Improving network packet capture by using Linux kernel's huge pages

Master's thesis

Computer and Information Engineering

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1. Introduction
2. Problem analysis
3. Proposed solutions
4. Results
5. Conclusions

Introduction

Scenario

Internet of Things (IoT) phenomenon:

- multitude of type of connected devices
- sometimes sensitive data flow through the network

Network Traffic Analysis

Network Traffic Analysis is a common activity aimed at:

- network monitoring
- recognition of traffic characteristics
- information gathering for fighting criminal or terroristic activities

Problem analysis

Socket buffer

The OS's socket buffer has a key role:

- to store temporarily incoming packets before to be analysed
- to mitigate:
  - peaks of traffic
  - large per-packet processing time

Performance issue

Improving the performance of the buffer management to face with:

- increasing data rate supported by the network cards
  - 10 Gigabit Ethernet
- packet loss due to processing delay on packet
  - more or less frequent delays based on the type of analysis

Linux huge pages

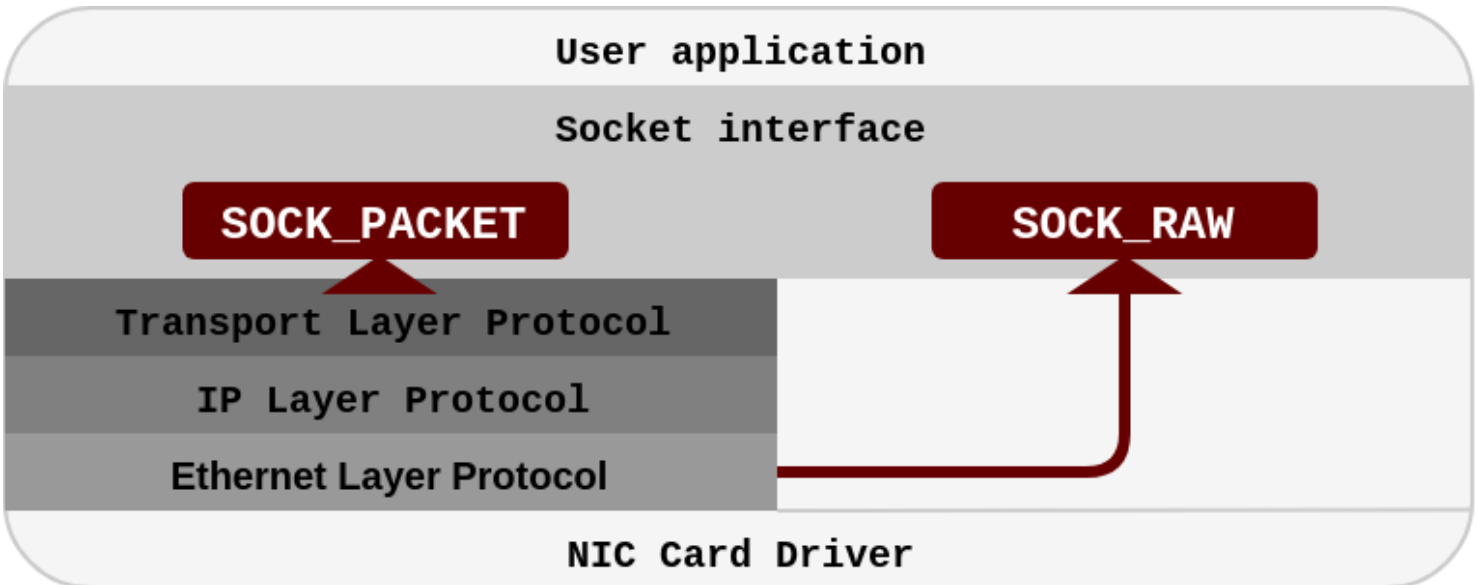
Low-level performance improvement using larger than normal memory pages → huge pages

- wider address range for each TLB entry
- the same number of TLB entry covers more addresses
- more likely TLB hits events

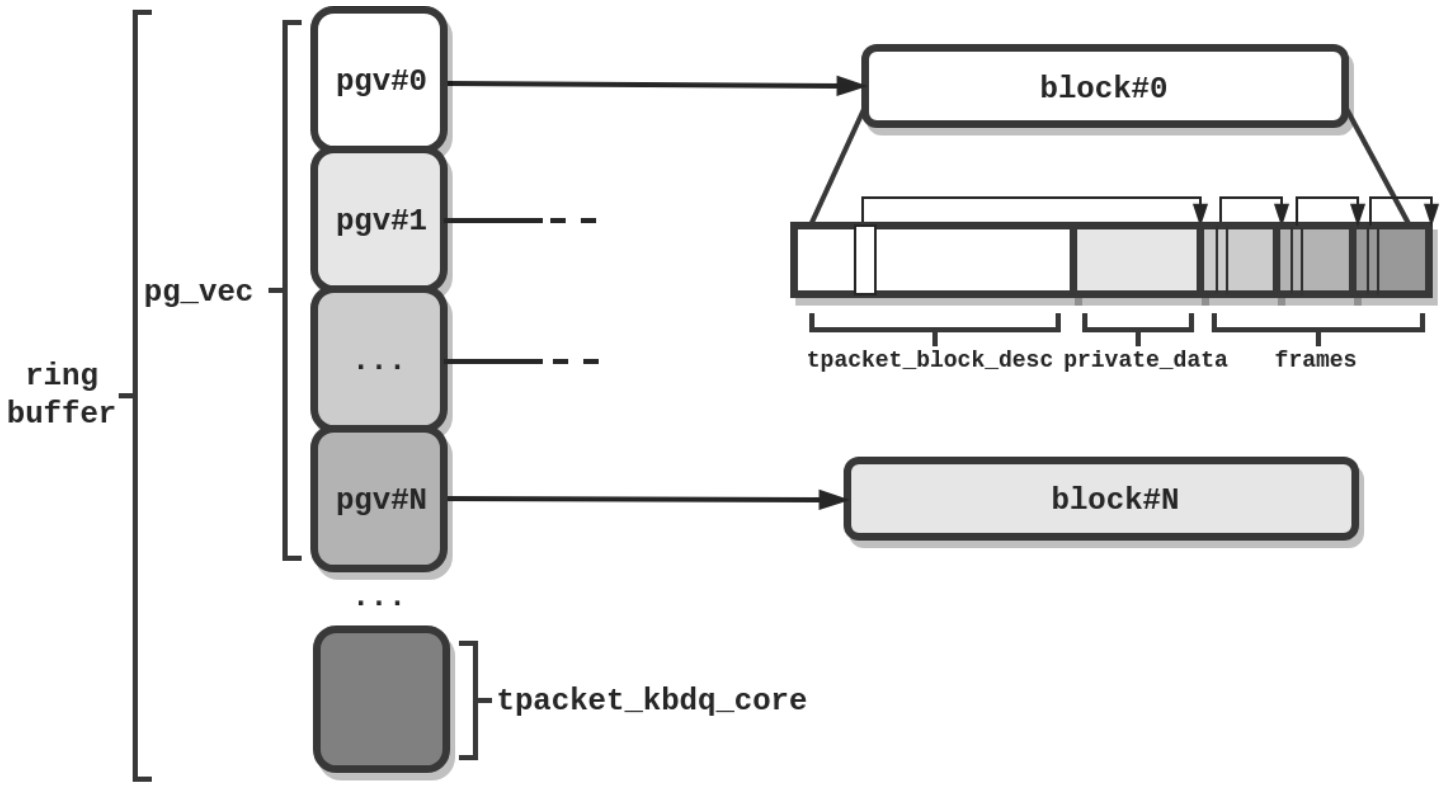
AF_PACKET kernel module

The `AF_PACKET` module implements the networking domain of the raw sockets:

- direct polling on the Ethernet Layer
- to avoid TCP/IP stack analysis overhead



Buffer implementation



Current buffer allocation policy

Attempts of block allocation in order of preference:

1. physically contiguous non-blocking memory reclaim
2. only virtually contiguous memory request
3. physically contiguous repeated memory reclaim

Proposed solutions

New block allocation policies

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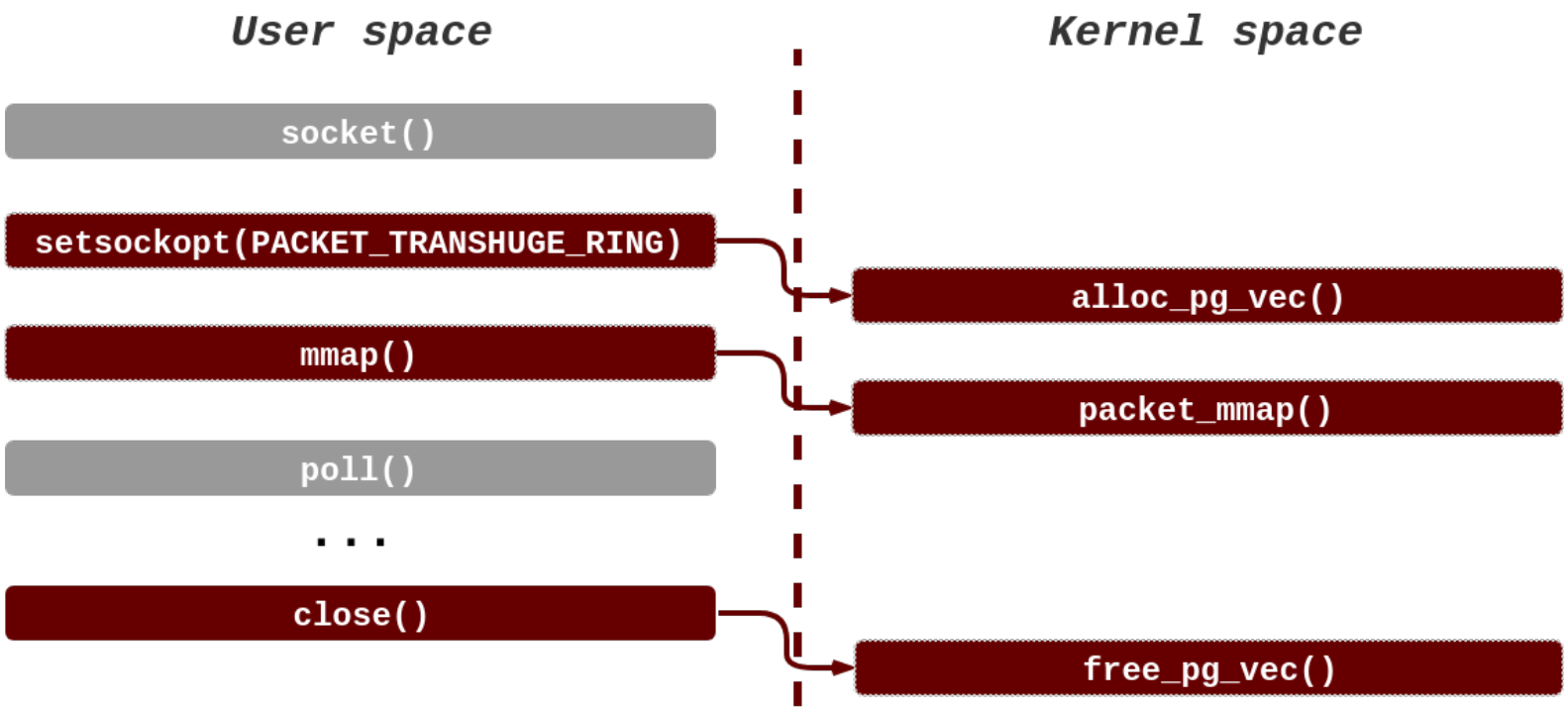
If not specified, the original allocation policy is performed.

Interface

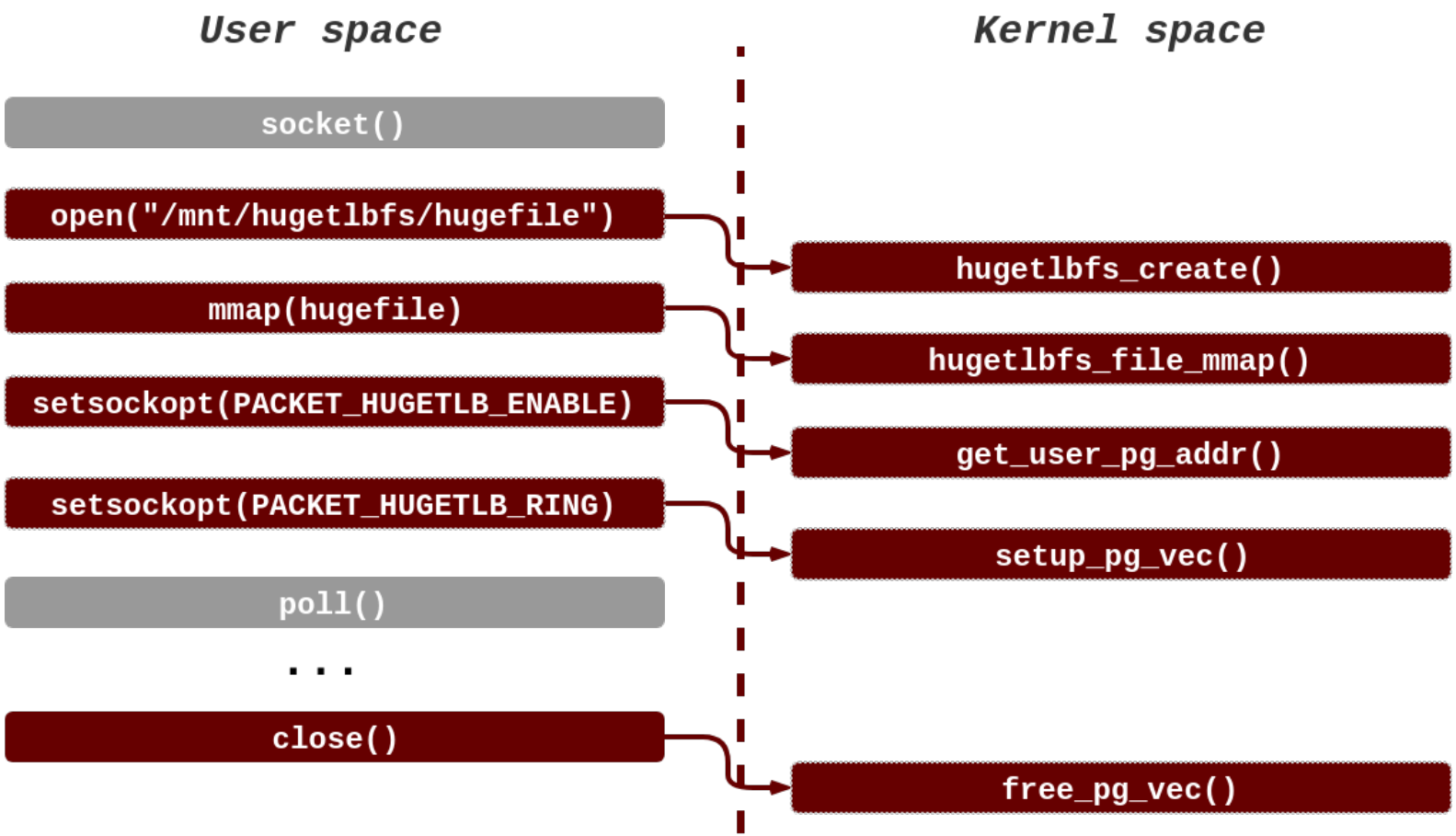
The solution is exported in user space as a socket configuration option.
Application awareness implies:

- easy testing activities
- to reach compatibility with existing implementations

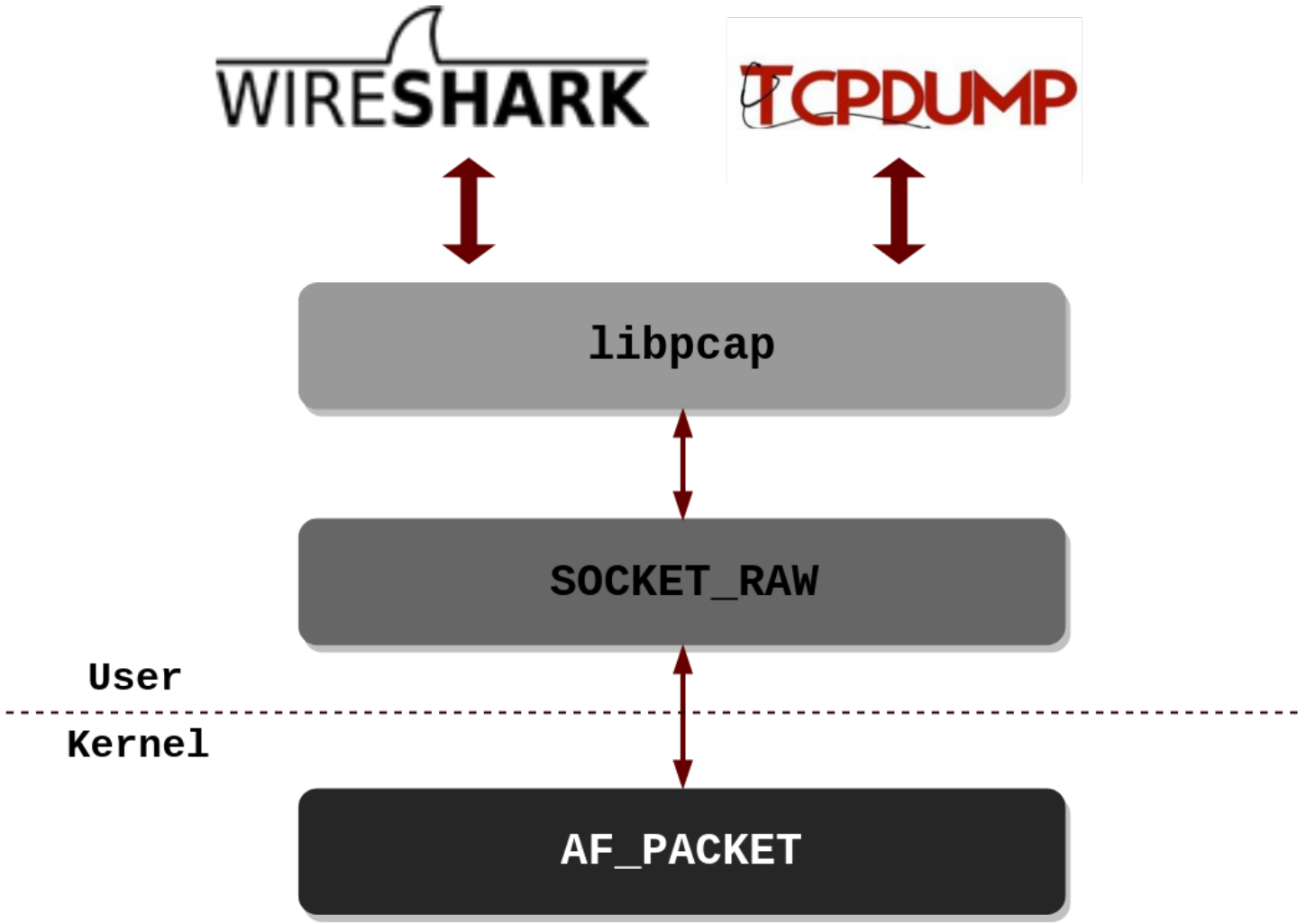
THP solution



HugeTLB filesystem solution



Integration with common applications



Integration with the `pcap` library

Making cascaded modifications to a library is a costly operation. → `LD_PRELOAD` trick

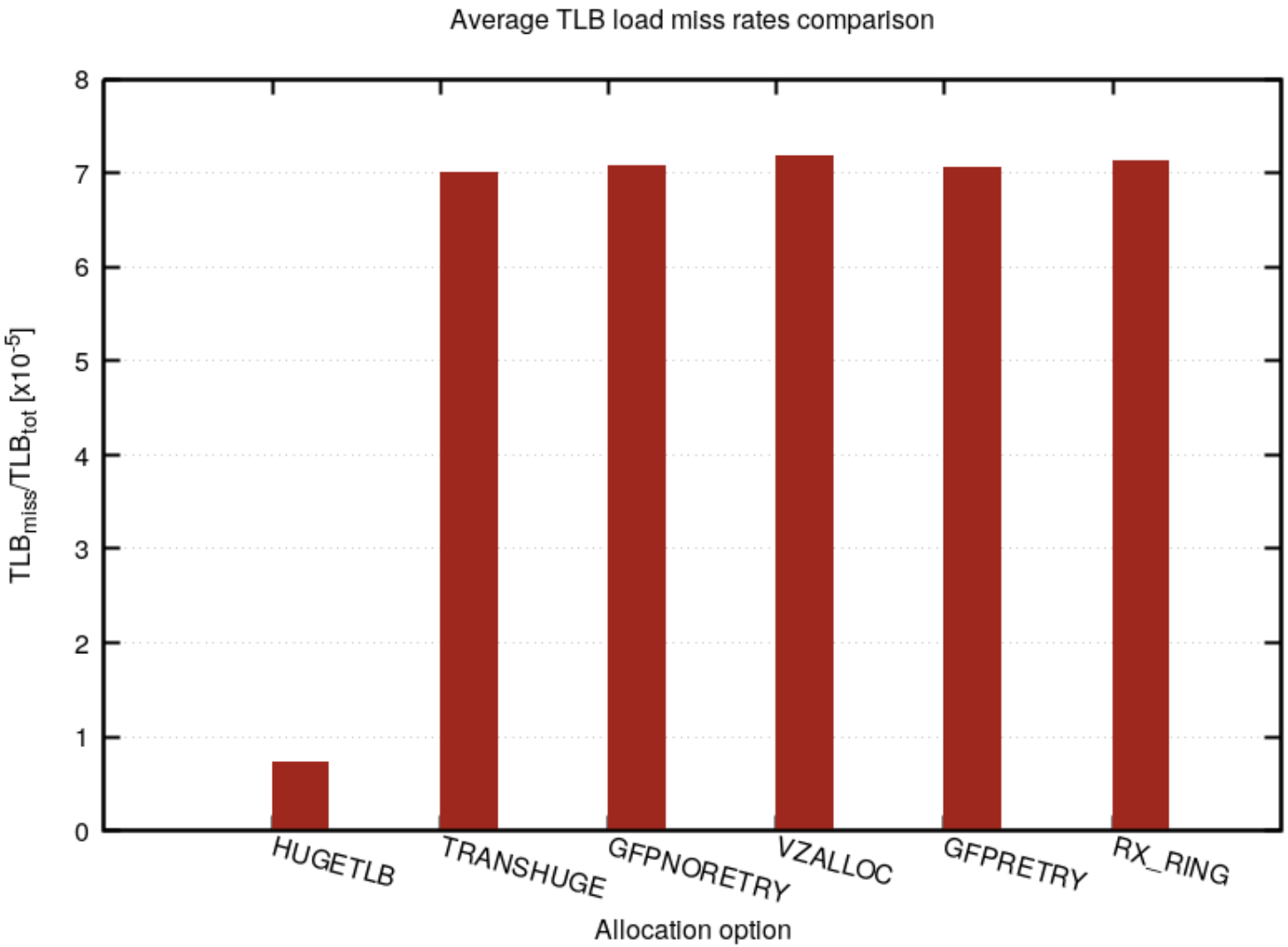
- exploiting library dynamic linking
- implementing alternative routines corresponding to the orginal symbols
- using environment variables to transfer not supported information

Results

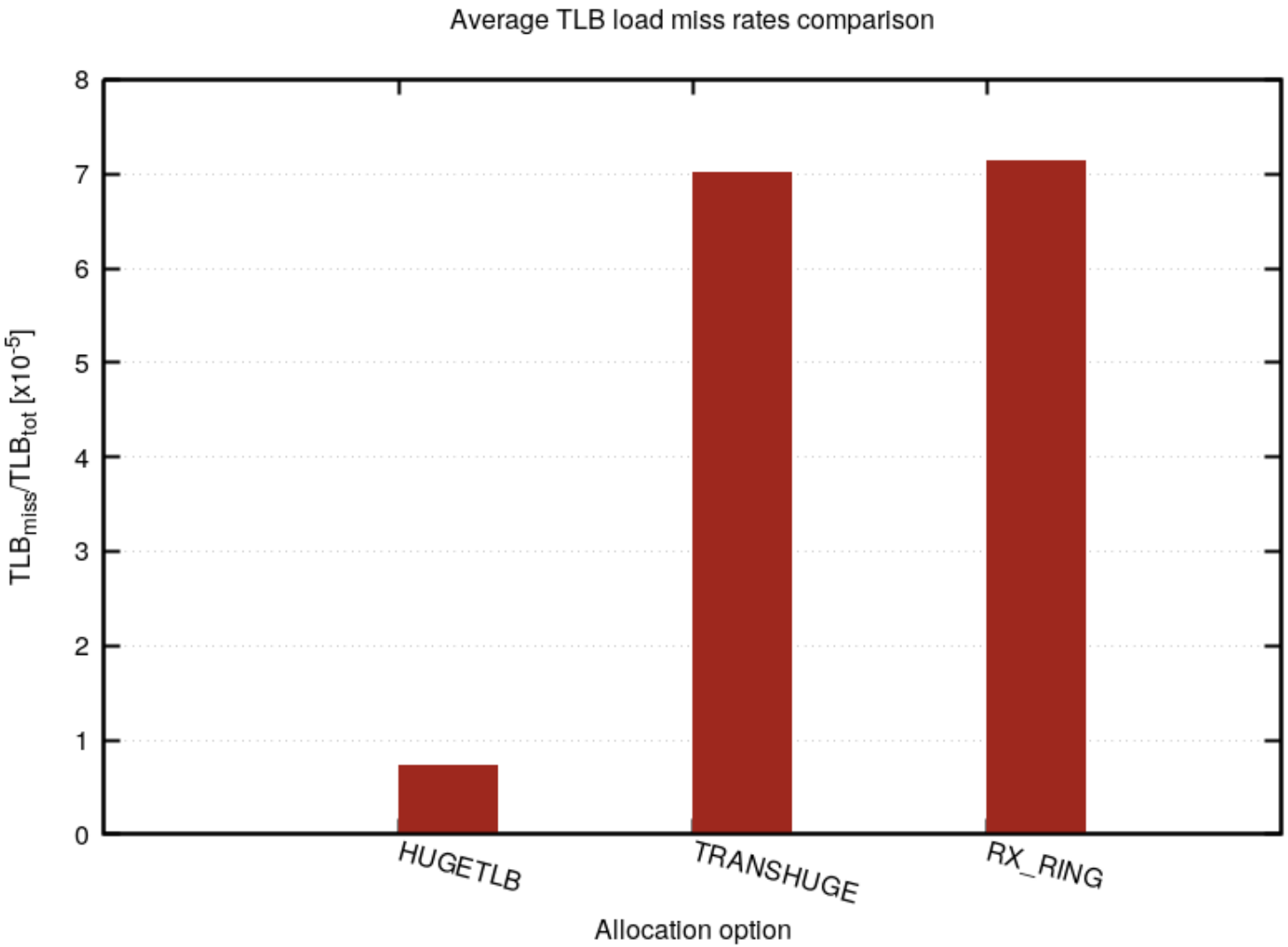
Test configuration

- generated synthethic randomized traffic
  - pktgen kernel tool
- traffic saved as a `pcap` trace
  - tcpdump tool
- `pcap` trace sent using tcpreplay tool
  - more instances to reach the desired rate
- rate at 10 Gb/s
  - nload tool

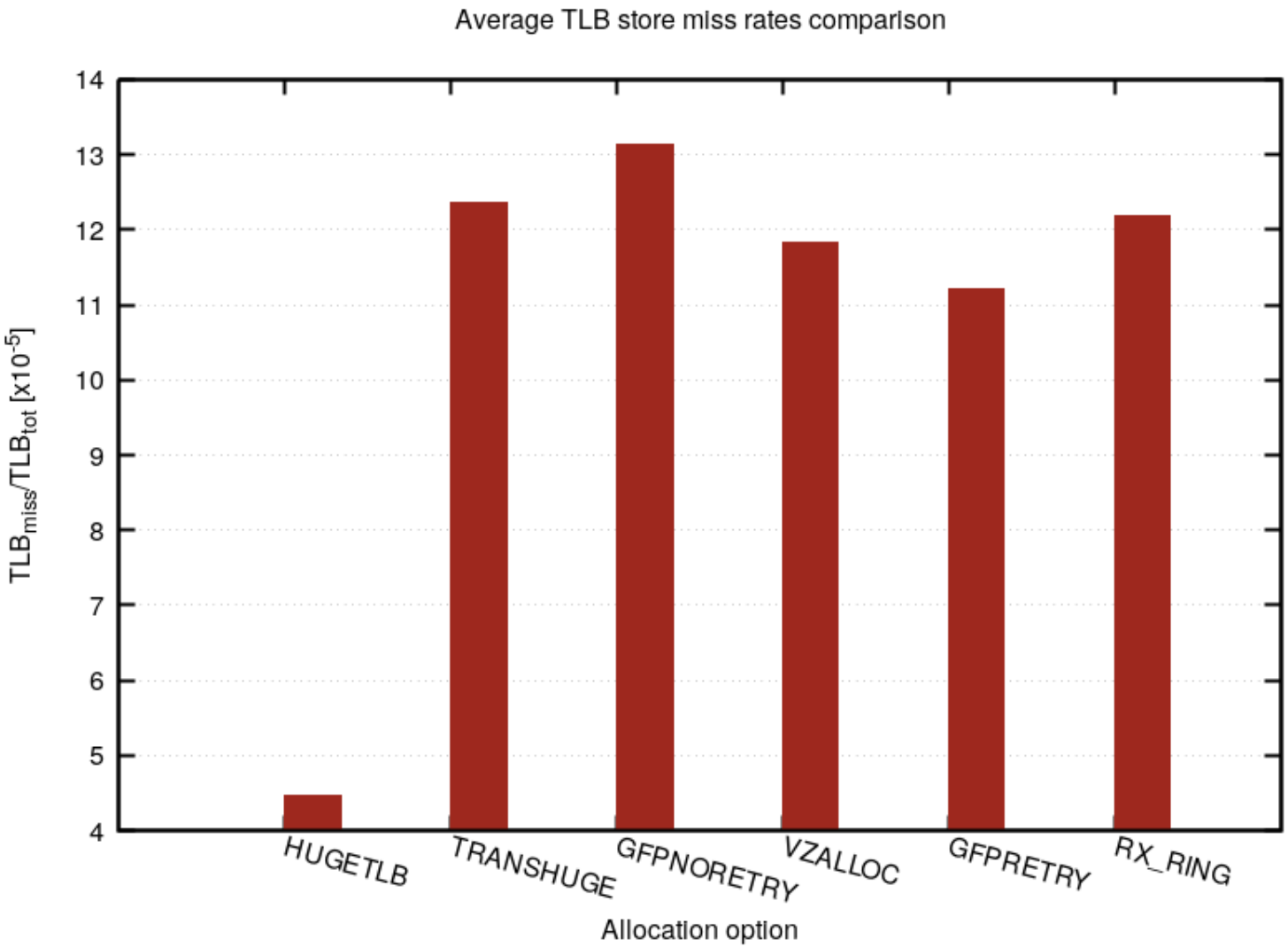
TLB load miss rates



TLB load miss rates - main policies



TLB store miss rates



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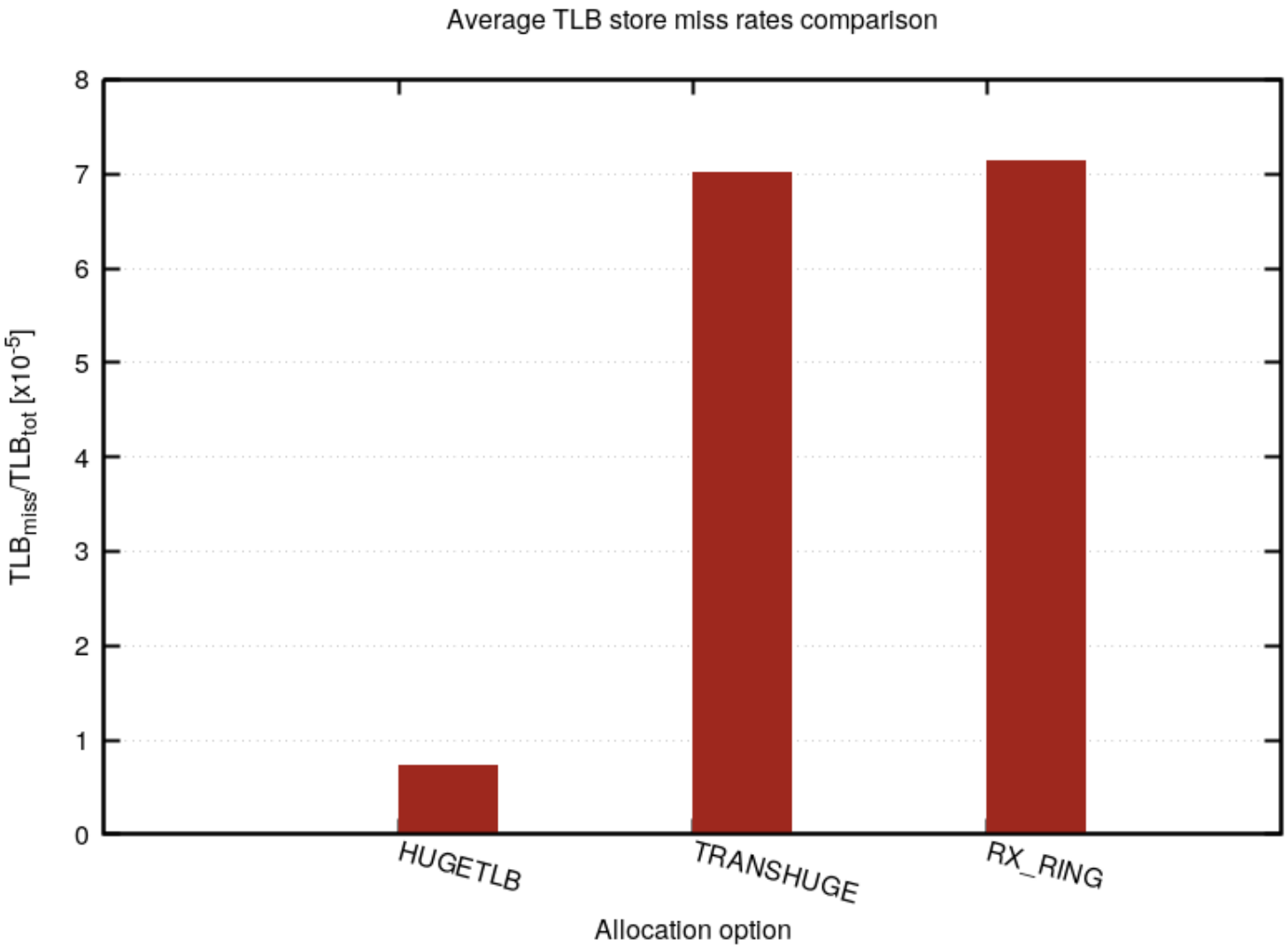
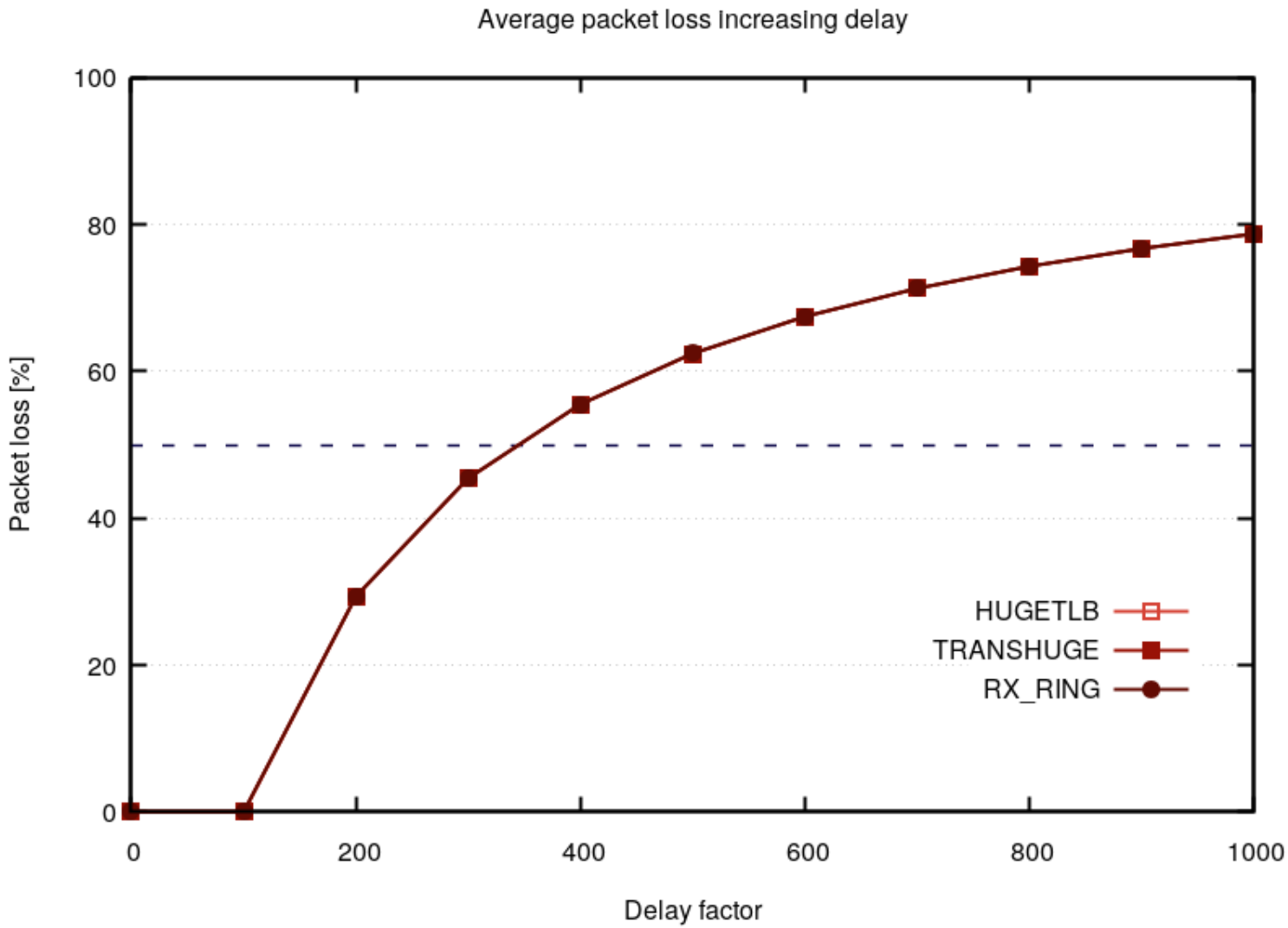


Packet loss



Conclusions

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In conclusion, ...

Ideas for future works

- grouping all block allocation modes in only one option
- making allocation policies completely transparent to the user
  - all the allocation modes in order of preference (as original implementation)

Thank You for listening!

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