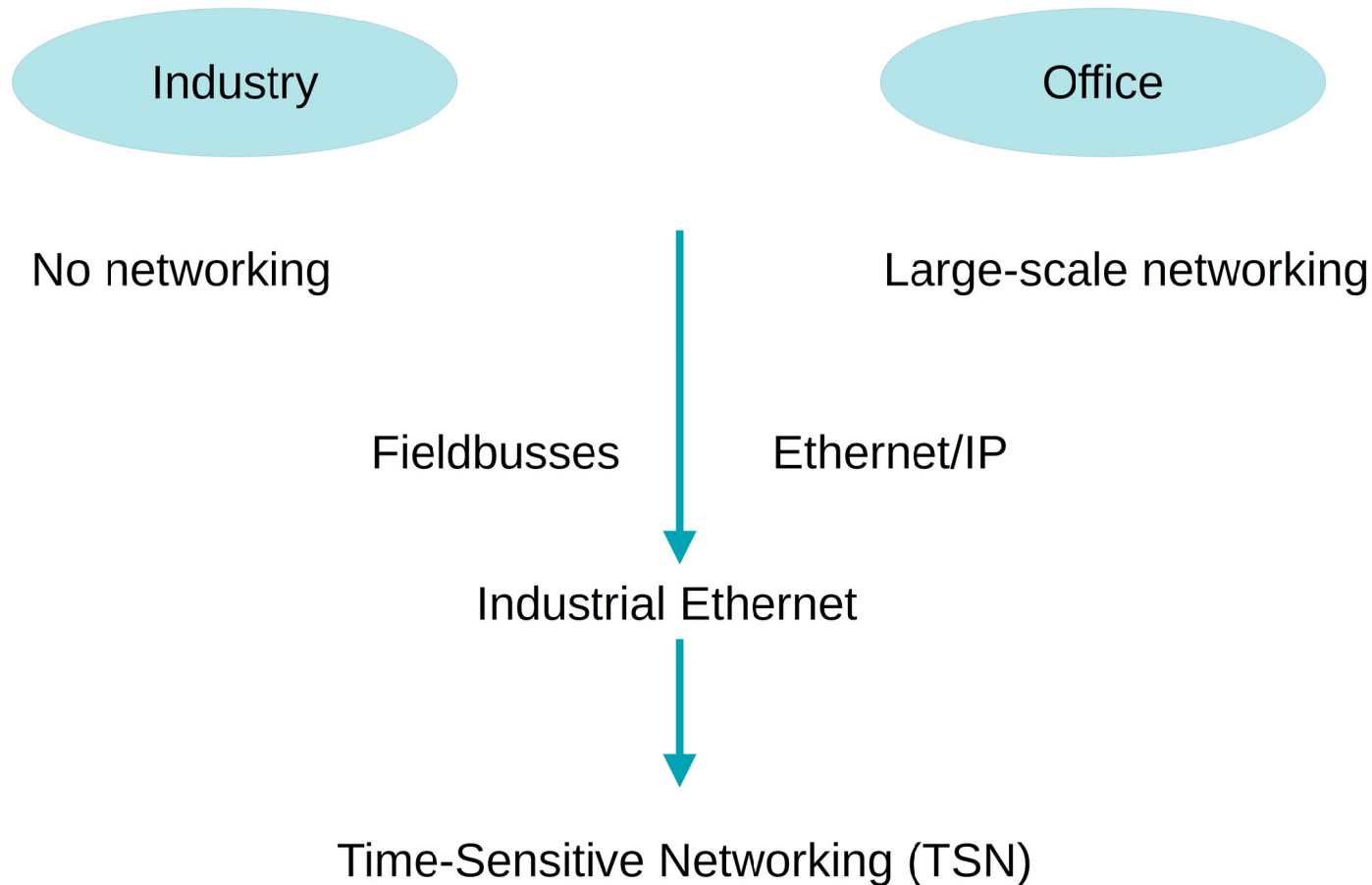# Enhancing Security in Time-Sensitive Networks: Simulation and Evaluation of PSFP

4. GI/ITG KuVS Fachgespräch "Network Softwarization"

Peter Danielis, Willi Brekenfelder, Helge Parzyjegla, Florian Bayer, Gero Mühl
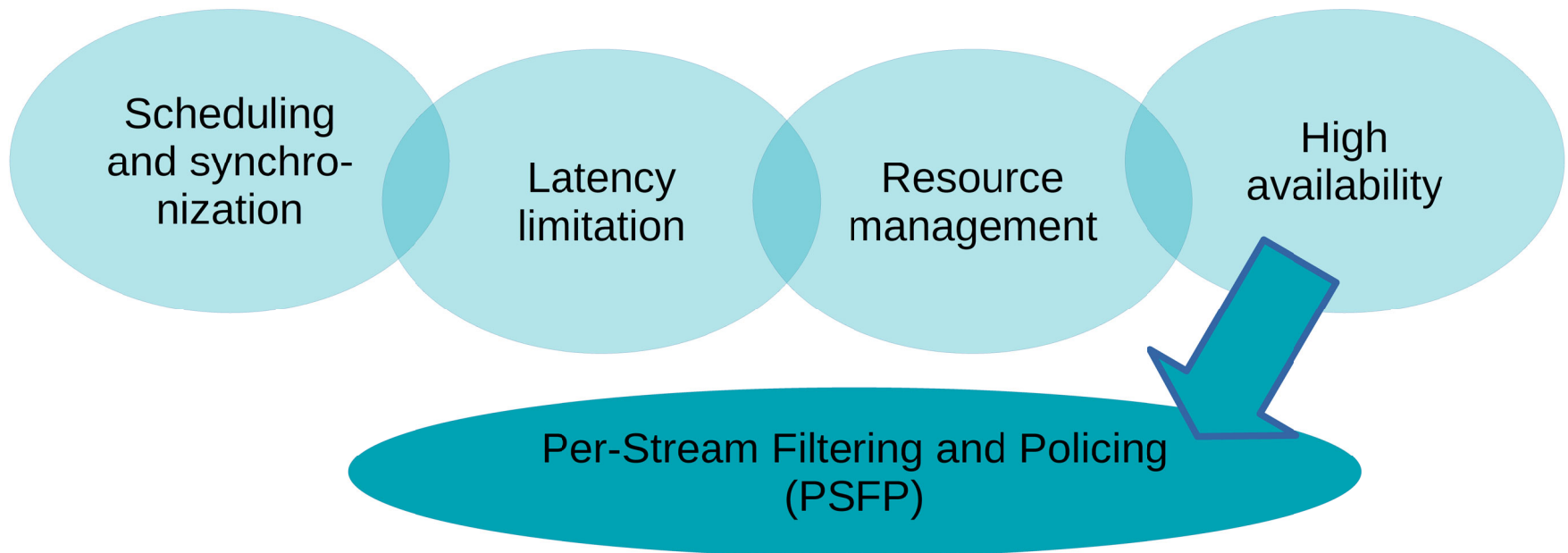
Faculty of Computer Science and Electrical Engineering
Institute of Computer Science,
University of Rostock, Rostock, Germany

Motivation

Industry

Office

No networking

Large-scale networking

Fieldbusses   Ethernet/IP

Industrial Ethernet

Time-Sensitive Networking (TSN)

Time-Sensitive Networking (TSN)

- IEEE 802.1Q
- Extension of Ethernet
- Adaptation at layer 2
- Modular principle

Scheduling and synchro-nization

Latency limitation

Resource management

High availability

Per-Stream Filtering and Policing (PSFP)

Per Stream Filtering and Policing (PSFP)

- IEEE 802.1Qci
- Protects against defective devices/attacks
- Filters Ethernet frames
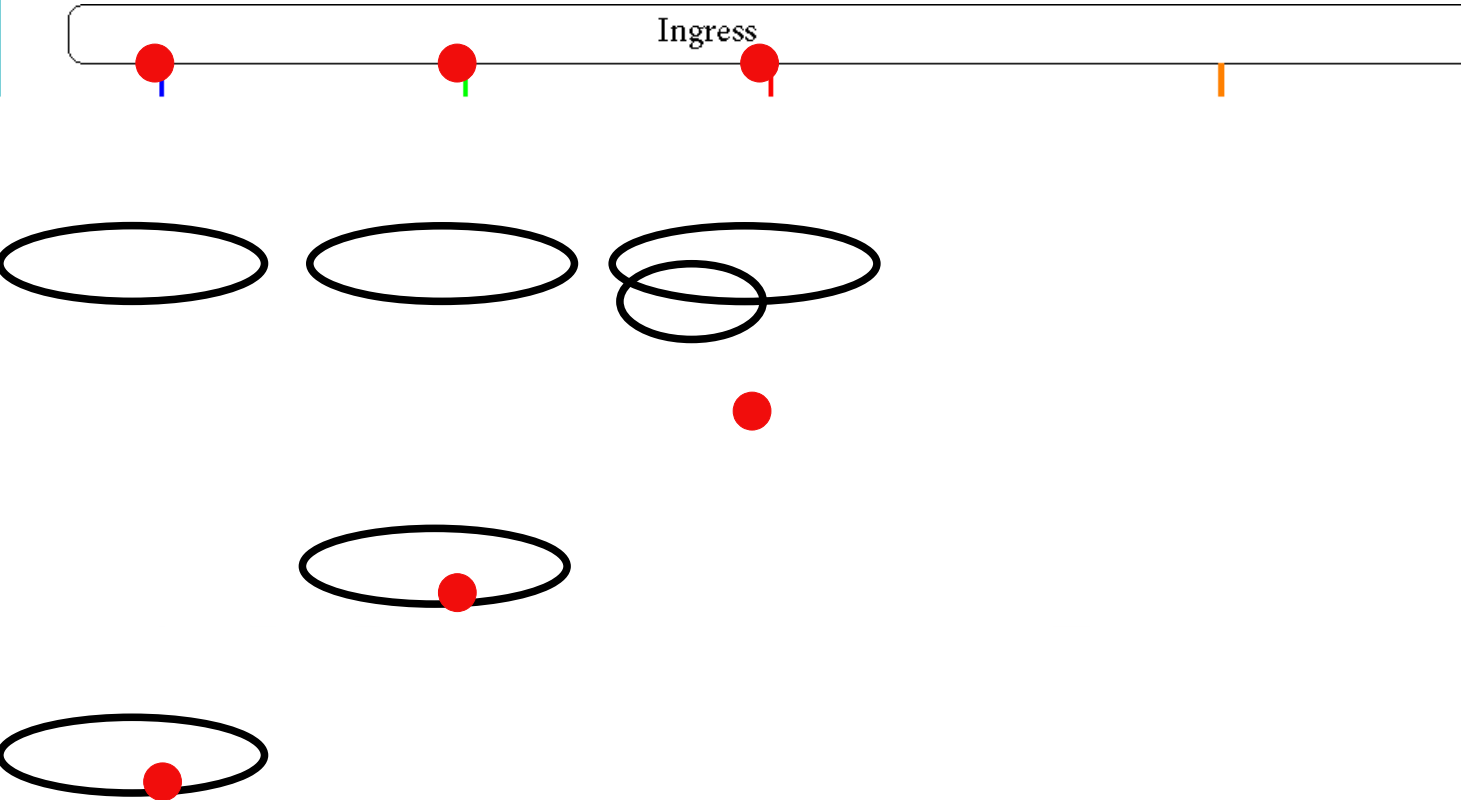- Acts at the ingress of the switch
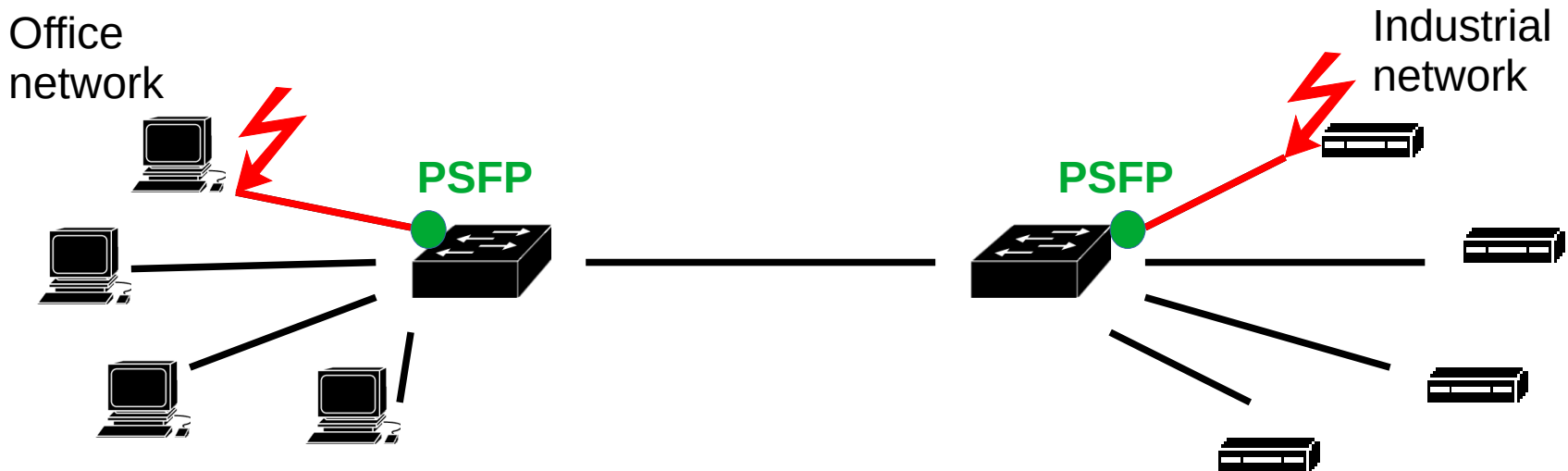
Questions

1. Which attacks can be defended against with PSFP?

2. How must PSFP be configured?

3. What are the limits of PSFP?

4. What is the difference to traffic shaping?

Ingress

Parameters for configuring the frame and stream properties

Frame and stream properties	Essential	Additional
Stream parameter (Source, dest., VID, priority)	stream handle specification priority specification	
Size	filter specifications	streamBlockedDueToOversiceFrameEnable, streamBlockedDueToOversiceFrame
Time	stream gate state, stream gate control list	gateClosedDueToInvalidRxEnable, gateClosedDueToInvalidRx, gateClosedDueToOctetsExceededEnable, gateClosedDueToOctetsExceeded
Data rate	CIR, CBS, EIR, EBS	CouplingFlag, ColorMode, dropOnYellow, markAllFramesRedEnable, markAllFramesRed

Types of attack

- STRIDE model

  - Describes security risks

- What effects on a stream?

  - Elimination

  - Injection: will be covered in the presentation

  - Inspection

  - Manipulation

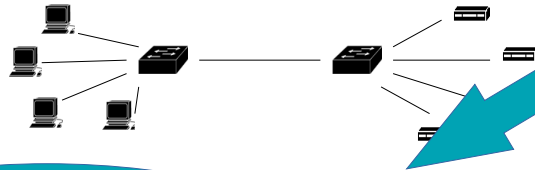 - Redirection

  - Reordering

  - Rescheduling

Injection
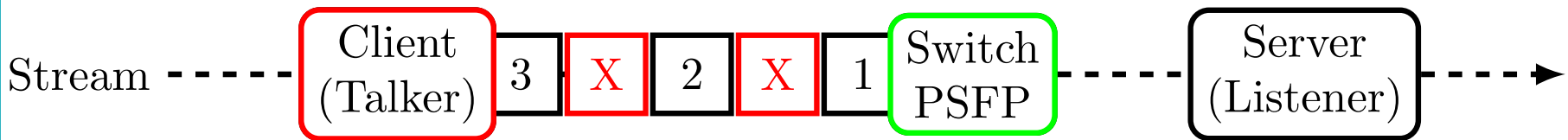
- ## Inserting additional frames

  - Data rate increases

  - Transmission time of injected stream varies

  - Injected frame properties unknownt

Concept

Network planning

→

Create PSFP filter stages

- Layout?
- Whi...

Parameter determination

- Distances?

- Per Switch
  - Stream parameters
- Per Port
  - Size
- Per Stream
  - Time
- Default rule at the end:
  - Data rate
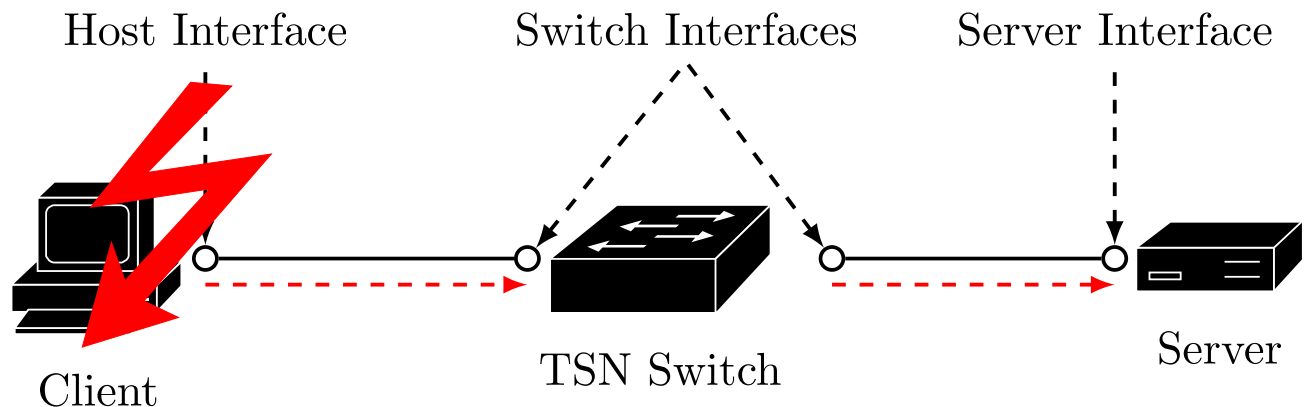 - Discards remaining frames

Simulation

- Simulation in OMNeT++/INET

- Reproduction of the attacks
    - A defective device
    - Attack starts from 0.5s
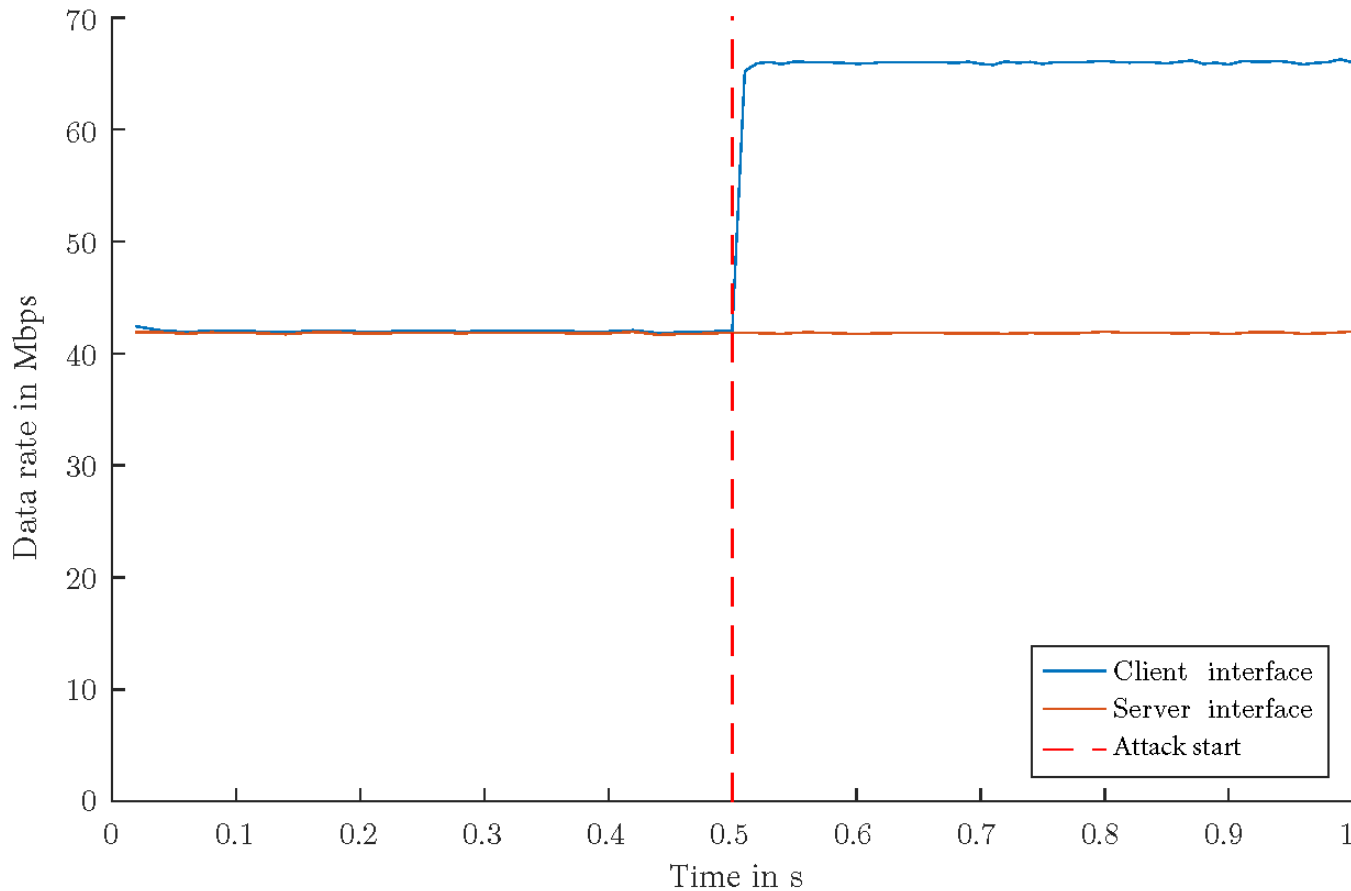
- One simulation scenario

Simulation

Simulation scenario

- Injection attack, filter by
  - Stream parameters
  - Size
  - Time
  - Data rate

Host Interface   Switch Interfaces   Server Interface

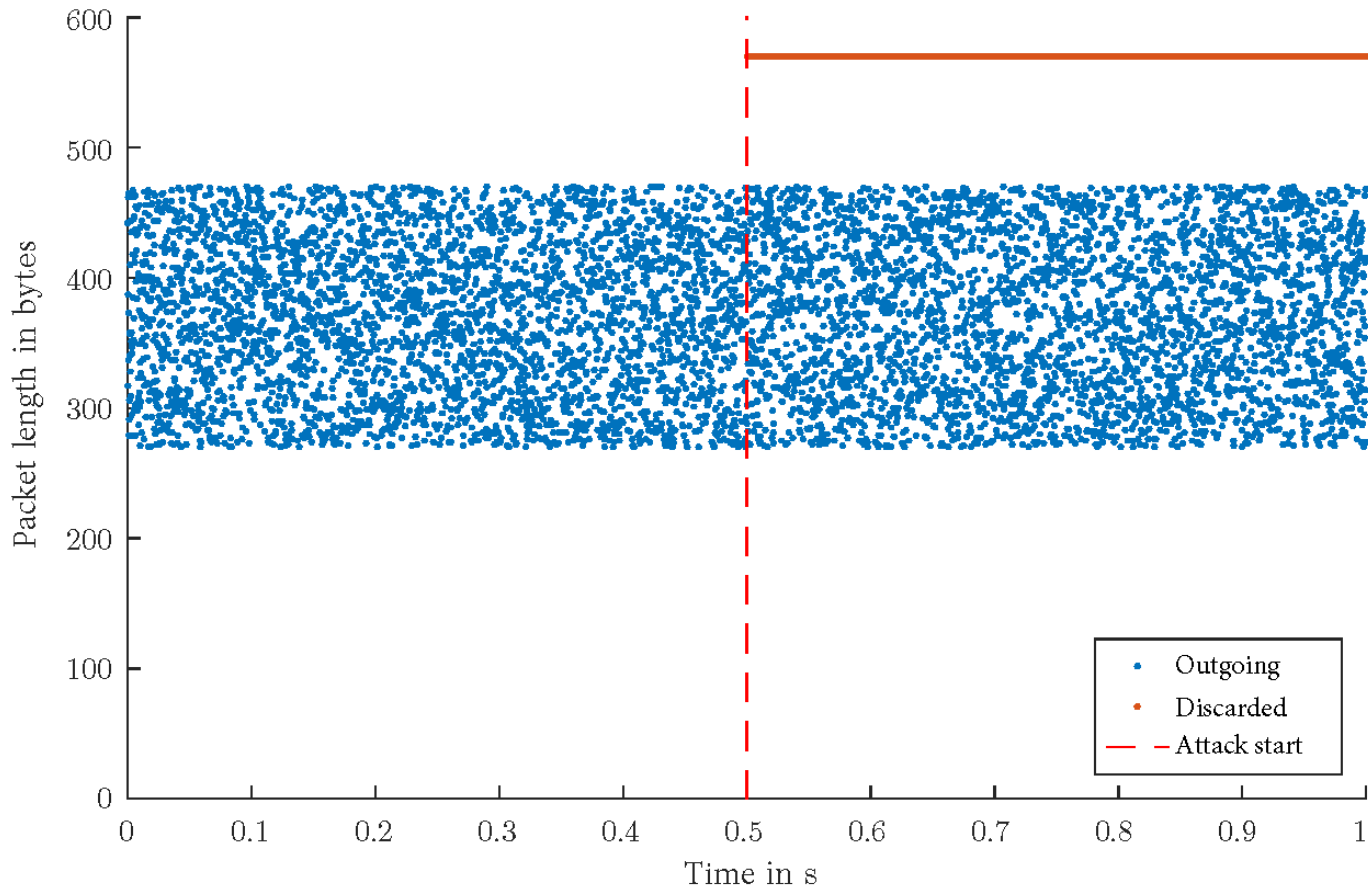Client   TSN Switch   Server

Stream parameters

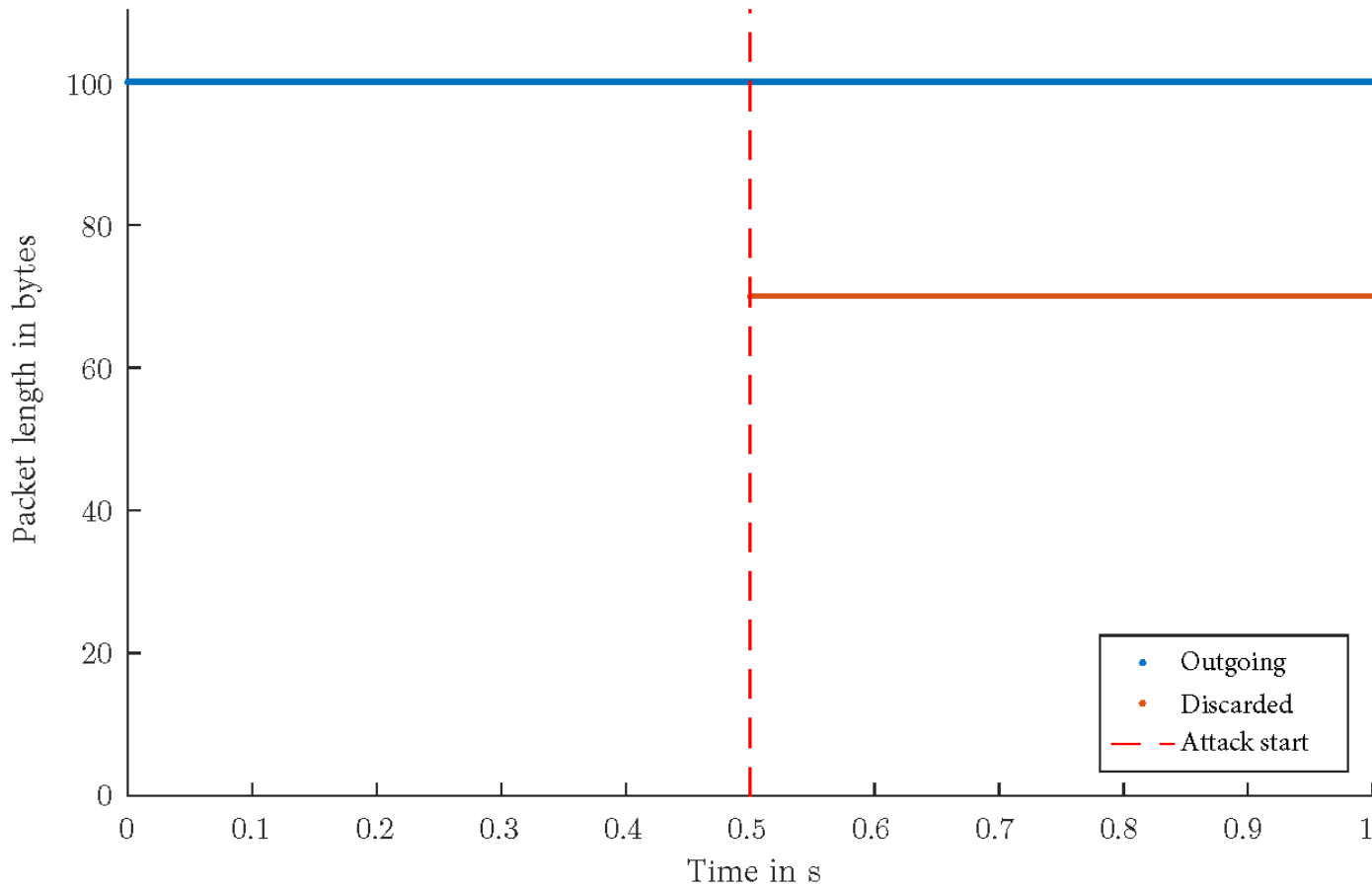Data rate of the client and the servers with PSFP

Size

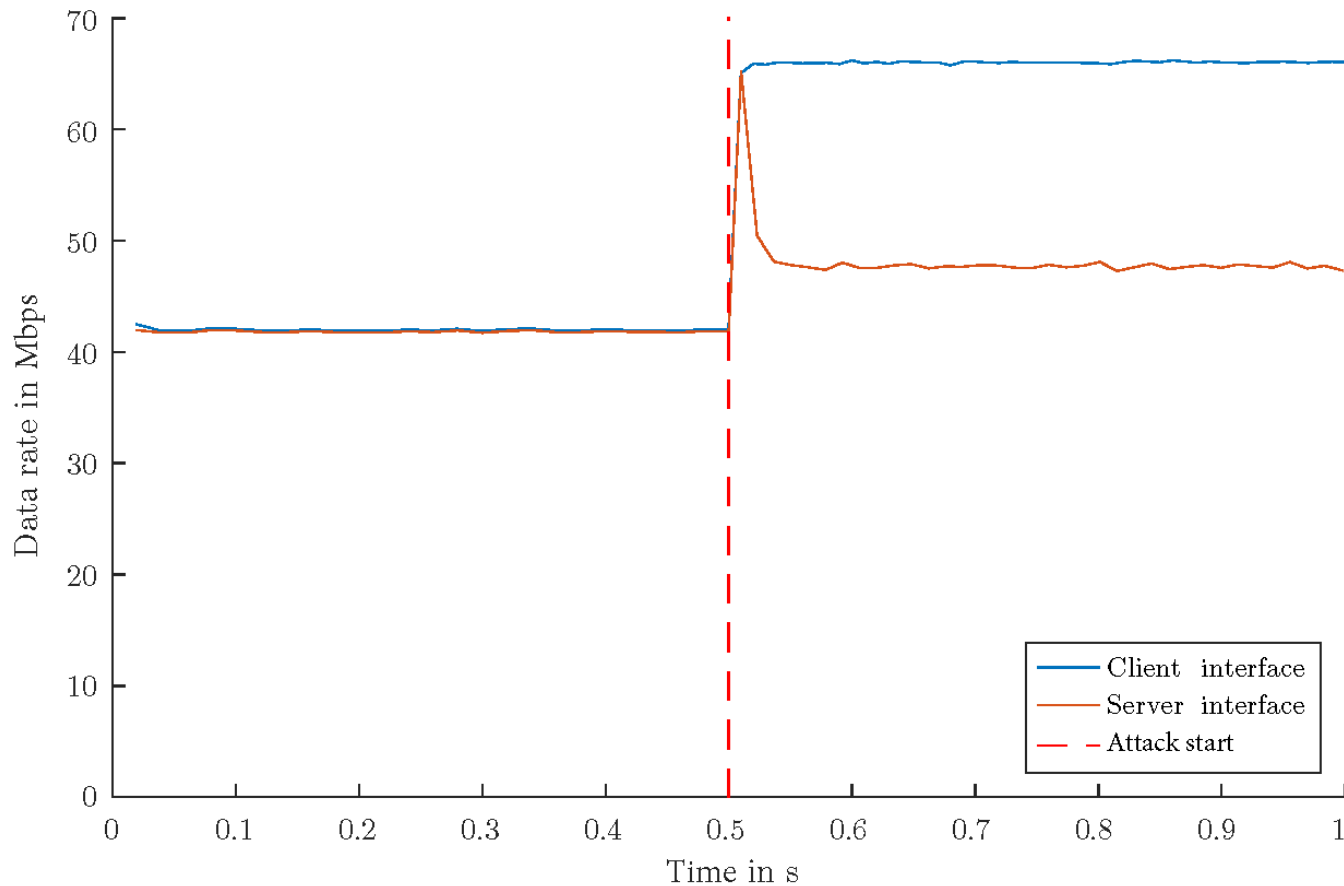Packet length of outgoing and discarded frames in the stream filter

Time

Packet length of outgoing and discarded frames in the stream gate

Data rate

Data rate of the client and the server with PSFP

Research results

- Filtering with PSFP by
  - Stream parameters, size, time, data rate

- Difference between PSFP and TAS
  - PSFP filters per stream
  - TAS controls data rate per stream class

- Limits
  - Unsynchronized devices vulnerable due to stream gates
  - Forwarding defective frames

Conclusion

- Investigation of the PSFP standard

  - Overview of possible attacks

  - Linking the effects of attacks with the PSFP parameters

- Development of a concept for the PSFP standard

- Simulation with OMNeT++/INET

  - Simulation of the injection attack

  - Creation of a simulation scenario

  - Verification of the concept

Outlook

- Implementation of the remaining parameters in OMNeT++/INET

- Configuration using AI/ML
  - Independent learning
  - Adaptation in productive operation

- More complex scenarios
  - Interaction with other sub-standards
  - Consideration of larger networks
  - Considering the behavior of other protocols
  - Implementation in hardware

Thank you for your attention!

Questions?