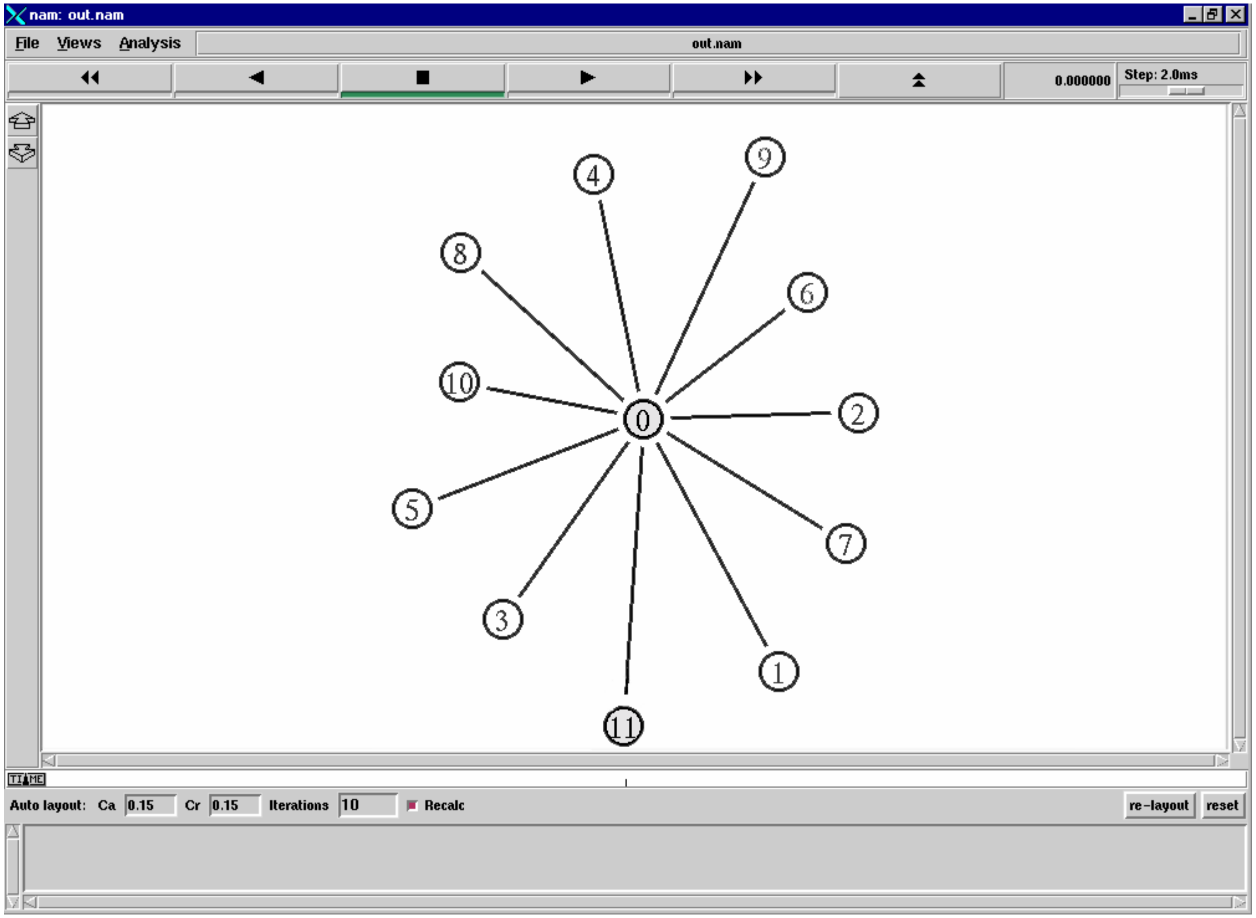
# QoS parameters for multimedia applications

- Packet loss
- Packet delay
- Delay jitter
- Cell delay variation
  - Packet loss probability
  - Packet loss behavior

# Introduction

- Video transfers over User Datagram Protocol (UDP)
- Packet loss behavior
- ns-2 simulator, driven by a “Star Wars” trace
- Wavelet-based analysis

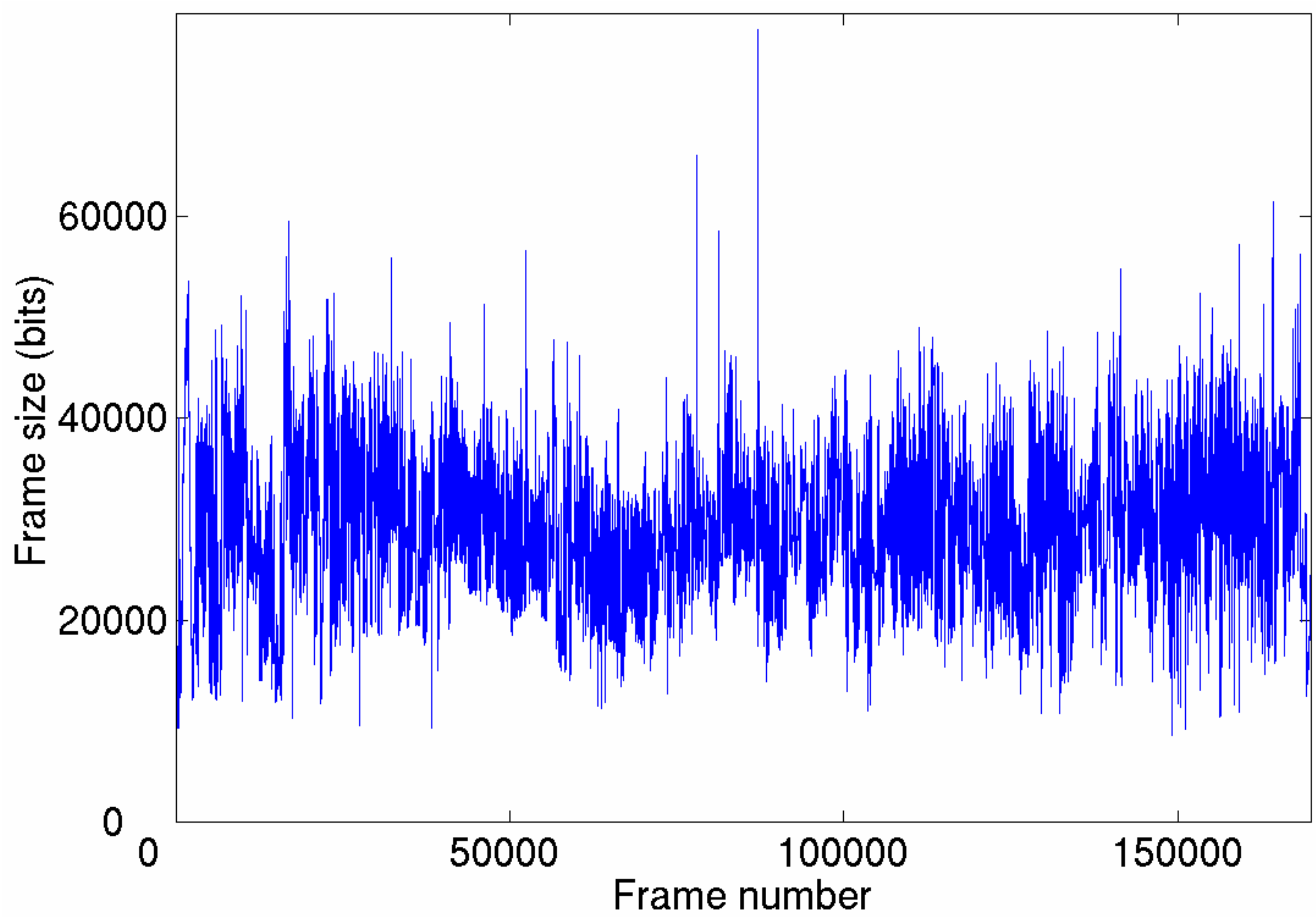
# Simulation scenario



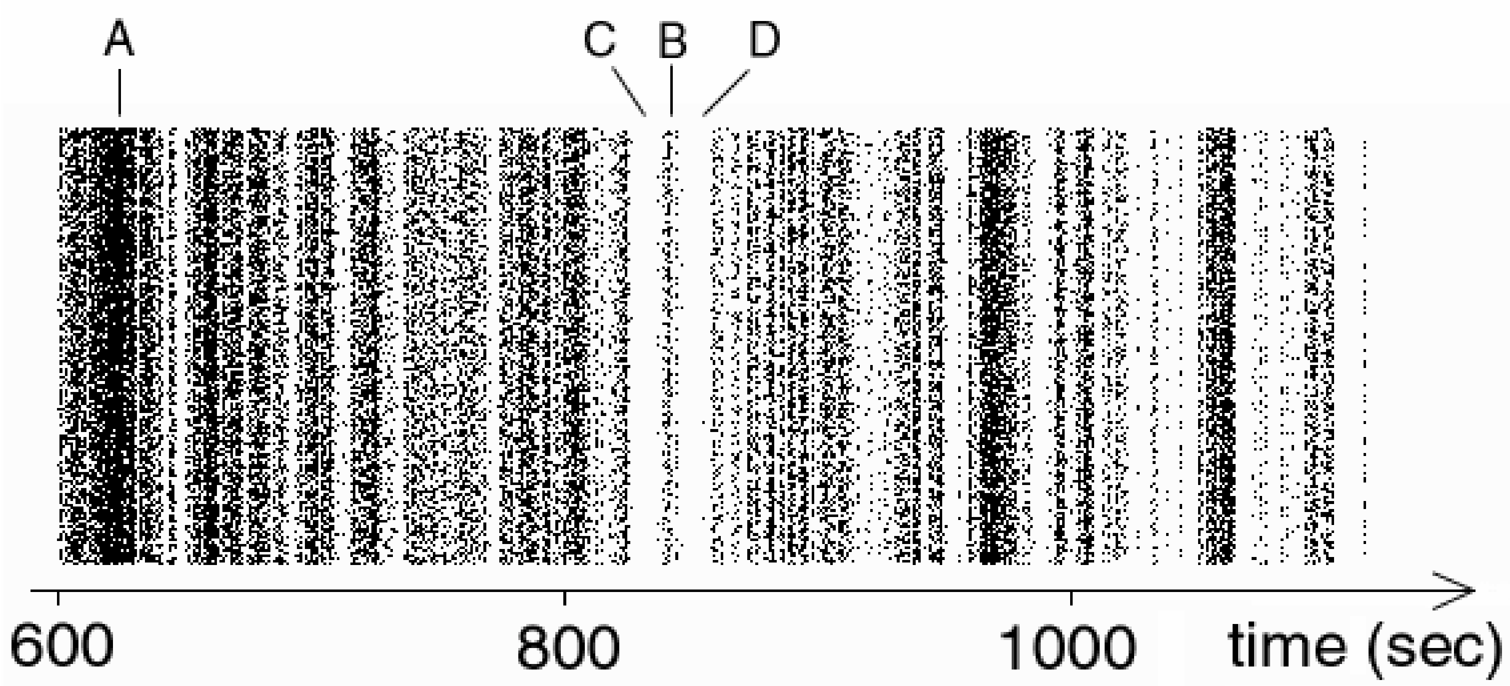

*n*: source number, *B*: buffer size

ns-2 network simulator, 1999: http://www-mash.cs.berkeley.edu/ns/ .

# Traffic trace



# Textured dot strip plot for packet loss times




Simulation run with buffer size *B* = 512 packets and *n* = 80 sources.

# Packet loss and loss bursts

Packets with sequence numbers

1, 4, and 6 are successfully received

2, 3, and 5 are lost.

First *loss burst*:

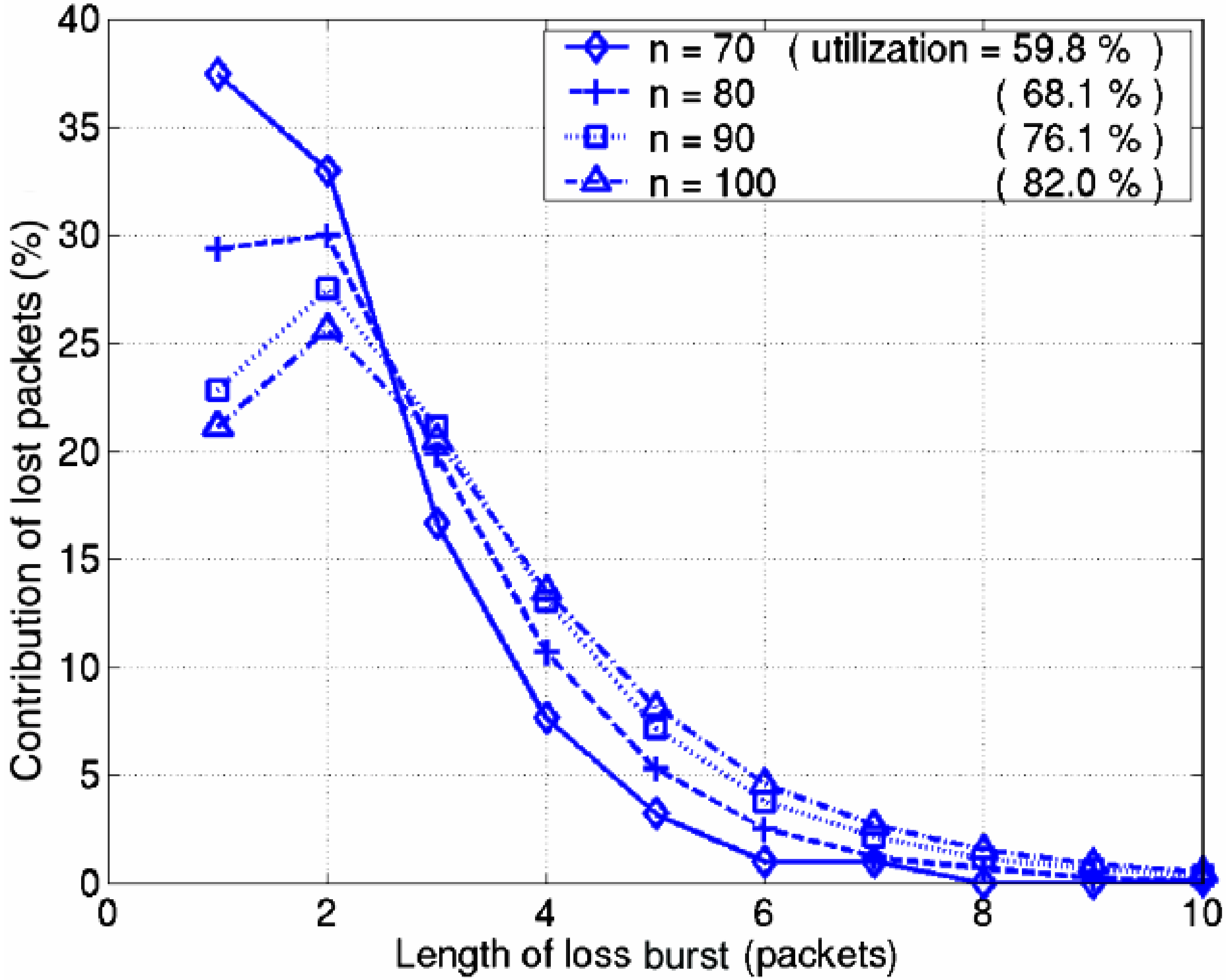
Begins with packet 2 and ends with packet 3.
*Length* = two packets.

Second *loss burst*:

Begins and ends with packet 5.

*Length* = one packet.

# Contribution of lost packets




Buffer size *B* = 512 packets

# Contribution of loss bursts

Example: Total number of lost packets = 200.

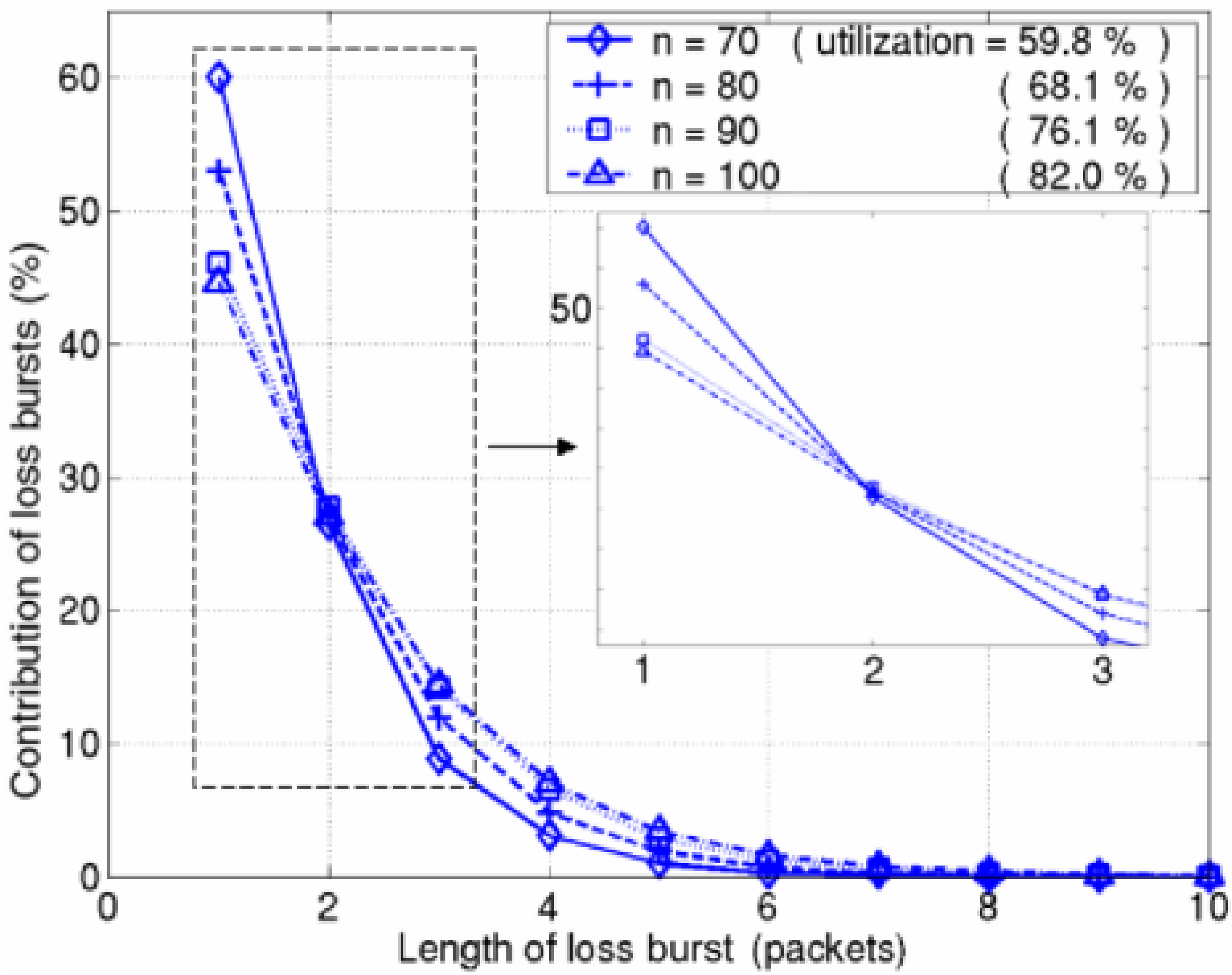
| Loss burst of length: | No. of packets: |
|---|---|
| 1: 70 | 1 x 70 = 70 |
| 2: 40 | 2 x 40 = 80 |
| 3: 10 | 3 x 10 = 30 |
| 4: 5 | 4 x 5 = 20 |

Contribution of loss burst of:

length 1: 70/200 = 0.35 length 2: 80/200 = 0.40

length 3: 30/200 = 0.15 length 4: 20/200 = 0.10

# Contribution of loss bursts

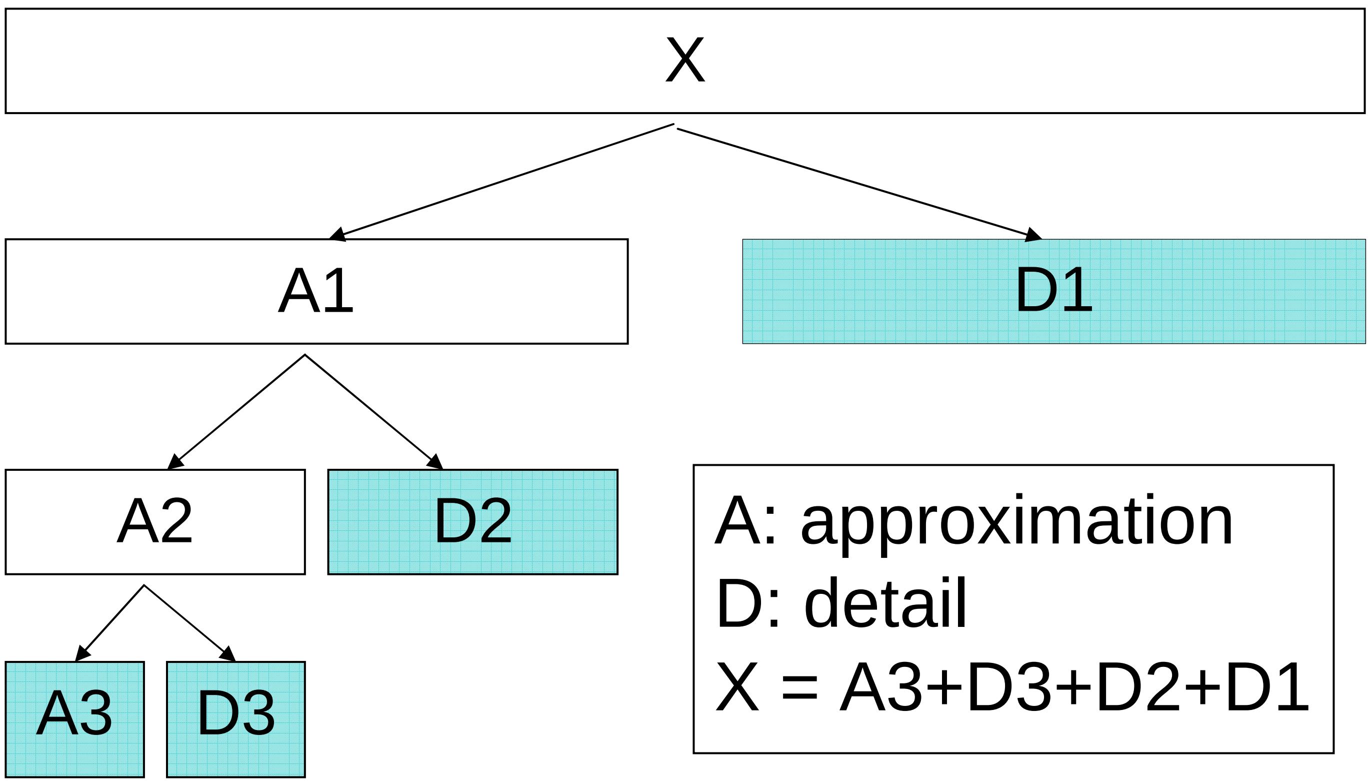



Buffer size *B* = 512 packets

# Lost packets and mean loss burst distances

| | Contribution of lost packets to overall loss (%) | | | | |
|---|---|---|---|---|---|
| *i (pkts)* | *1* | *2* | *3* | *4* | *5* |
| *Band A* | *25.98* | *28.75* | *19.77* | *12.59* | *6.56* |
| *Band B* | *43.84* | *28.99* | *16.30* | *7.25* | *3.62* |
| *Band A* | *Mean loss burst distance = 148* | | | | |
| *Band B* | *Mean loss burst distance = 1145* | | | | |

# Wavelet analysis



# LRD and Hurst parameter

- Self-similar process:
  - long-range dependent (LRD)
  - fractal
  - with heavy-tailed distributions
- Network traffic exhibits self-similarity
- Hurst parameter: $0.5 < H < 1$

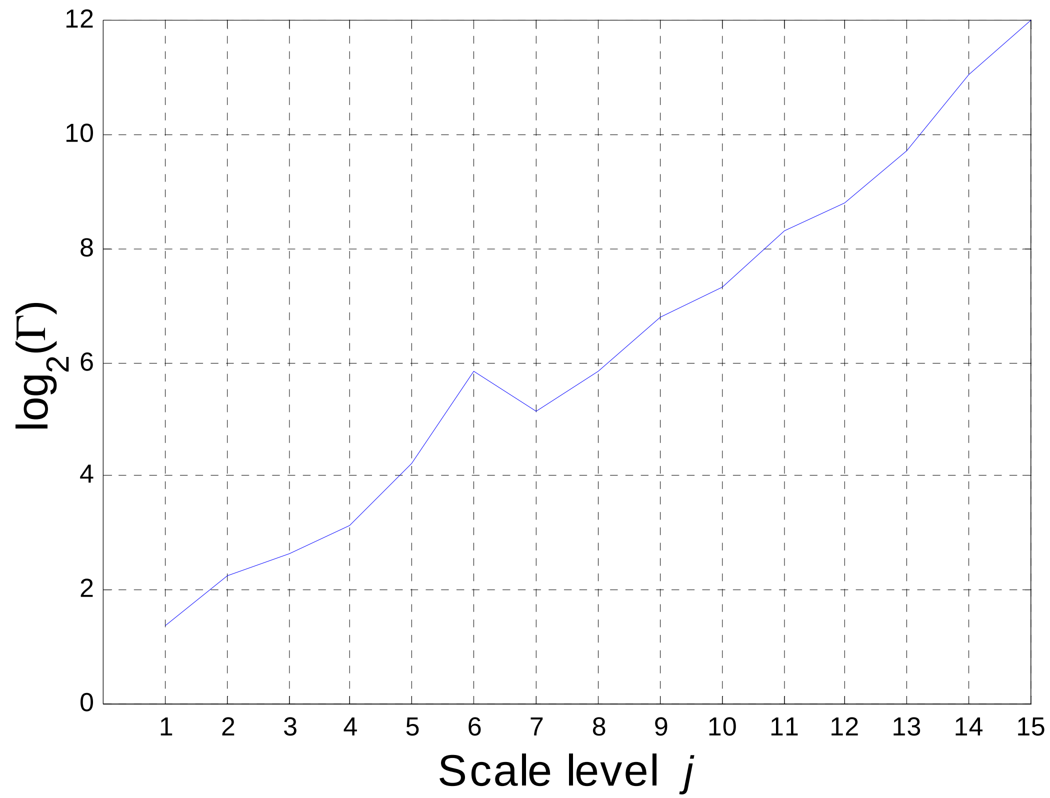
# Wavelet-based Hurst parameter estimator

$$\Gamma(2^{-j} v_0) = \frac{1}{n_j} \sum_k \left| d(j,k) \right|^2$$

- $\Gamma$: spectrum of time series
  $d(j,k)$: the detail coefficients at level $j$
  $n_j$: the number of coefficients at level

- Linear relationship between $\log_2(\Gamma)$ and $j$ indicate LRD.
- $\log_2(\Gamma) = (2H - 1)j + c$, $H$: estimated Hurst parameter

# Traffic analysis example: $\log_2(\Gamma)$ vs. *j* plot of trace *pOct.TL*



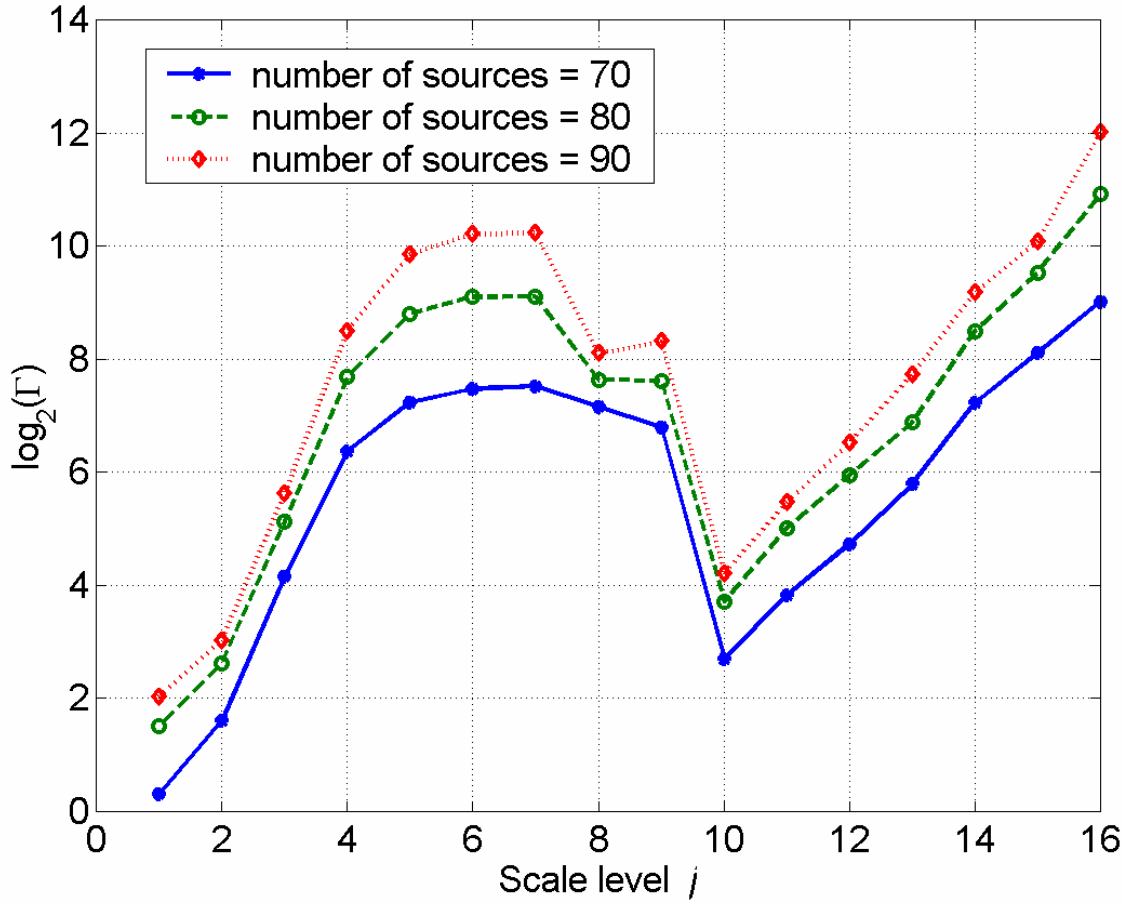

Graph indicates linear behavior in the range [7,13].

# Wavelet analysis of packet loss

- We use wavelet-based analysis to detect both the presence and the location of LRD.
- Loss rate process:

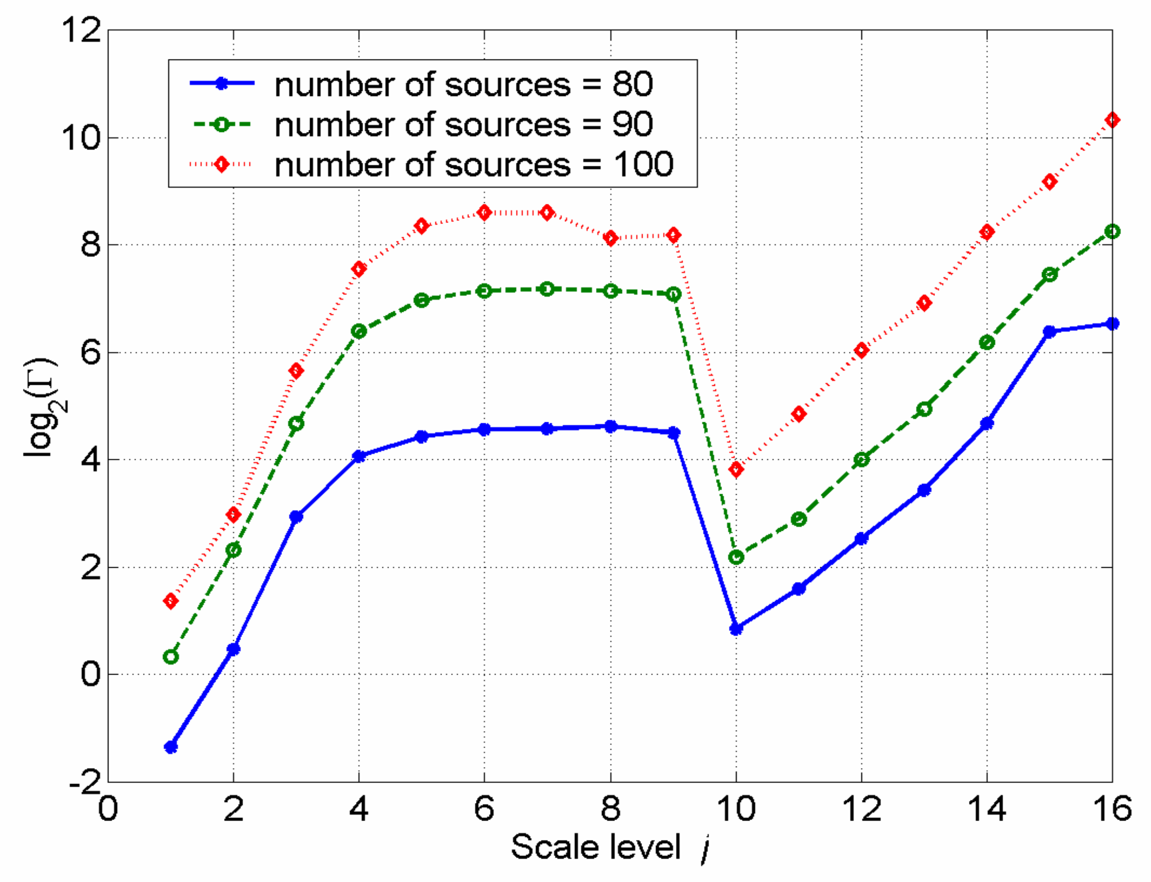
  each sample represents the number of loss packets over 1,000 ms.

# Experiment results (1)



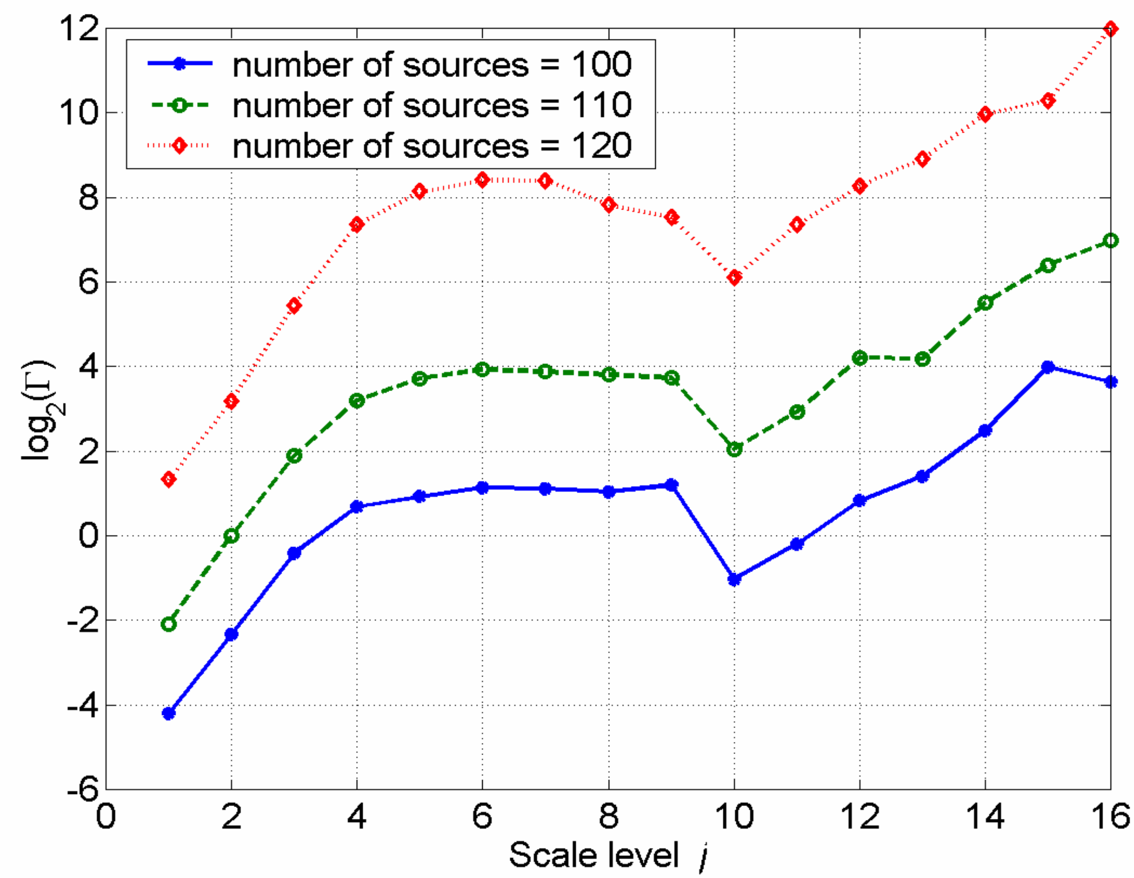

Buffer size $B$ = 128 packets

# Experiment results (2)




Buffer size $B$ = 512 packets

# Experiment results (3)




Buffer size $B$ = 1024 packets

# Packet loss behavior

- Packet loss behavior and loss properties vary over different time scales.
- Linear relationship between $\log_2(\Gamma)$ and *j* is evident for the coarser scales, i.e., beyond the break-point = 10.

# Hurst parameter estimation

Table 1: Estimated Hurst parameters of a packet loss process with 1,000 ms granularity, *n* sources, and buffer size *B* = 128.

| *n* | Variance - time | R/S |
|---|---|---|
| 70 | 0.8273 | 0.8326 |
| 80 | 0.6667 | 0.8663 |
| 90 | 0.6647 | 0.7971 |

All estimated Hurst parameters are larger than 0.5, which indicates the existence of LRD in packet loss on coarser time scales.

# Concluding remarks

- Increased utilization causes lengthier loss bursts.
- Periods of lower congestion are characterized with more frequent single loss bursts and with wider loss burst distances.
- Packet loss exhibits long-range dependence over the coarser time scales.

# Concluding remarks

- Time scales are important for estimating behavior of packet loss.
- Wavelet-based analysis proved useful for finding time scale break-points beyond which long-range dependency can be detected.

# Future work

- Influence of network protocols (such as TCP) and their feedback mechanisms on the occurrence of packet loss.
- Simulation and analysis of packet delays in UDP and TCP networks.

# References


- P. Abry and D. Veitch, “Wavelet analysis of long-range dependent traffic,” *IEEE Trans. on Information Theory*, vol. 44, pp. 2–15, 1998.
- M. S. Borella, D. Swider, S. Uludag, and G. B. Brewster, “Internet packet loss: measurement and implications for end-to-end QoS,” in *Proc. Int. Conference on Parallel Processing*, Minneapolis, MN, pp. 3–15, Aug. 1998.
- M. W. Garrett and W. Willinger, “Analysis, modeling and generation of self-similar VBR video traffic,” in *Proc. ACM SIGCOMM’94*, London, UK, Aug. 1994, pp. 269–280.
- D. S. Swayne, D. Cook, and A. Buja, “XGobi: Interactive dynamic data visualization in the X window system,” *Journal of Computational and Graphical Statistics*, vol. 7, no. 1, pp. 113–130, Mar. 1998.
- F. Xue, V. Markovski, and Lj. Trajkovic, “Wavelet analysis of packet loss in video transfer over UDP,” to be presented at *the 1st International Conference on Internet Computing* , June 26–29, 2000, Las Vegas, USA.