A Method for Monitoring of QoS Parameters in IP-Based Virtual Private Networks

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Outline

- Introduction
- A method for monitoring in IP networks
- Simulations based on traffic data
- Implementation issues
- Summary

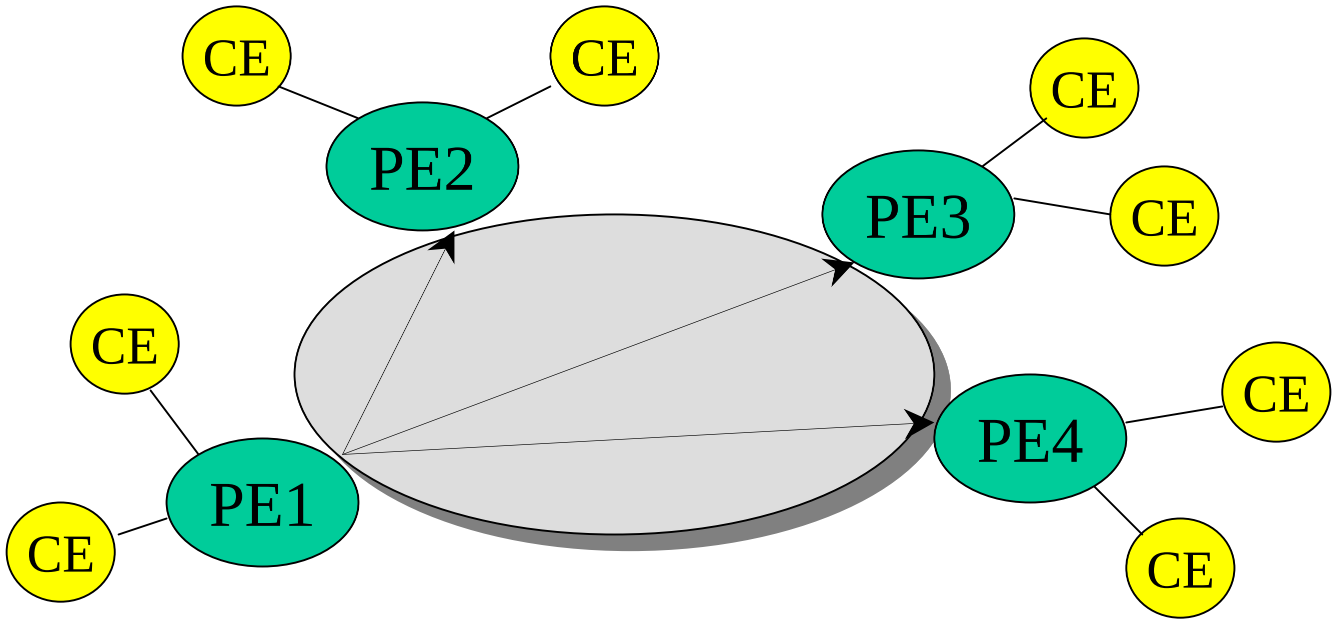
Introduction

- Basic approach
  - Monitoring functions in the network elements
  - In-service method
    - Measure and estimate user traffic
- Applications
  - Monitoring of service level agreements
  - Support for operations and control

A method for performance monitoring in IP networks

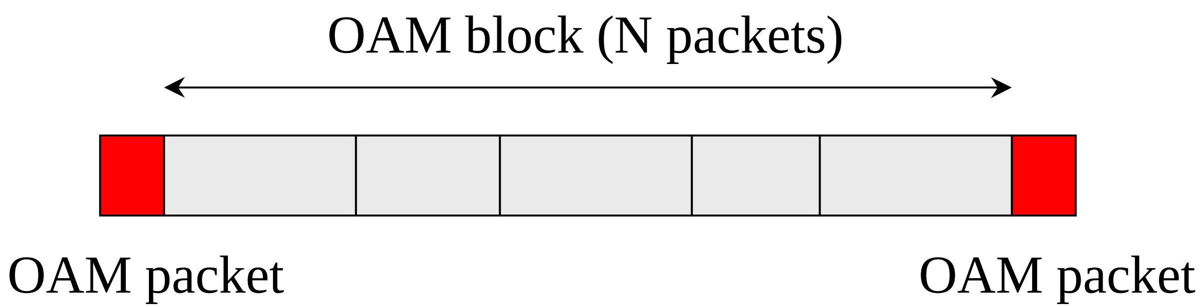
- Measurement and estimation of
  - Packet losses
  - Delays
  - Throughput
- Applied to IP-based virtual private networks

- Monitoring of traffic in IP-based VPNs

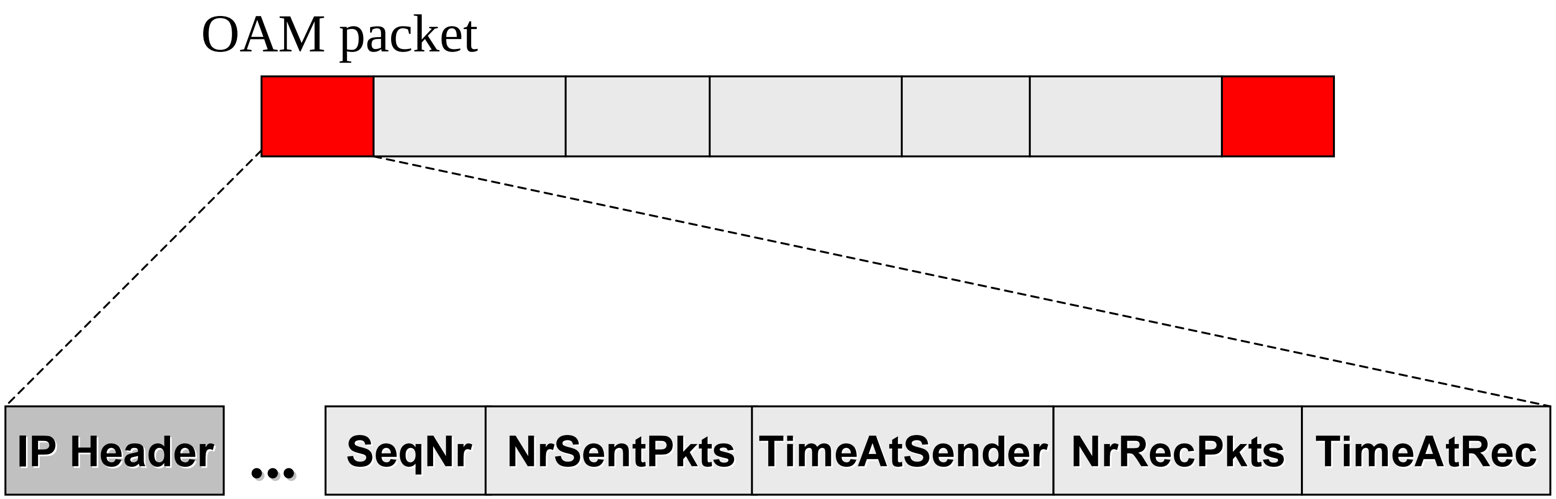


  - Provider edge node 1 is an entry-monitoring node and PE2-PE4 are exit-monitoring nodes for the outgoing traffic from PE1

- Monitoring packets
  - OAM packets are inserted between blocks of user traffic
  - Existing routers maintain traffic counters and timestamping functions



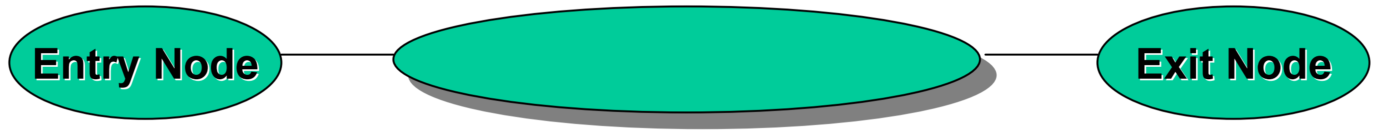
- OAM packets



OAM packet
IP Header
...
SeqNr
NrSentPkts
TimeAtSender
NrRecPkts
TimeAtRec

- The monitoring method
  - Traffic meters
    - Transmitted packets are counted by the entry nodes
    - Received packets are counted by the exit nodes
    - Samples of the packet length
  - Monitoring packets
    - Carry time stamps and counter values of the number of sent/received packets, or
    - Synchronise storage of these traffic meter values in entry and exit-monitoring nodes

- OAM packets transfer monitoring data (1)



.....

0	0	10	1000	2	→

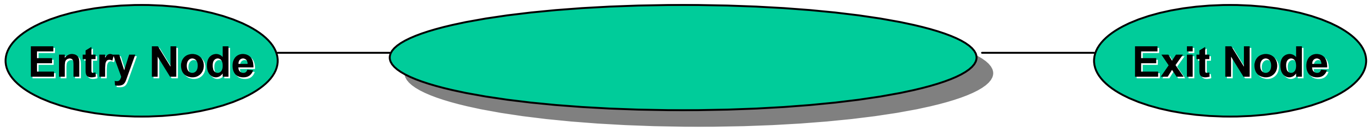
←	2	1000	10	990	13

.....

0	0	22	2010	3	→

←	3	2010	22	2000	26

- OAM packets synchronise local storage (2)



OAM packet #	Time stamp	Number of sent pkts		Time stamp	Number of received pkts
1	0	0		2	0
2	10	1000		13	990
3	22	2010		26	2000
4	26	3000		29	2900

- Monitoring functions
  - Determine which of the exit-monitoring nodes the packets will pass through
    - A simplified problem for VPNs based on IP tunnels
  - Maintain counters and time functions
    - Insert the cumulative number of transmitted packets and a time stamp into the OAM packet
  - Estimate the packet length
  - Corresponding functions in exit-monitoring nodes

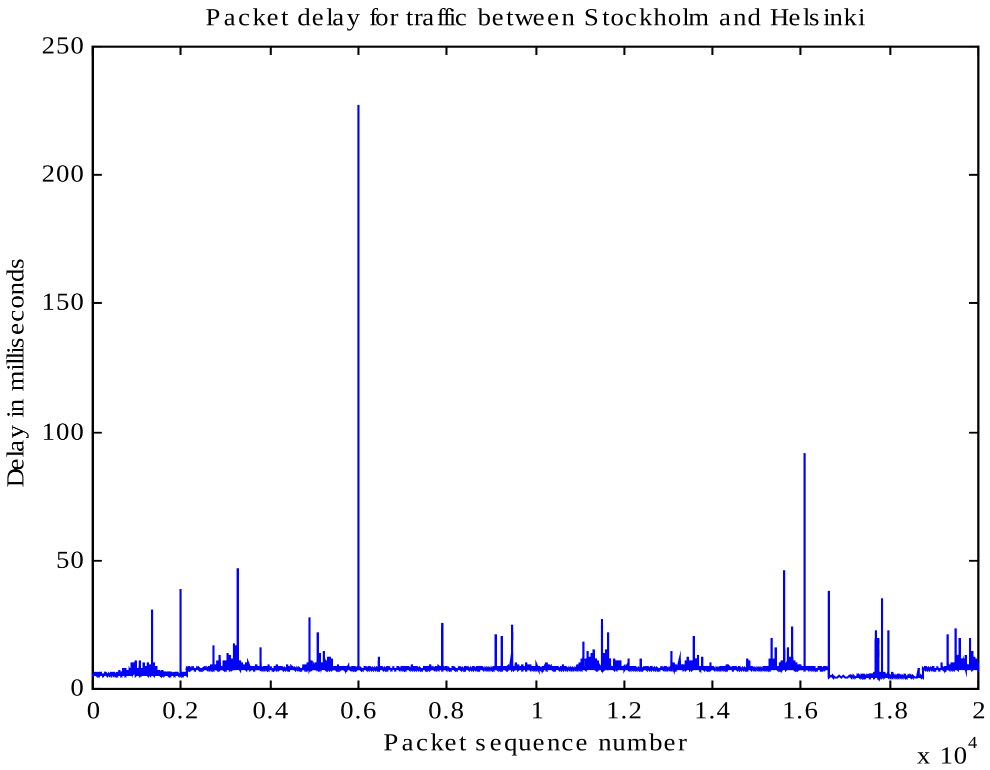
- Summary of results
  - Samples of delays and delay variations
  - Packet loss ratio
  - The average length of the loss-free period and the loss period
    - The number of consecutive OAM blocks with or without losses
  - Throughput between edge nodes

Simulations based on traffic data

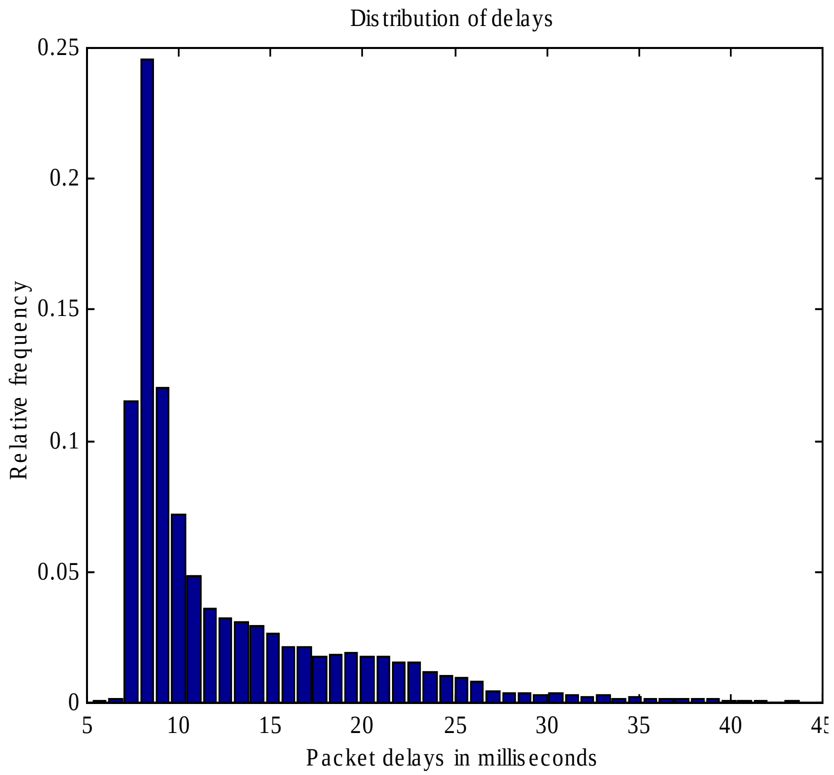
- Traffic between test boxes from RIPE
  - Sequence numbers
  - Time stamps and synchronised clocks
  - Traffic between Stockholm-Helsinki and Copenhagen-Stockholm during 10 days
- Simulations using Matlab

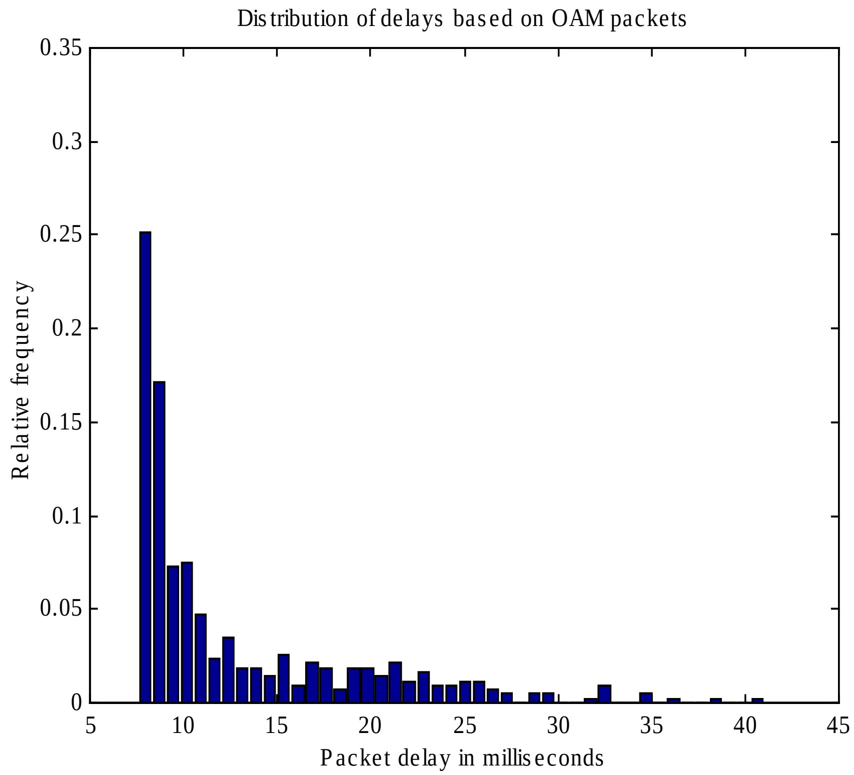
– Stockholm - Helsinki

- Average packet delay: 7 ms
- Maximum delay: 227 ms
- Packet loss ratio: 3.8 %



- Distribution of packet delays
  - Every packet
  - OAM block size 50 pkts



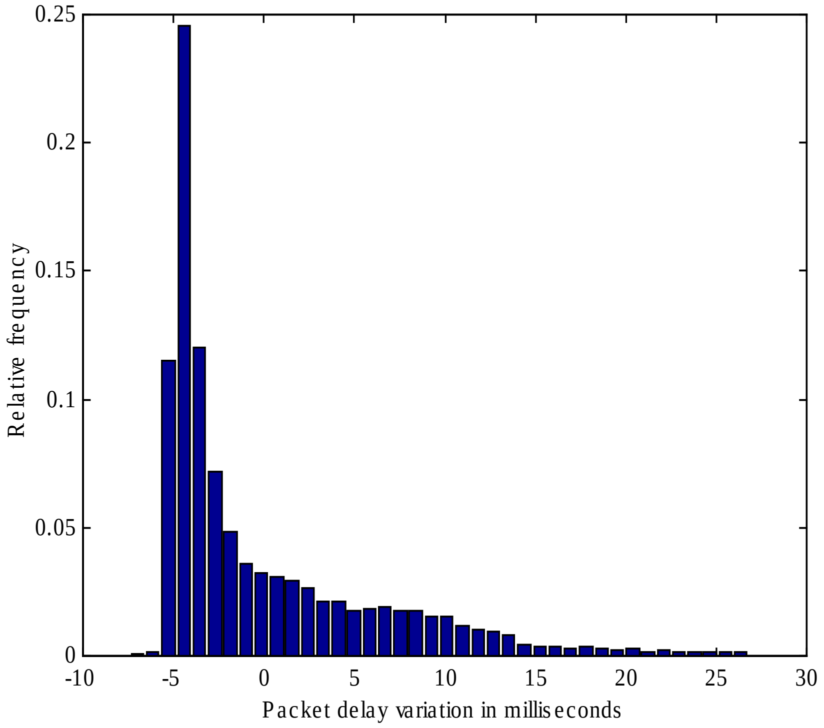


- Average delay
  - Relative errors: 0.2% - 3.7%
- Maximum delay
  - Estimates within the
    - 99.8 percentile for N=50 and N=100
    - 98.4 percentile for N=500 and N=1000

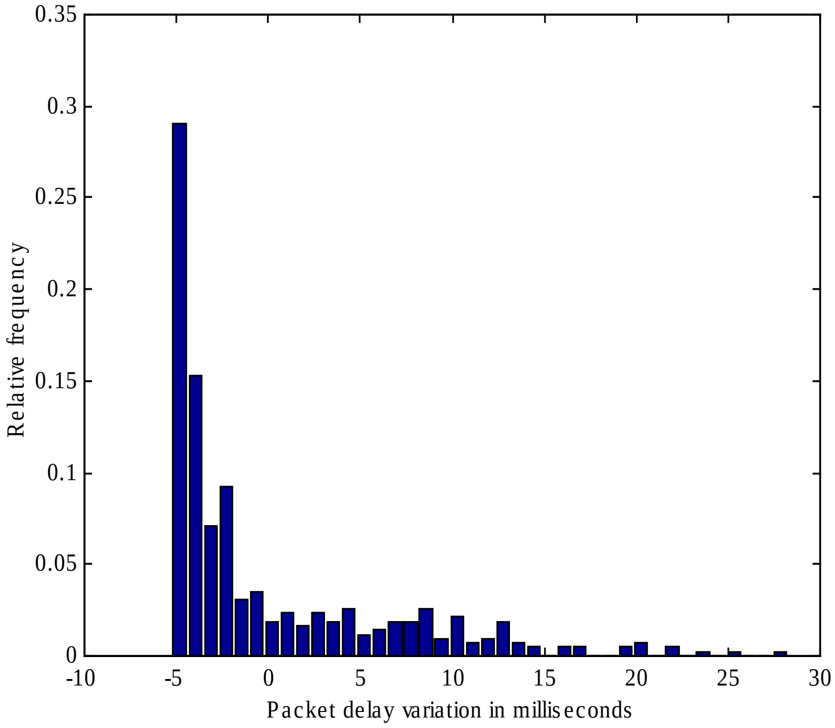
	Exact values	N=50	N=100	N=500	N=1000
Mean delay	12.69	12.79	12.49	12.22	12.67
Max delay	90.80	41.03	41.03	32.83	32.83
99.5 prctile	38.44				

- Packet delay variation
  - Difference between one-way packet delay and the average packet delay

Distribution of the delay variation



Distribution of delay variation based on OAM packets



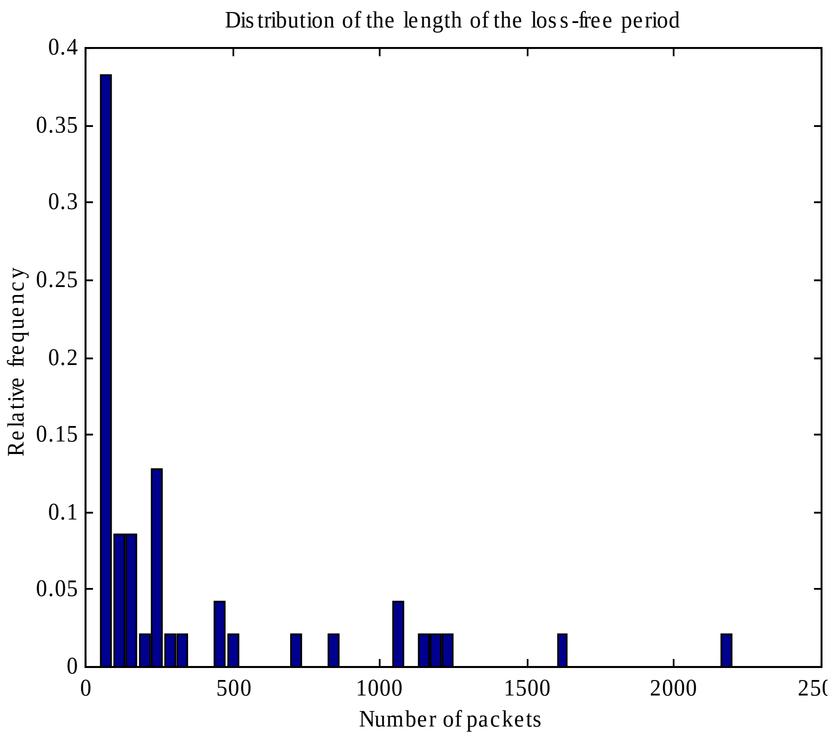
- Maximum delay variation
- Estimates within
  - 99.8 percentile for N=50 and N=100
  - 98.4 percentile for N=500 and N=1000

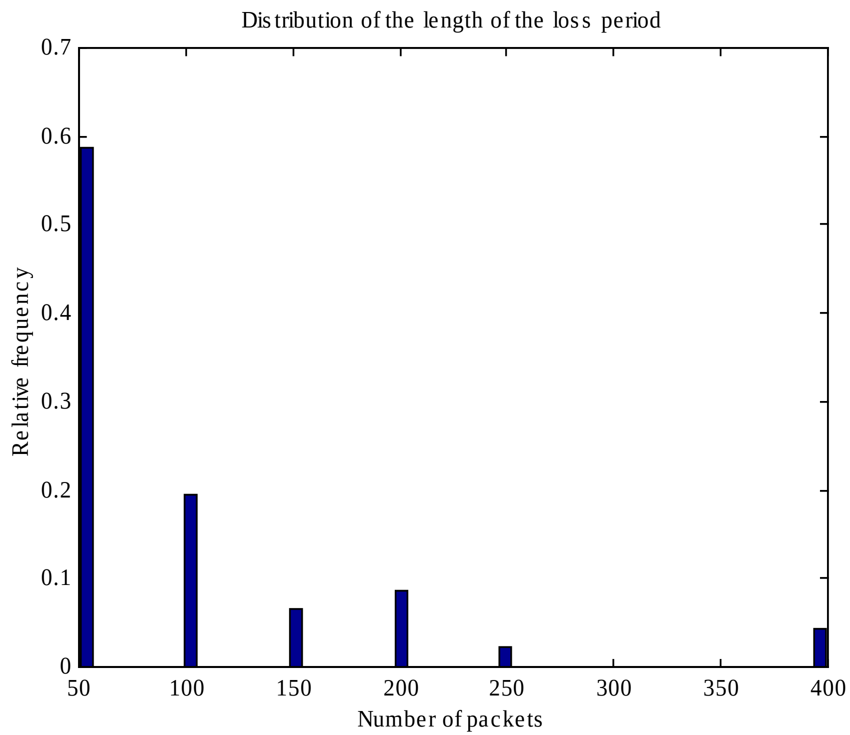
	Exact values	N=50	N=100	N=500	N=1000
Max delay variation	78.11	28.23	28.54	20.60	20.16
99.5 prctile	25.74				

- Packet losses
  - Loss-free periods
    - Number of consecutive OAM blocks without losses
  - Loss periods
    - Number of consecutive OAM blocks that contain lost packets
    - Distribution of the number of losses in loss periods
    - Packet loss ratio in loss periods

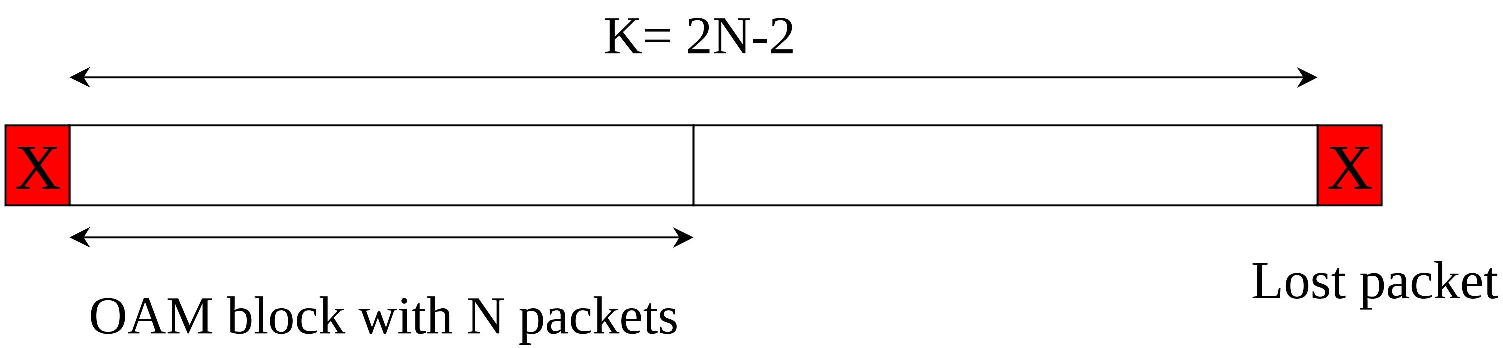
– Distribution of the length of

- loss-free periods
- loss periods



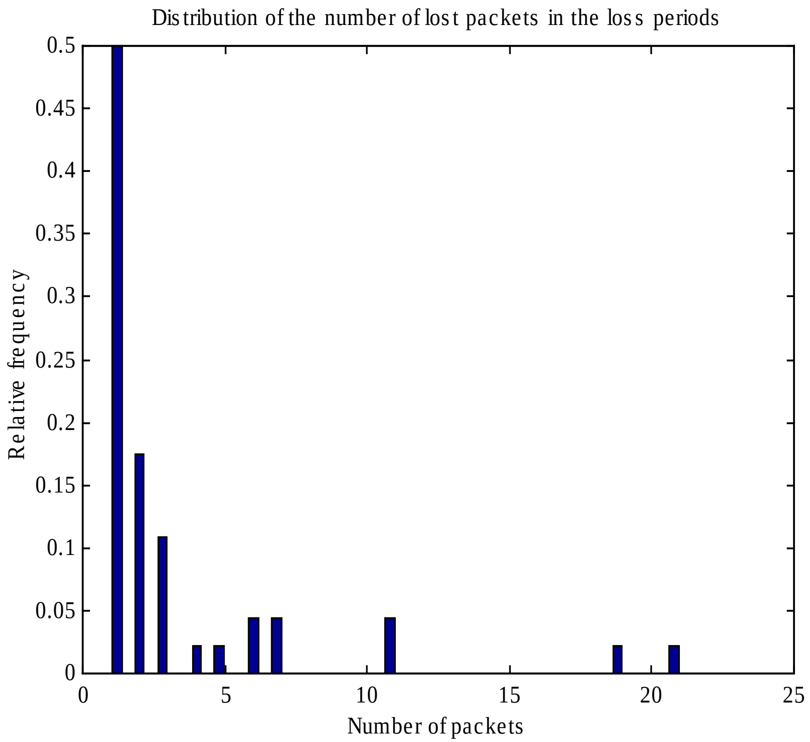


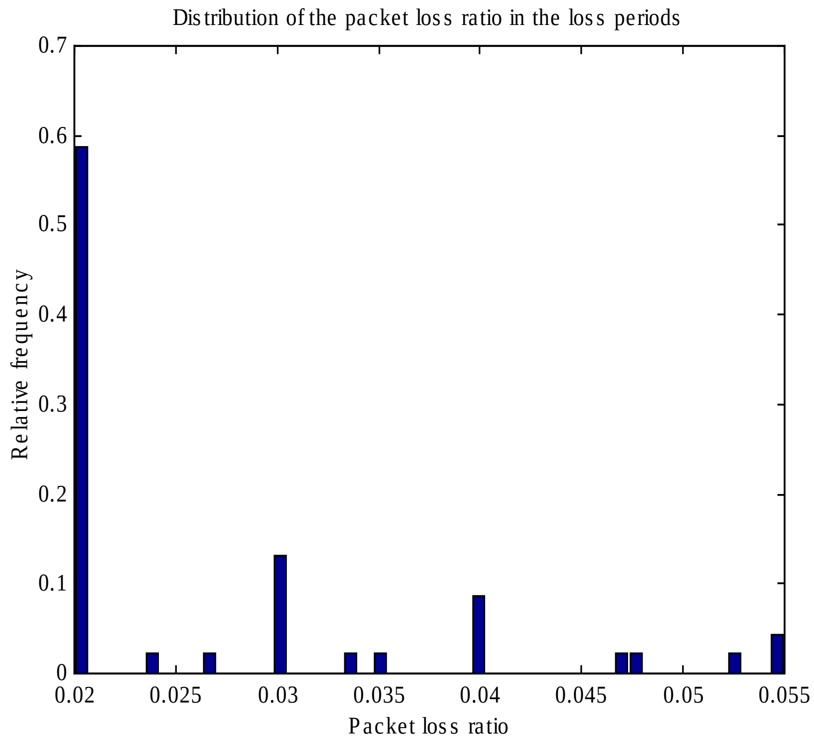
- Loss periods defined in terms of a parameter K
  - The maximum number of packets between two losses in a loss period
  - In this case
    - K=2•the block length – 2



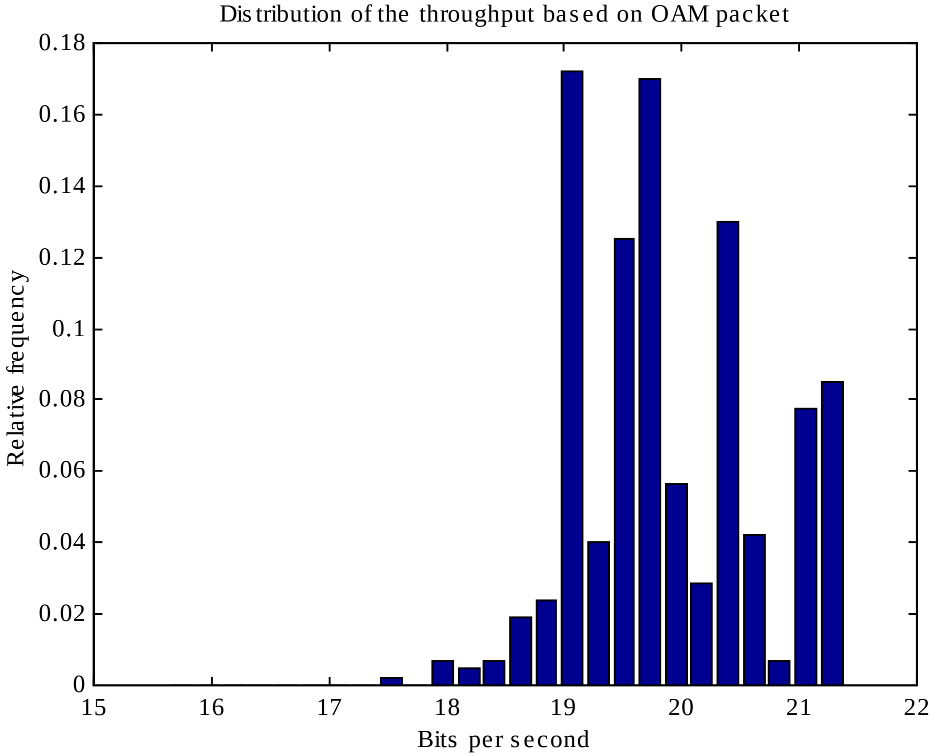
– Number of losses in loss periods

– Packet loss ratio in loss periods





- Throughput
  - Distribution of throughput per monitoring block



- Summary of the simulations
  - Estimates of average delay and delay variation
  - Overall packet loss ratio
  - Length of loss-free periods and loss periods
  - Throughput per monitoring block

- The size of the monitoring block
  - Small block sizes
    - High resolution and accuracy
    - Increased complexity and extra load
  - Large block sizes are often sufficient. Example:
    - Monitor traffic of mean rate 1 Mb/s during one hour
    - 99% confidence level and 0.4 confidence interval
    - A block size of 2700 packets is enough to estimate the mean packet delay

Implementation issues

- A simple prototype
  - Packet filters
    - Netfilter/iptables in Linux
  - Alternative approach
    - Network interface

- Synchronisation of counters and OAM packets
  - OAM packets that trigger monitoring functions instead of carrying data
- Disordering of packets - changes in routing
  - Uncertain which block packets and losses belong to
  - When routing is changed - group the OAM blocks into larger entities
- Extending the method
  - Efficient methods to look up the exit/entry monitoring nodes given the IP destination/source addresses

Summary

- A simple method for embedded monitoring
  - OAM packets
    - Transfer or synchronise monitoring data
  - Estimates of
    - Packet losses
    - Length of loss-free periods and loss periods
    - Average delay and delay variation
    - Throughput between edge nodes
- Implementation