Duplicate detection methodology for IP network traffic analysis

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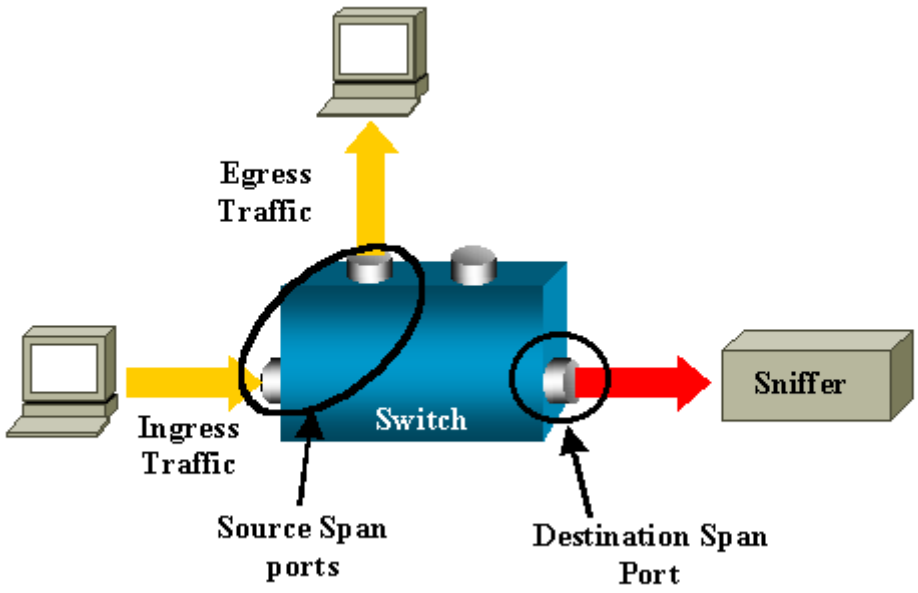
1. Introduction

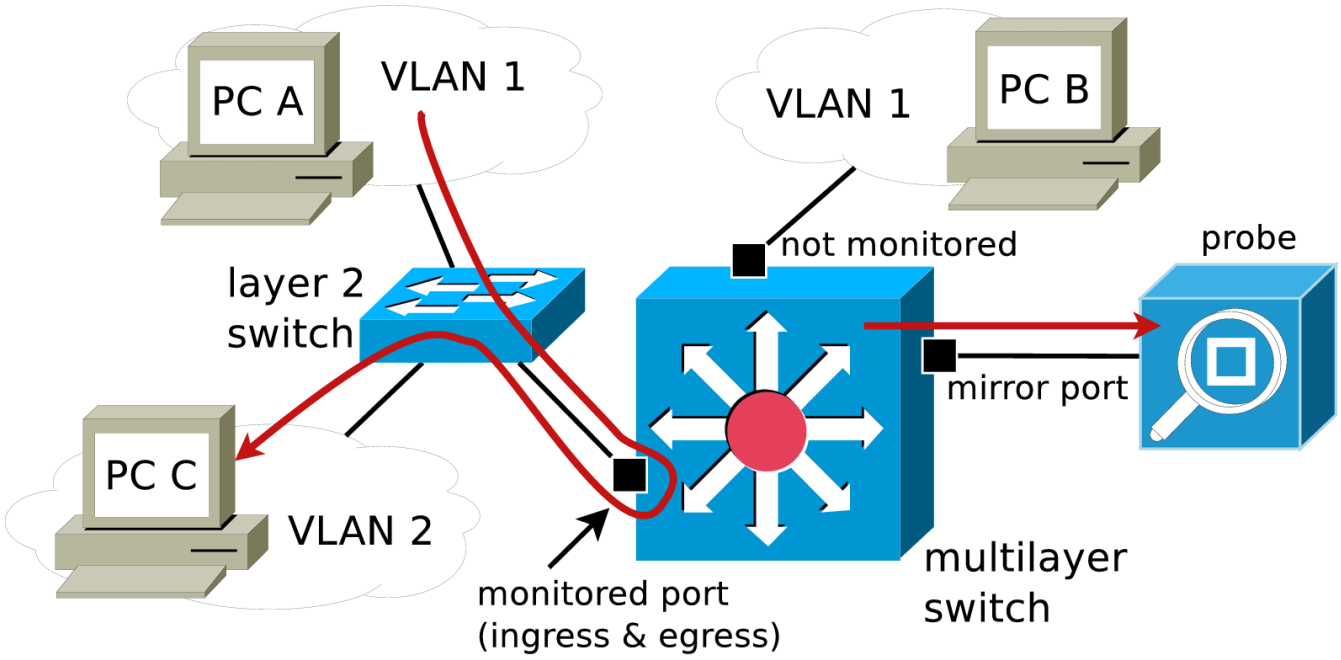
1. Introduction

- Traffic monitoring in Ethernet-based packet-switched networks
  - Port mirroring (Cisco´s SPAN)



1. Introduction

- A simple example



1. Introduction

- Impact of duplicate packets
  - Throughput duplication (some streams may be affected, others may not)
    - SLA planning
    - Threshold-based alerting
    - Traffic matrix characterization
    - Heavy hitters
    - Packet size distributions
    - …
  - Tracking of stateful connections
    - A duplicated TCP sequence can be mistaken for a valid retransmission

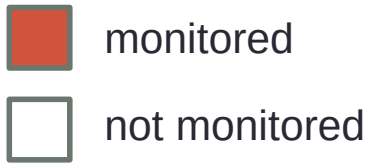
2. Theoretical analysis

Duplication mechanisms | Types of duplicates

2. Theoretical analysis

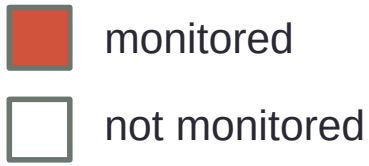
- Referred but not limited to a switched Ethernet environment
- IPv4 as layer 3 (IPv6 case is analogous)

2. Theoretical analysis



- Referred but not limited to a switched Ethernet environment
- IPv4 as layer 3 (IPv6 case is analogous)
- Packet traversing a monitored device, 3 possibilities…

2. Theoretical analysis



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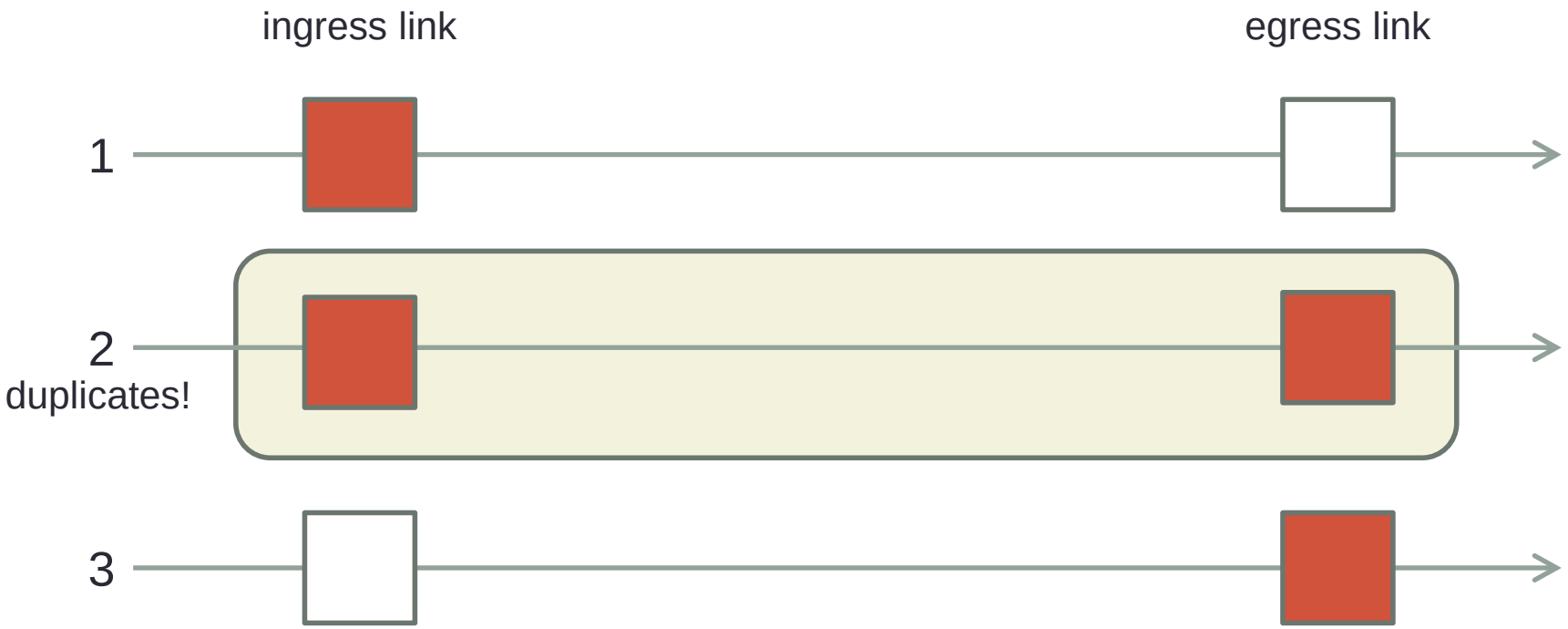

2. Theoretical analysis

monitored

not monitored

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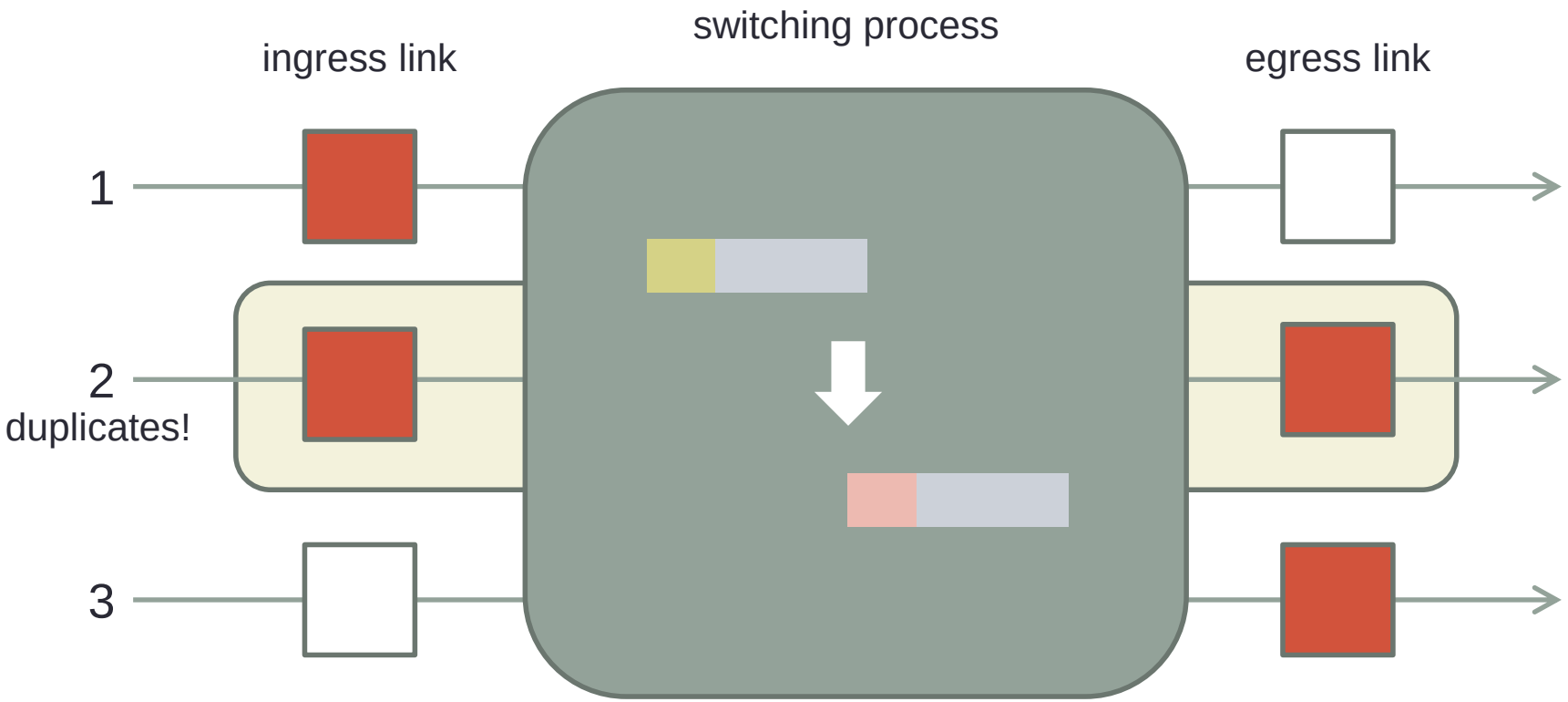

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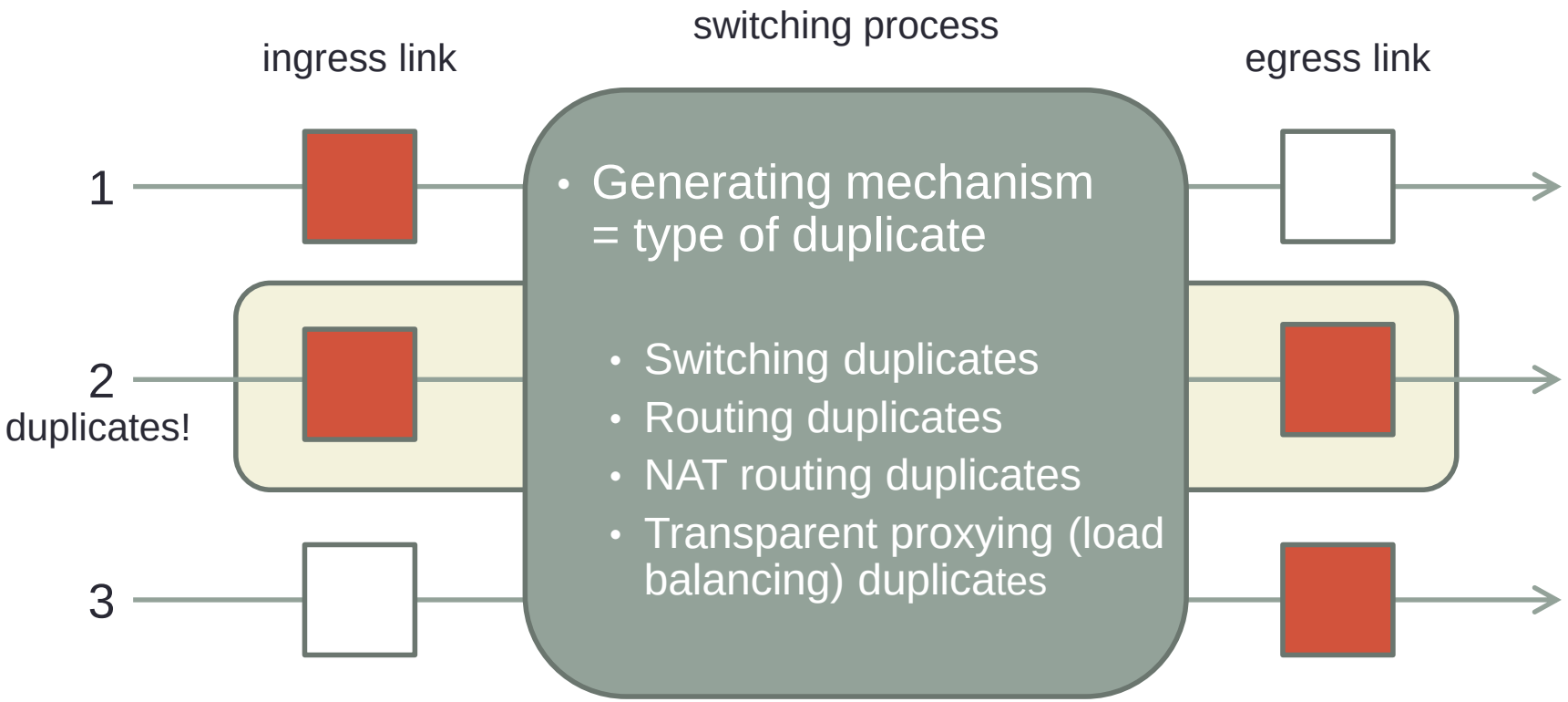
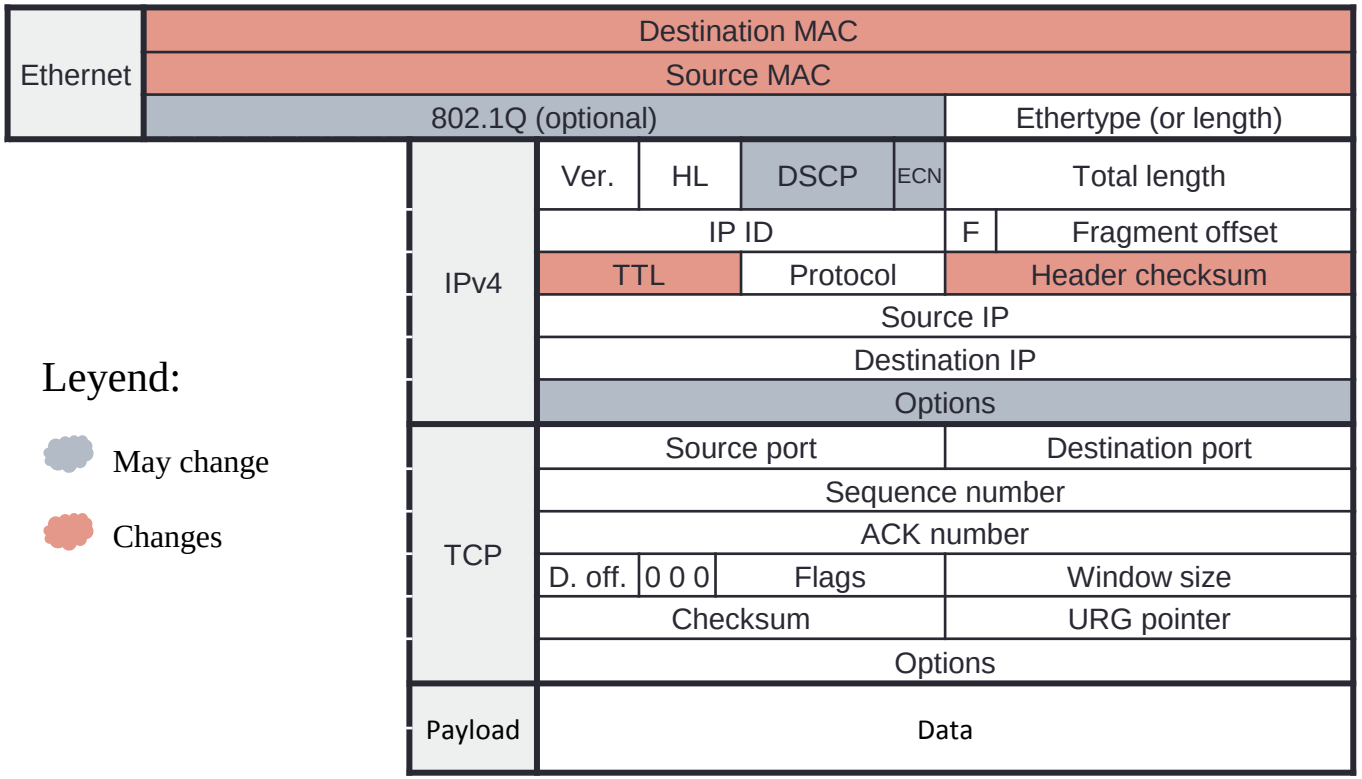


2. Theoretical analysis

- Example: **routing duplicates** over IPv4 and TCP



3. Duplicate detection methodology

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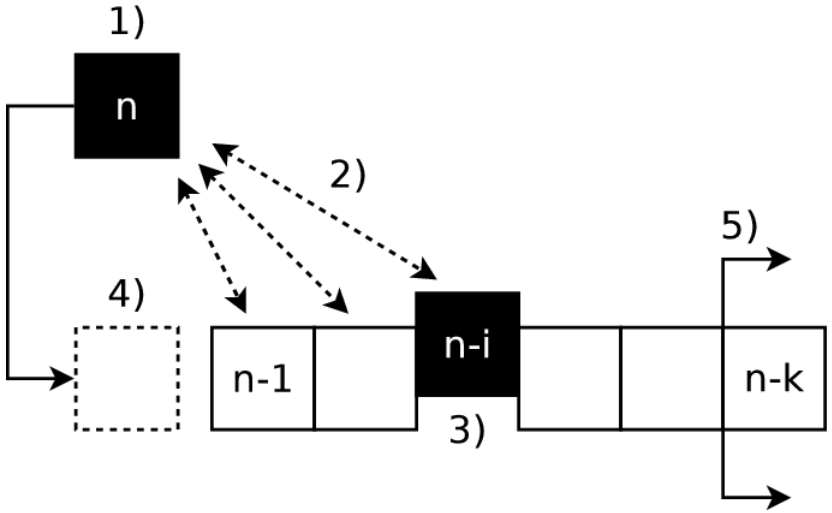
- To compare only the payloads is not an option
  - There will be many packets without data
  - The type of duplicate is a valuable information

	Switching	Routing	NAT	Proxying
Utilization factor per VLAN				
Transport level statistics				
To study both sides of a NAT or proxy				

3. Duplicate detection methodology

- Intended to work offline on previously saved captures
- Sliding window
- Packet comparison
  1. Highest layer payload
  2. Fields that do not change
     - All of them must be compared
  3. Fields that change
     - TTL and checksums are not compared
     - Source and destination MACs must be compared to ensure that they change
  4. Fields that may change
     - Trunking encapsulation, DSCP value and options are not compared
     - The pairs src/dst IPs (NAT, proxy), src/dst ports (NAT) and TCP sequence/ACK (proxy) must be compared to ensure that only one changes



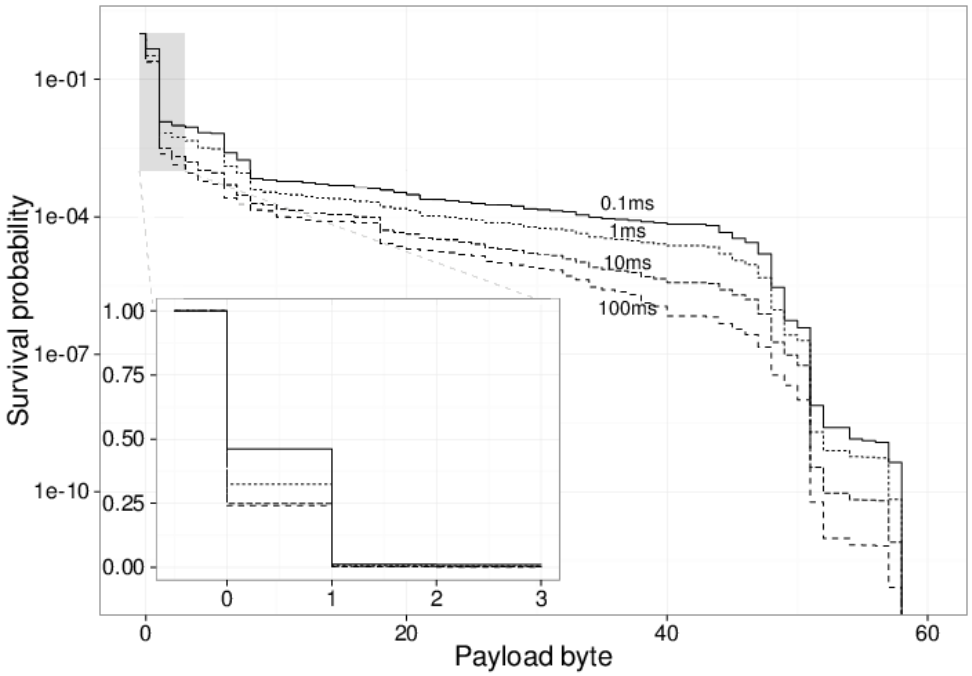
- Implementation available at Github: https://github.com/Enchufa2/nantools

4. Efficiency aspects

Single comparison | Number of comparisons

4. Efficiency aspects

- Efficiency of a single comparison
  - Resolve a non-duplicate pair using the smallest possible number of fields
  - The payload constitutes the most significant difference



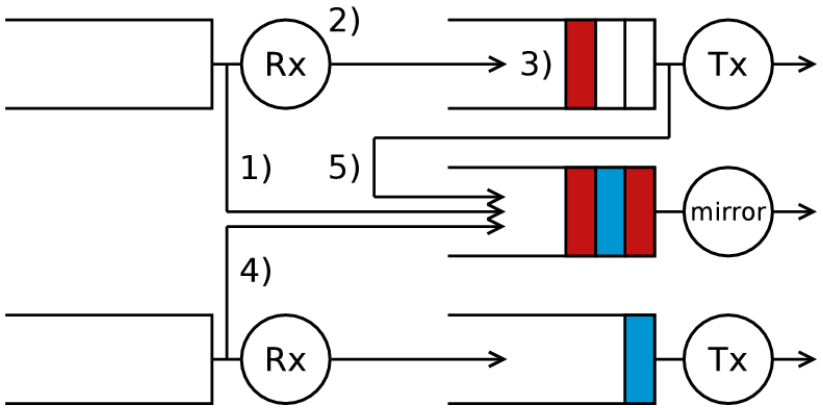
- Experiment with a deduplicated trace of real Internet traffic
- Comparisons over a sliding window, 4 window sizes
- Number of bytes compared until the mismatch was found
- More than the 99 % falls within the first byte

4. Efficiency aspects

- Reducing the total number of comparisons
  - Duplicates are expected to be close
  - Using the smallest possible window is desirable (without losing duplicates)
  - Enclosing the distance between duplicates…
  - **Window size in terms of time or number of packets?**

4. Efficiency aspects

- Model
  1. Ingress copy
  2. Switching time
  3. Queueing time (Tx)
  4. Other packets
  5. Egress copy



1 2 3 4

- Time between copies: $\Delta t_n = -w'_n + x_n + w_n + w''_n = s_n + (w''_n - w'_n)$

$$\overline{\Delta t} = \bar{x} + \bar{w} = \bar{s}$$

- Packets between copies: $\overline{\Delta n} = \sum \mu_i \bar{s}$

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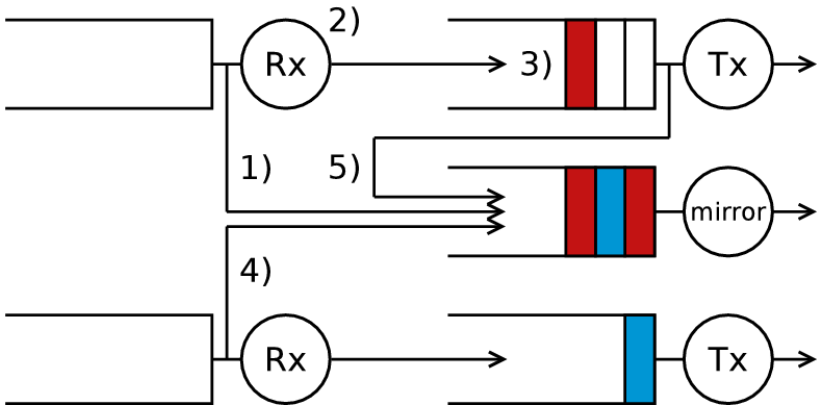

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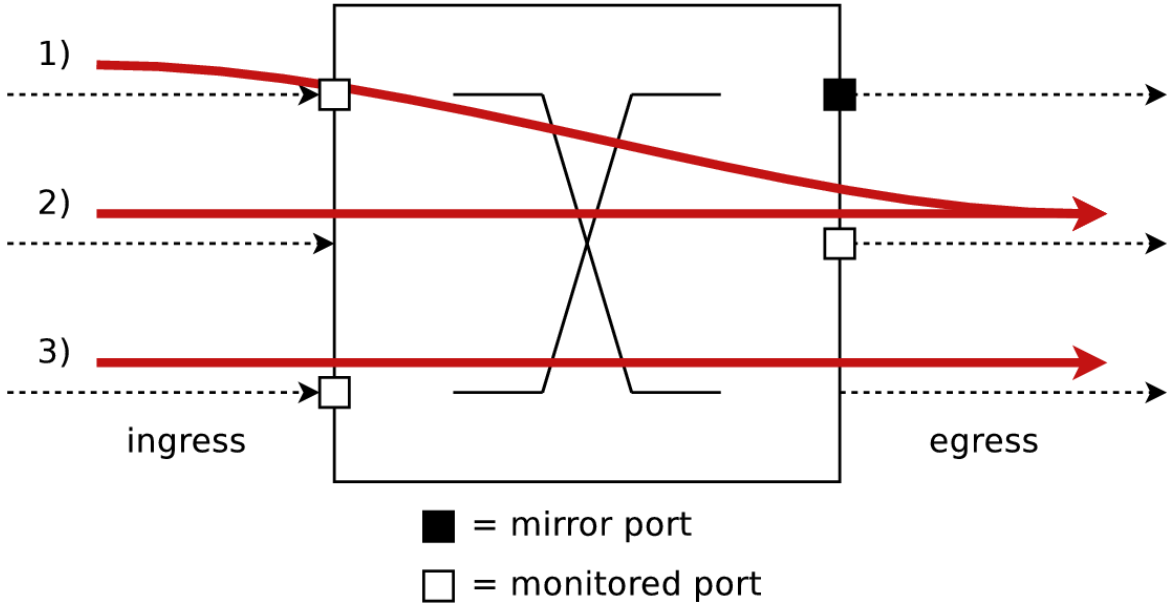
$\overline{\Delta t} = \bar{x} + \bar{w} = \bar{s}$ → system time, M/D/1

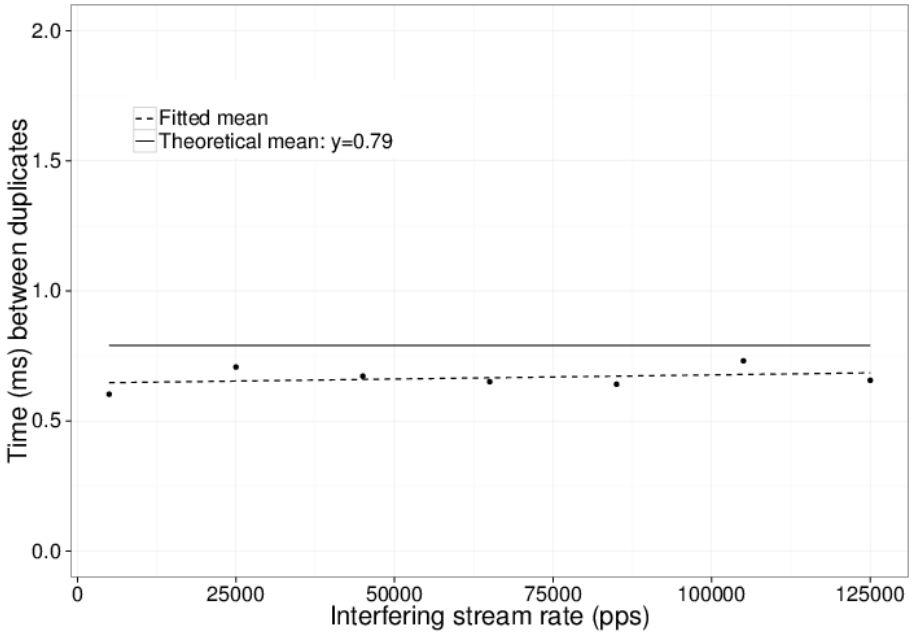
- Packets between copies: $\overline{\Delta n} = \sum \mu_i \bar{s}$

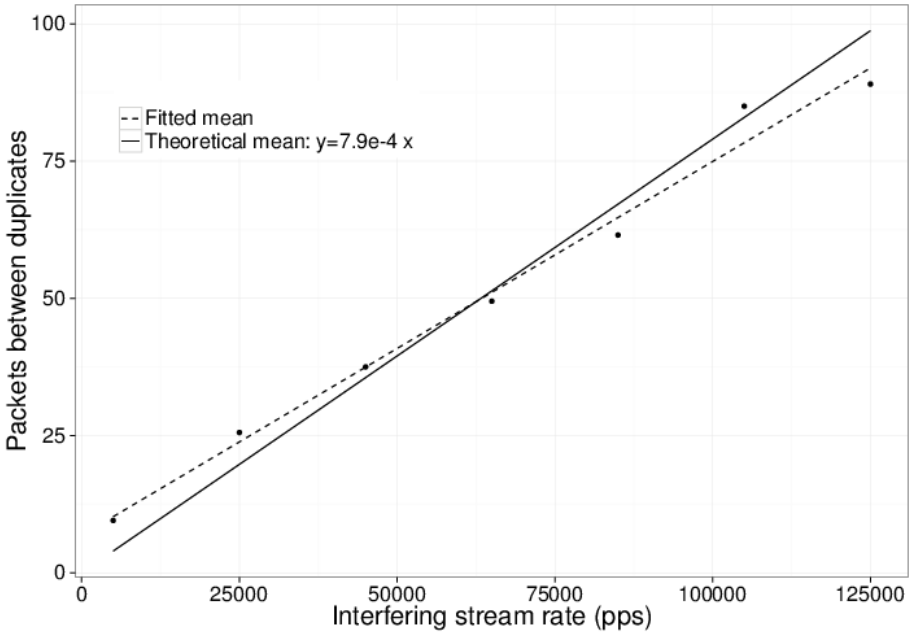
4. Efficiency aspects

- Scenario
  1. Main stream generates duplicates
  2. Auxiliary stream forces queueing
  3. Interfering stream inserts packets between duplicates at different rates



4. Efficiency aspects





4. Efficiency aspects

- A time-based sliding window is the best option
- 3 contributions to the time difference:
  - Main contribution: queueing time at the transmission port (w_n)
  - Switching time (x_n) is negligible as compared to the queueing time
  - Queueing time at the mirror port ($w''_n - w'_n$) is zero on average
- Upper bound in terms of time as a dimensioning rule

$$WindowSize = \frac{3 \cdot \max(N_q) \cdot \max(M)}{\min(C)}$$

  - $\max(N_q)$ maximum length of the largest queue
  - $\max(M)$ maximum packet length
  - $\min(C)$ slowest link capacity

5. Conclusions

5. Conclusions

- This paper addresses an important and unattended problem
- The theoretical background has been exposed
  - Generating mechanisms / types of duplicates
- A duplicate detection methodology is proposed
- Efficiency aspects have been discussed analytically and experimentally
- Further research with other equipment is needed in order to refine these results

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