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Communication Networks

Benchmarking VPN-Systems

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Agenda

- Motivation
- VPN-Systems
  - OpenVPN
  - IPsec
  - WireGuard
- Experimental Setup
- Results

Motivation

- Master-modul: research project
- Most VPN benchmarks are out of date
- No benchmarks including WireGuard from independent sources

OpenVPN

- Open-source, cross-platform

- Many features:
  - IPv6
  - TCP or UDP as transport protocol
  - NAT
  - PSK, certificate authentication, RADIUS

- Supports many algorithms for
  - crypto
  - hashes
  - compressions

- Critique: large complex code base

IPsec

- Integrated in Linux since v2.6
- Protocols
  - Authentication Header (AH)
  - Encapsulating Security Payloads (ESP)
- Modes
  - Transport
  - Tunnel
- Critique
  - Fragmented documentation
  - Complex protocol
  - Incompatible implementations

WireGuard

- Developed by Jason A. Donenfeld
- Modern crypto
  - ChaCha20
  - Poly1305
  - Curve25519
  - BLAKE2
- Simple configuration, high performance
- <10000 lines of code
- Critique
  - No control plane
  - Too simple for some use cases

Linux Kernel v5.6

Wireguard is now in Linus' tree

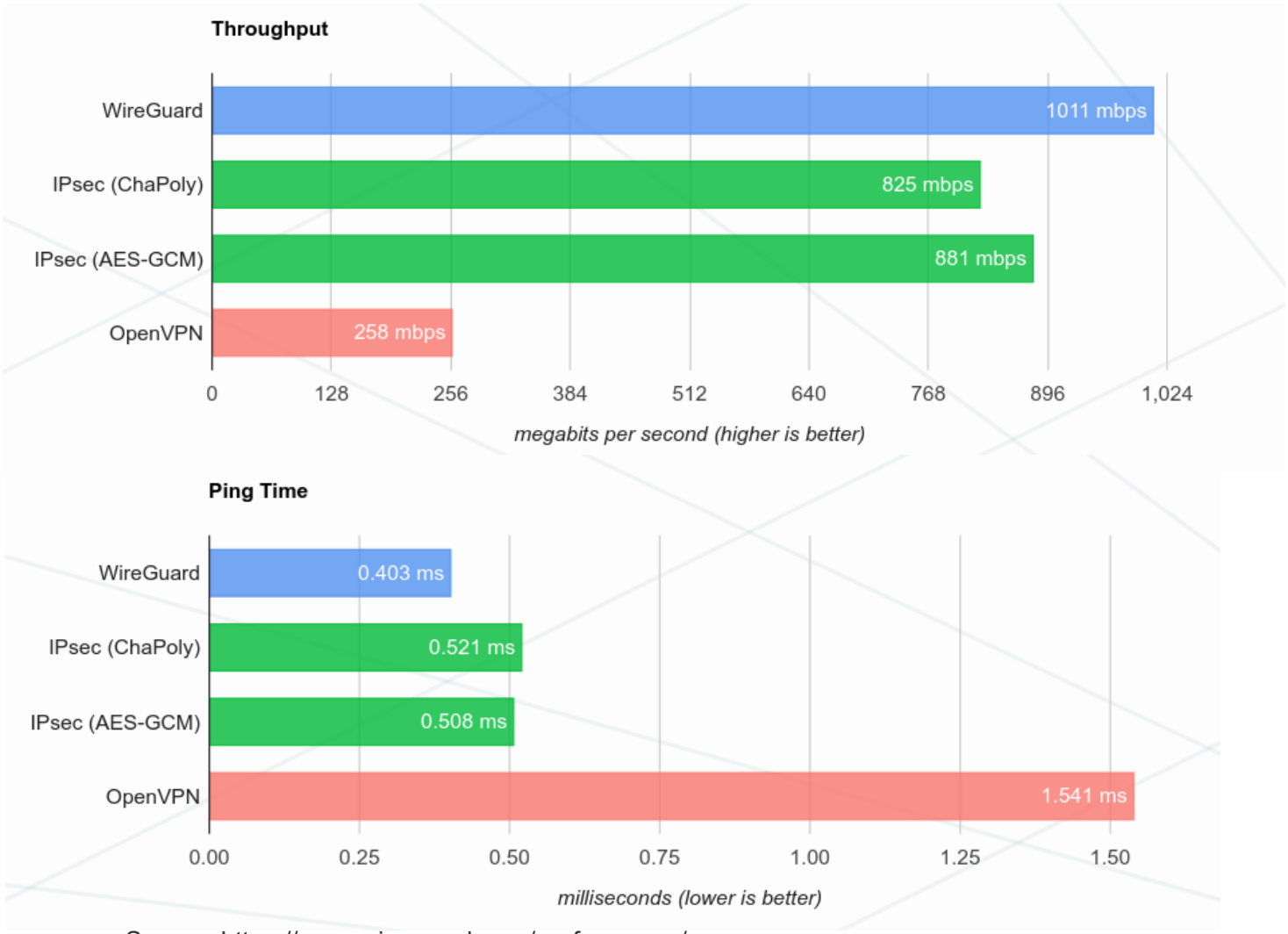
Bruno Wolff III bruno at wolff.to
Wed Jan 29 01:21:59 CET 2020

- Previous message: [ANNOUNCE] wireguard-linux-compat v0.0.20200128 released
- Next message: Wireguard is now in Linus' tree
- **Messages sorted by:** [date] [thread] [subject] [author]

```
Linus pulled in net-next about a half hour ago. So WireGuard is now
officially upstream. Yeah!
```

Source: https://lists.zx2c4.com/pipermail/wireguard/2020-January/004906.html

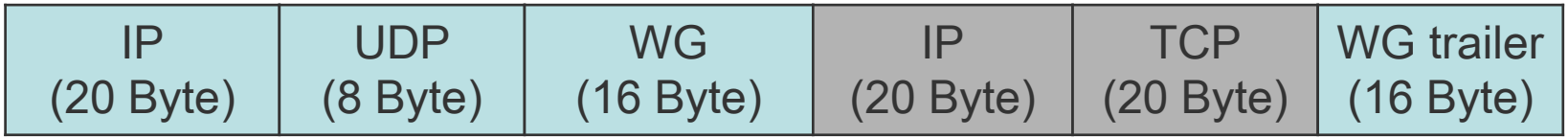
Benchmarks from WireGuard



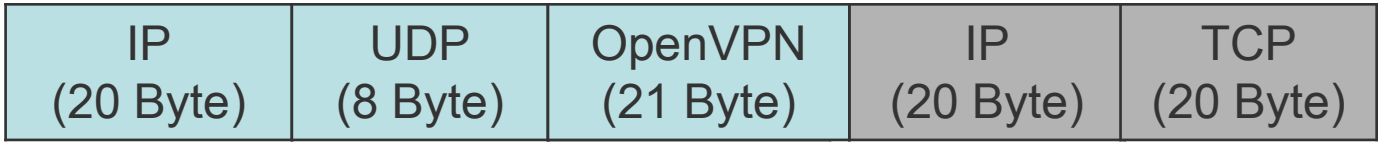
Source: https://www.wireguard.com/performance/

Protocol Headers

WireGuard

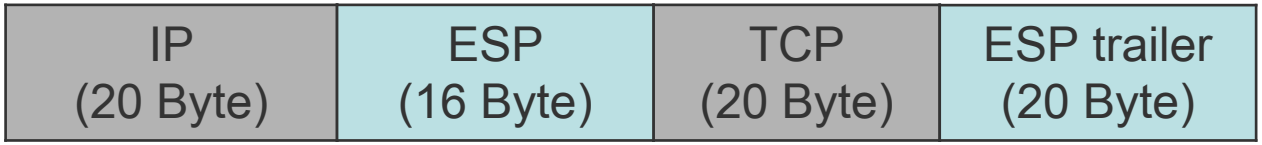


OpenVPN (Data_V1)



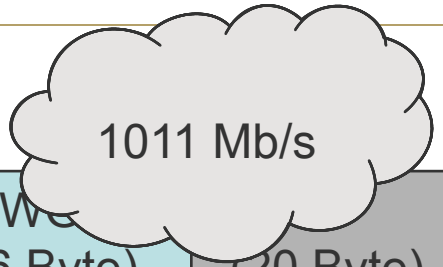
IPsec (tunnel mode)

IPsec (transport mode)



Maximum Throughput

WireGuard: Max. 910.3 Mb/s



IP (20 Byte)	UDP (8 Byte)	WG (16 Byte)	(20 Byte)	TCP (20 Byte)	WG trailer (16 Byte)

OpenVPN (Data_V1): Max. 917.4 Mb/s

IP (20 Byte)	UDP (8 Byte)	OpenVPN (21 Byte)	IP (20 Byte)	TCP (20 Byte)

IPsec (tunnel mode): Max. 912.9 Mb/s

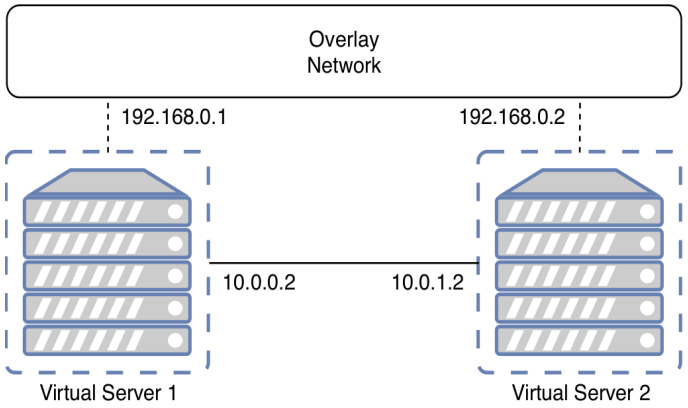
IP (20 Byte)	ESP (16 Byte)	IP (20 Byte)	TCP (20 Byte)	ESP trailer (20 Byte)

IPsec (transport mode): Max. 925.9 Mb/s

IP (20 Byte)	ESP (16 Byte)	TCP (20 Byte)	ESP trailer (20 Byte)

Performance Evaluation

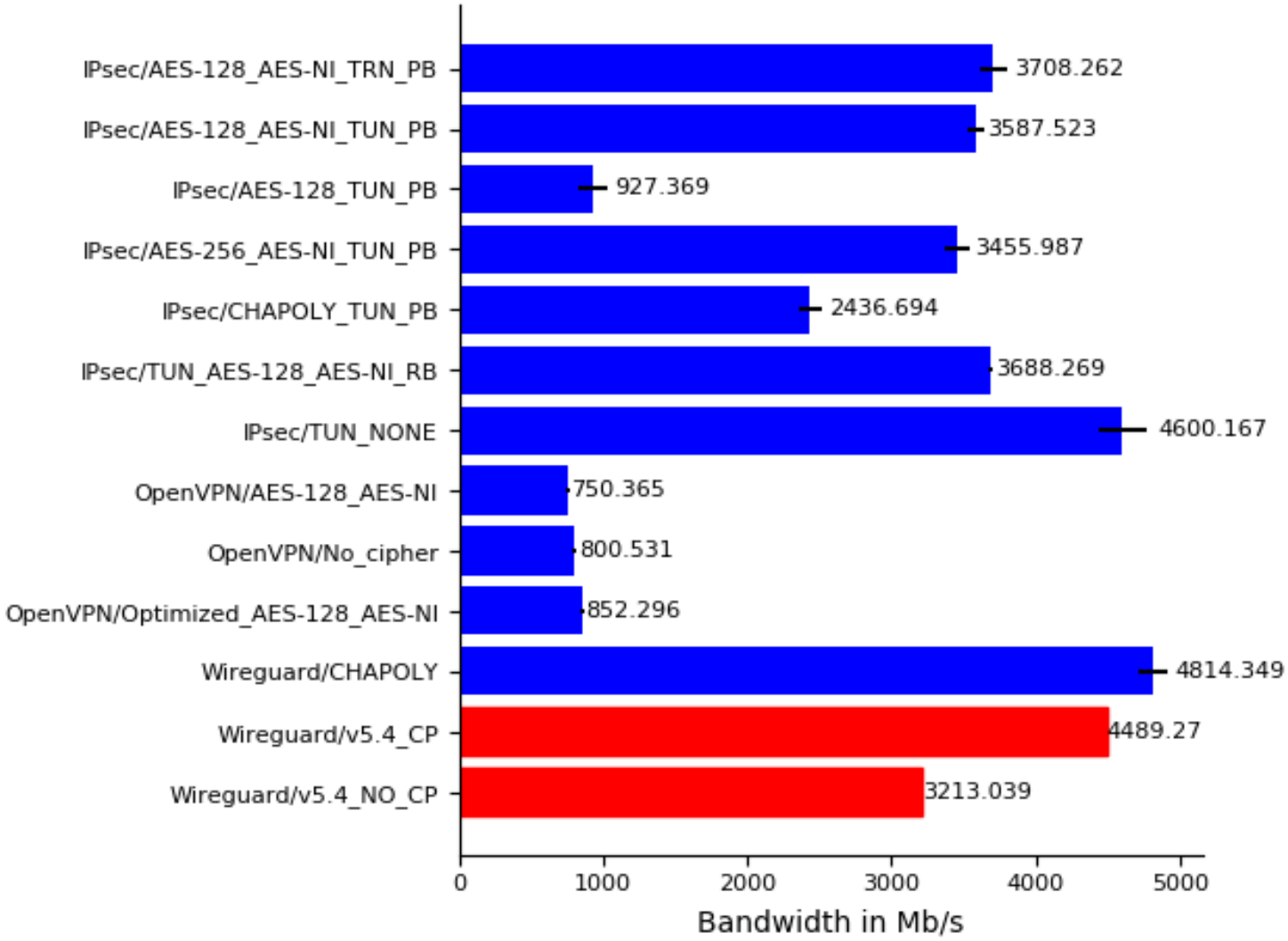
- Objective: comparison of
  - WireGuard
  - IPsec
  - OpenVPN



- Experimental setup
  - Transmission between two VMs with dedicated 10 Gb/s NICs
  - VM
    - 3 Cores @ 3.20GHz und 16 GB RAM pro VM
    - Ubuntu 18.04, Kernel 5.6rc2

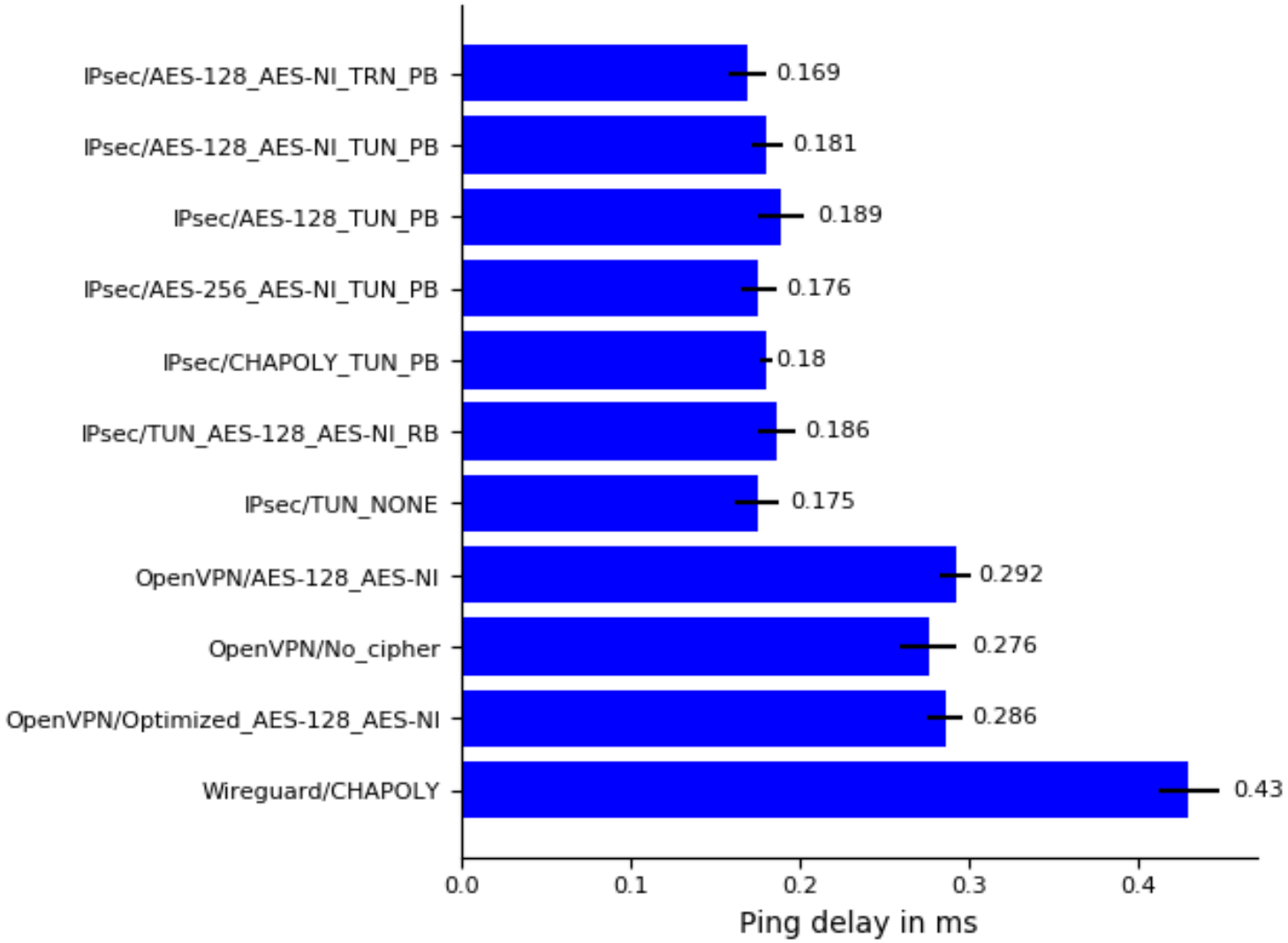
- Performance metrics
  - Nuttcp: throughput and TCP retransmissions
  - Ping: ping time
  - Mpstat: CPU utilization

Throughput on Linux v5.6rc2

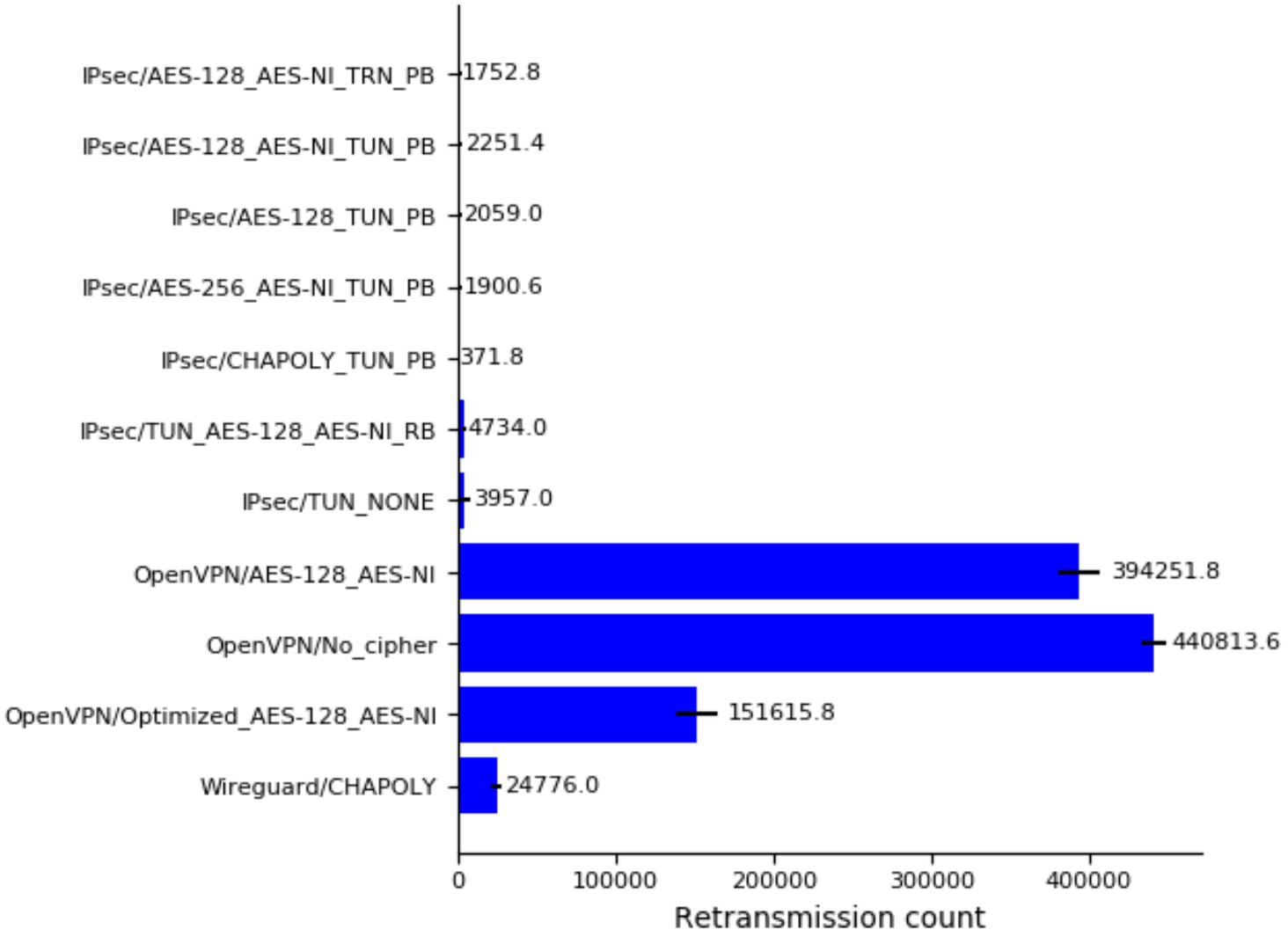


TRN = transport
TUN = tunnel
RB = route based
PB = policy based
CP = CPU pinning

Ping Time

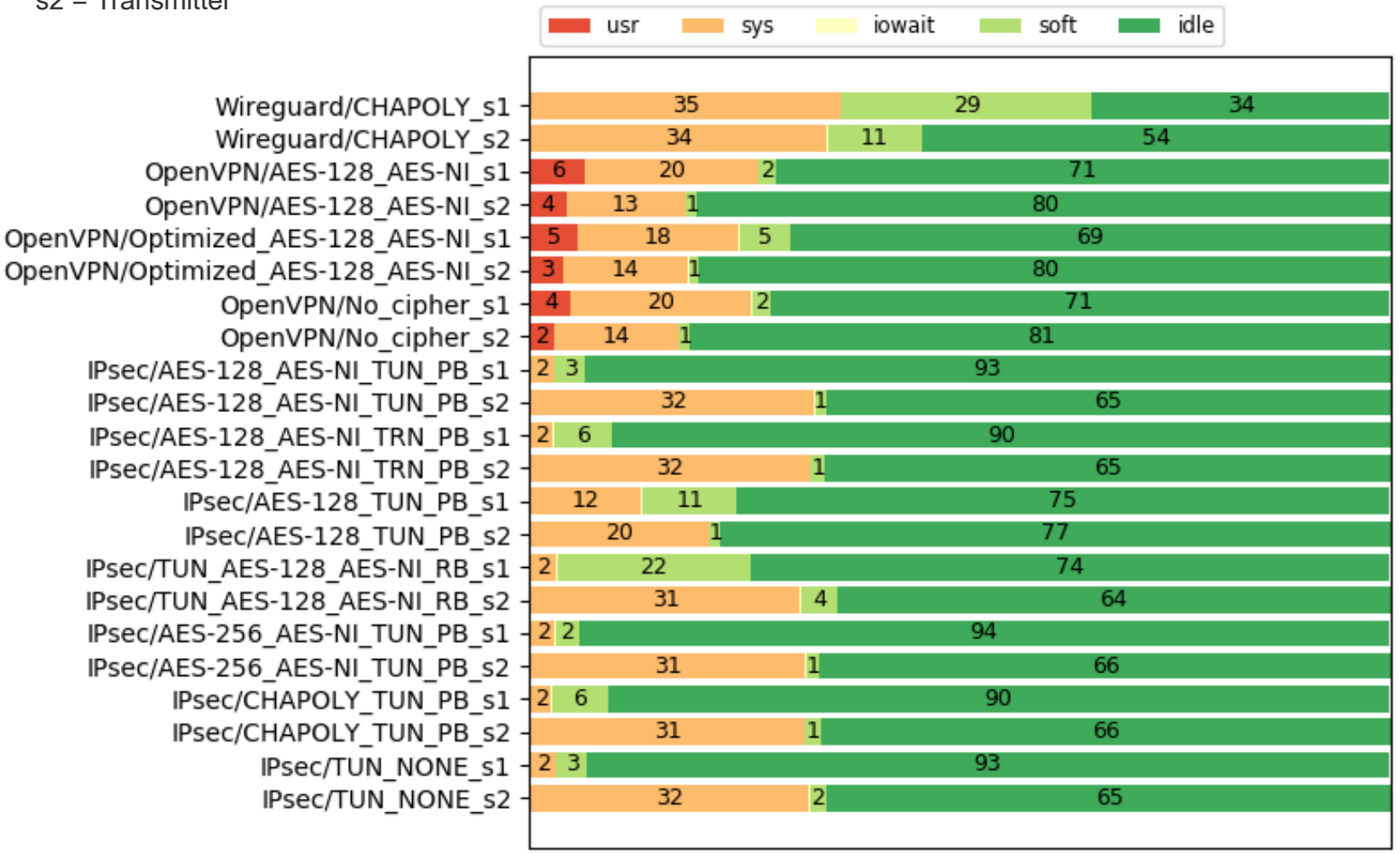

IPsec/AES-128_AES-NI_TRN_PB
IPsec/AES-128_AES-NI_TUN_PB
IPsec/AES-128_TUN_PB
IPsec/AES-256_AES-NI_TUN_PB
IPsec/CHAPOLY_TUN_PB
IPsec/TUN_AES-128_AES-NI_RB
IPsec/TUN_NONE
OpenVPN/AES-128_AES-NI
OpenVPN/No_cipher
OpenVPN/Optimized_AES-128_AES-NI
Wireguard/CHAPOLY
0.169
0.181
0.189
0.176
0.18
0.186
0.175
0.292
0.276
0.286
0.43
0.0
0.1
0.2
0.3
0.4
Ping delay in ms

TCP Retransmissions



CPU Utilization

s1 = Receiver
s2 = Transmitter



Conclusion

- Results:
  - WireGuard
    - → Highest throughput
    - → Highest CPU utilization
    - → Longest ping times
  - IPsec
    - → High throughput, depends on variant
    - → Shortest ping times
  - OpenVPN
    - → Low throughput, user-space implementation

Thank you.

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