Service Aware Zero Trust Container Network and Its Offloading to DPU

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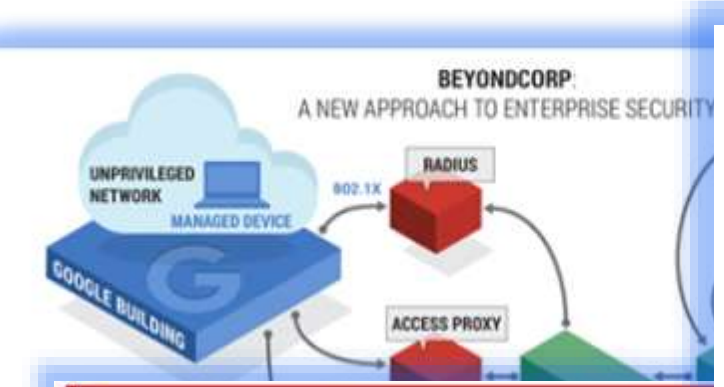
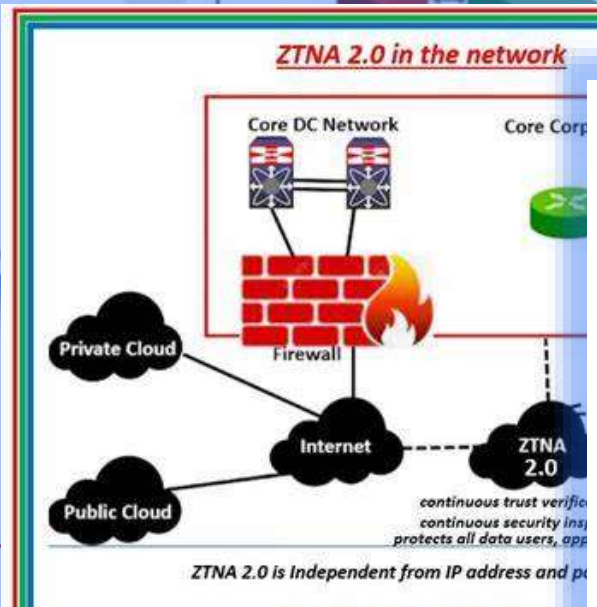
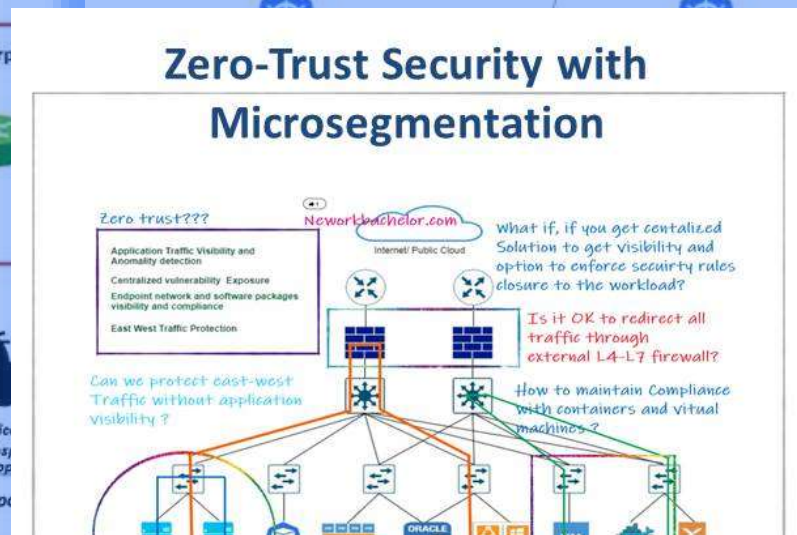
Security Level:

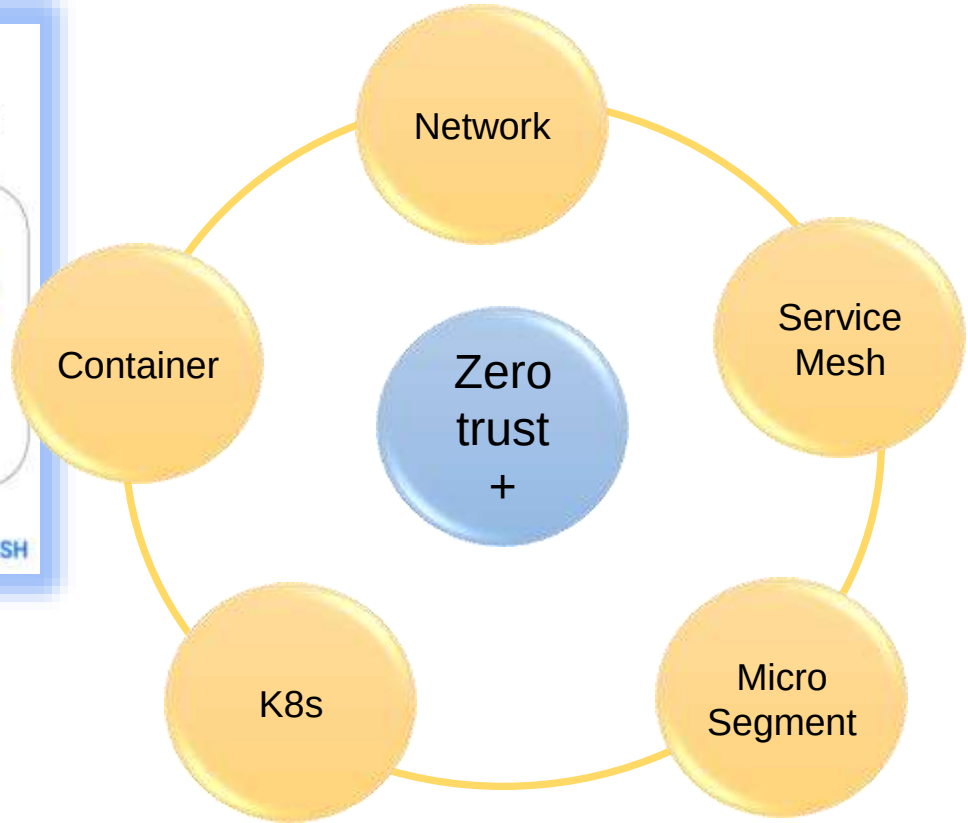
What is zero trust

- does not grant implicit trust to users, devices, and services
- Pwd / certificate is not enough
- Zero trust + everything









How to achieve zero trust

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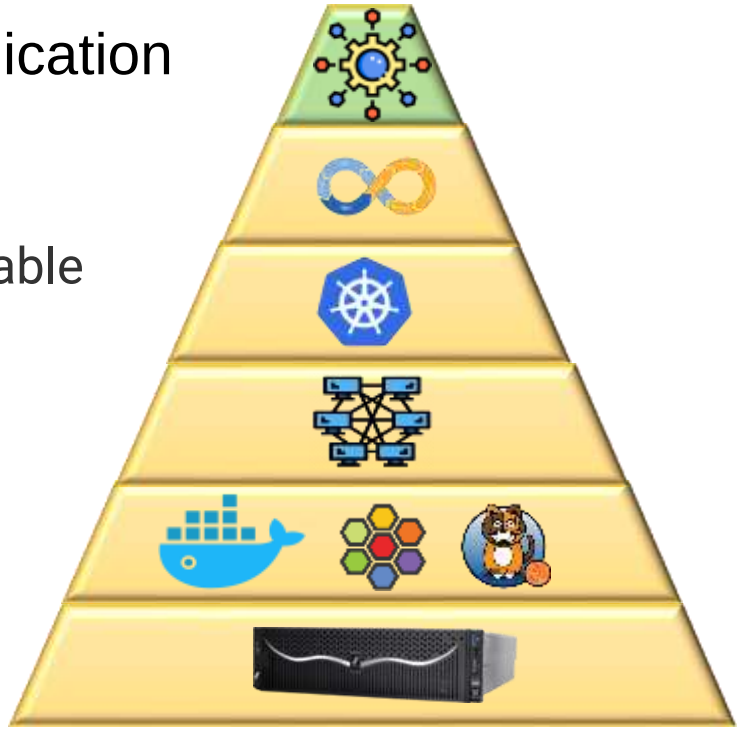
- Challenge
  - Identity theft is popular
  - east west lateral movement attack is popular
- Target
  - Limit the effect of identity theft
  - Limit the lateral movement attack
  - Block access based on any entity (user, device, service, location)
- Action--No single component or function is sufficient to implement ZTA
  - continuous verification: behavior, environment, AI/ML
  - all communications are encrypted
  - mutual authentication
  - certificate and key rotation
  - micro-segmentation : network, service
- A complete zero trust security posture may never be fully achieved
  - Performance , usability, price

Cloud Native Zero Trust Architecture

Container network and service mesh provide zero trust communication



- Cloud Native System
  - loosely coupled systems that are resilient, manageable, and observable
- Cloud Native Application
  - a collection of small, independent, and loosely coupled services
- Cloud Native Infrastructure
  - containers, network, orchestration , CI/CD
  - service mesh

- Action
  - Continuous verification
  - Encrypted communications
  - Mutual authentication
  - Certificate and key rotation
  - Micro-segmentation

→

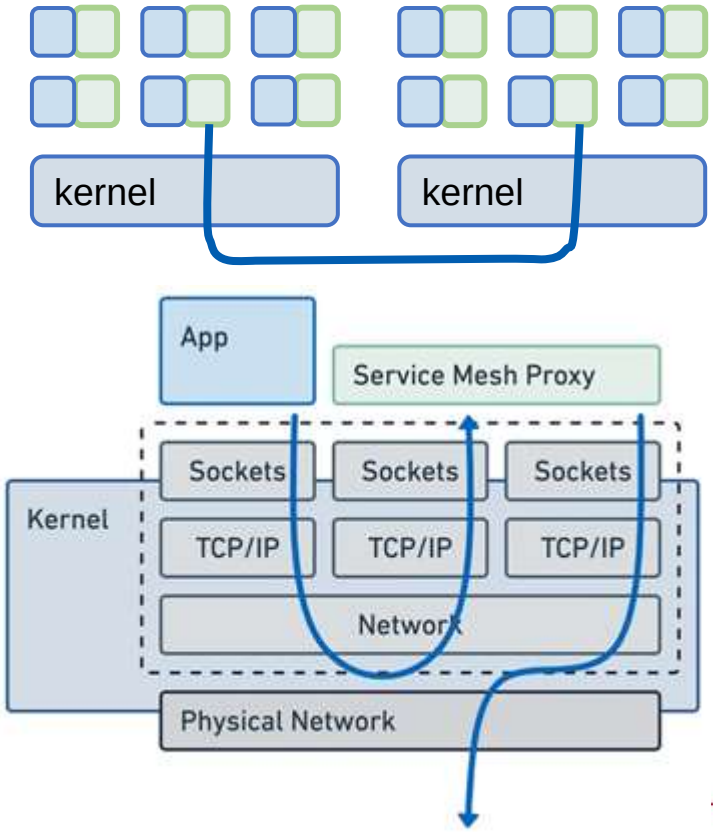
- Telemetry: container, network, service
- Session encryption
- Mutual service authentication
- Certificate and key rotation
- Microservice segmentation

Sidecar & sidecarless service mesh

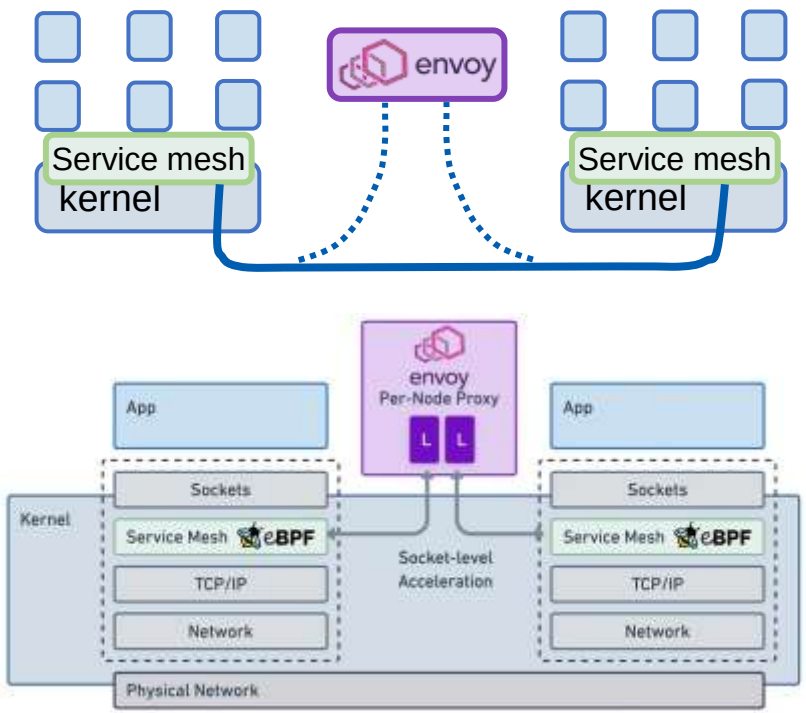
Move L4 to CNI
Decrease proxies
eBPF
Per node/service share

Reduce invasion
decouple POD and mesh infra
reduce latency
Reduce host usage

Istio

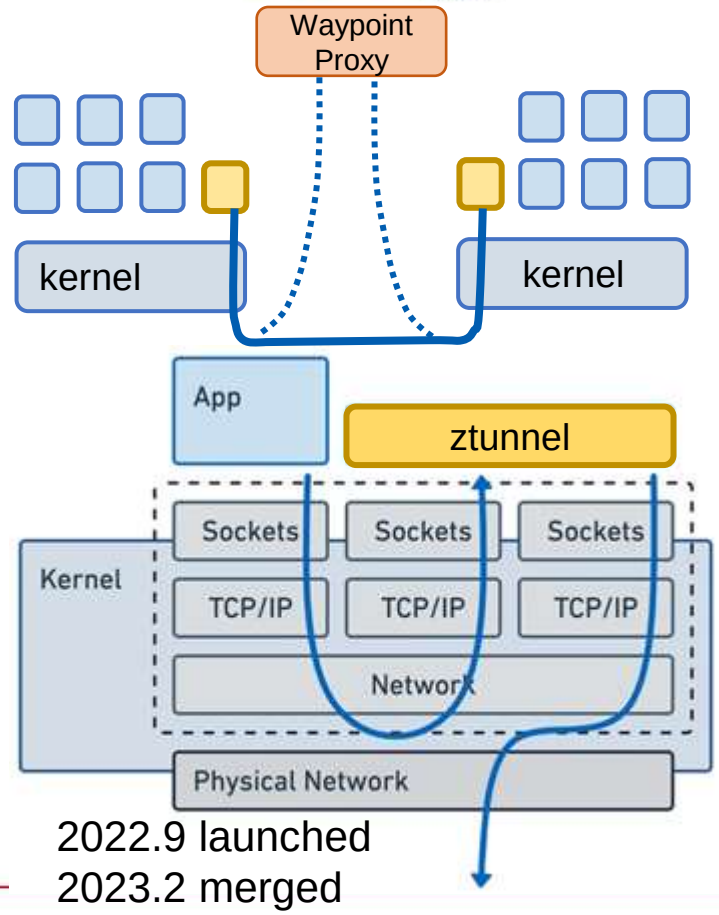


cilium



2022.7 v1.12

ambient mesh



2022.9 launched
2023.2 merged

No perfect solution

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Balance among performance, scalability, security

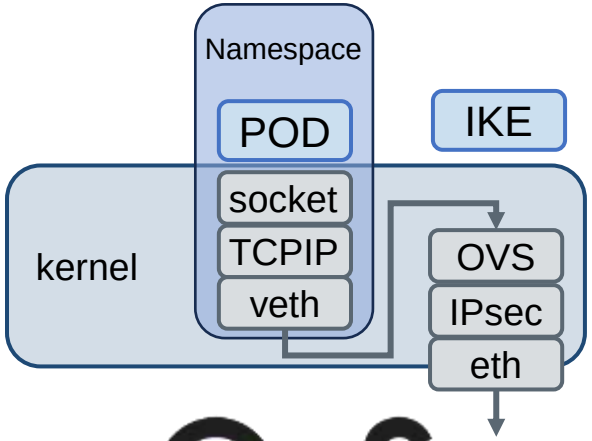
	Istio	cilium	ambient mesh
Latency	★★	★★★	★★
Host CPU usage	★★	★★★★	★★★★★
Host memory usage	★★	★★★★	★★★★★
POD invasion	★★	★★★★★	★★★★★
Kernel Req.	★★★★★	★	★★★★★
Istio compatibility	★★★★★	★★	★★★★
scalability	★★★★★	★★	★★★★
Service awareness	★★★★★	★★★	★★★
Breach radius	★★★★★ POD	★★ Node	★★ Node
vulnerability	★★ App, Envoy	★★★★ Envoy	★★★★ Ambient

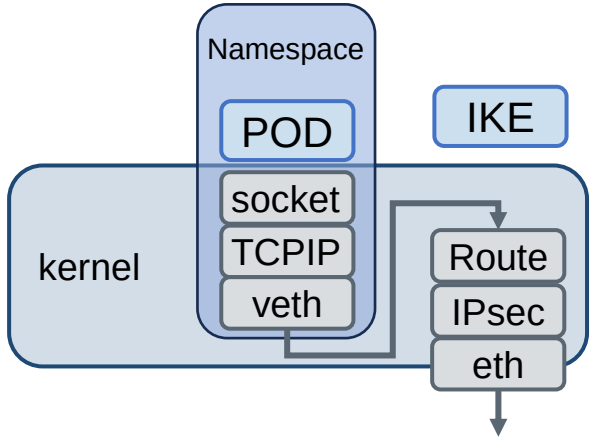
More stars is better

Zero trust container network

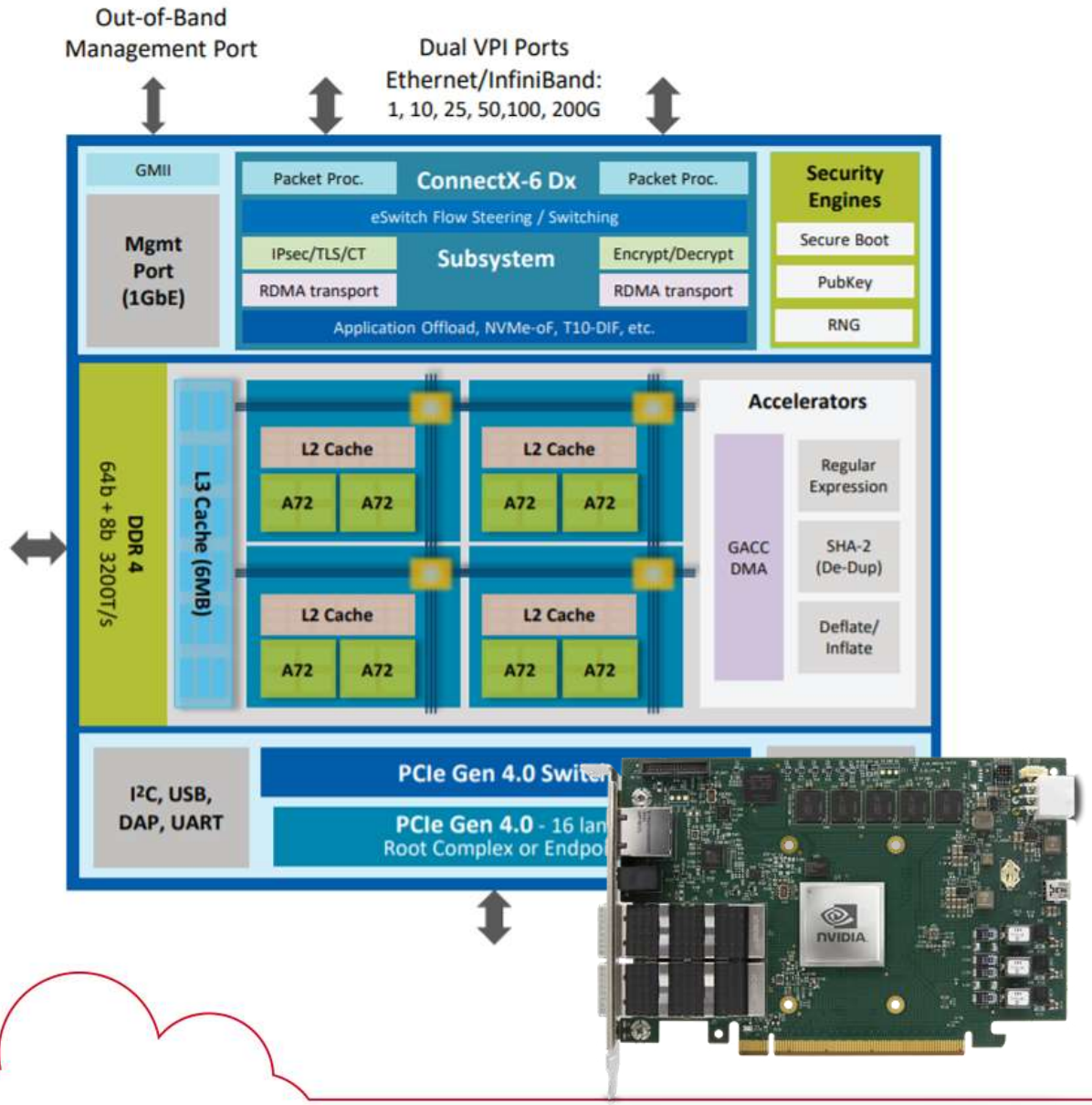
Service mesh is not deployed in many scenarios, service awareness is needed for service identity authentication in container network tunnel.

- packets are transported from one node to another via IPsec/wireguard tunnel.
- do not currently provide any support for IPsec encryption for traffic not encapsulated in a tunnel
- Workload identity is based on IP.





What does DPU provide



- Overlay network acceleration
  - VXLAN, GENEVE, NVGRE
- Connection tracking
- Flow sampling and statistics
- IPsec/TLS data-in-motion encryption
  - AES-GCM 128/256-bit key
- Public key accelerator (PKA)
  - RSA, Diffie-Hellman, DSA, ECC,EC-DSA, EC-DH

Zero trust cloud native with DPU

- Targets
  - Increase throughput, decrease latency
  - Compatible with istio eco.
  - Keep or improve security
  - Support scenarios w/o sidecar
  - Decouple app and infra

- Challenges of offloaded ZT CNI
  - Service aware
  - Breach radius

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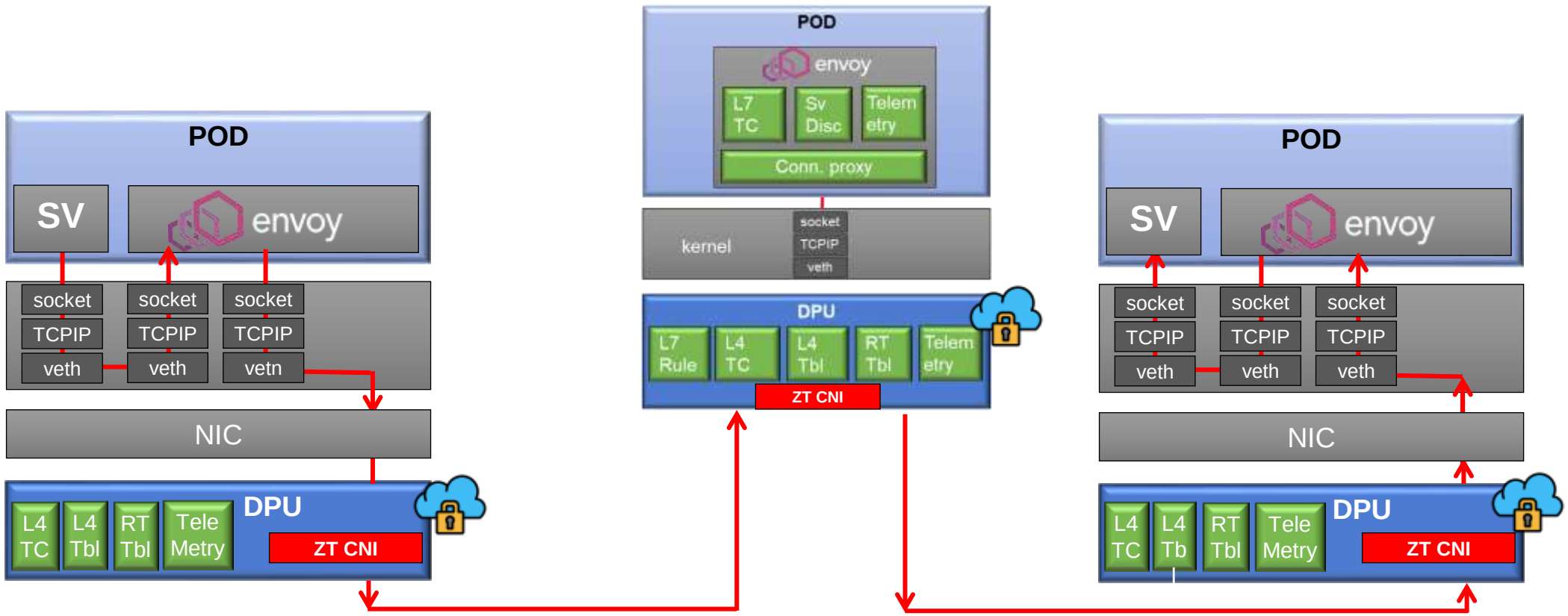

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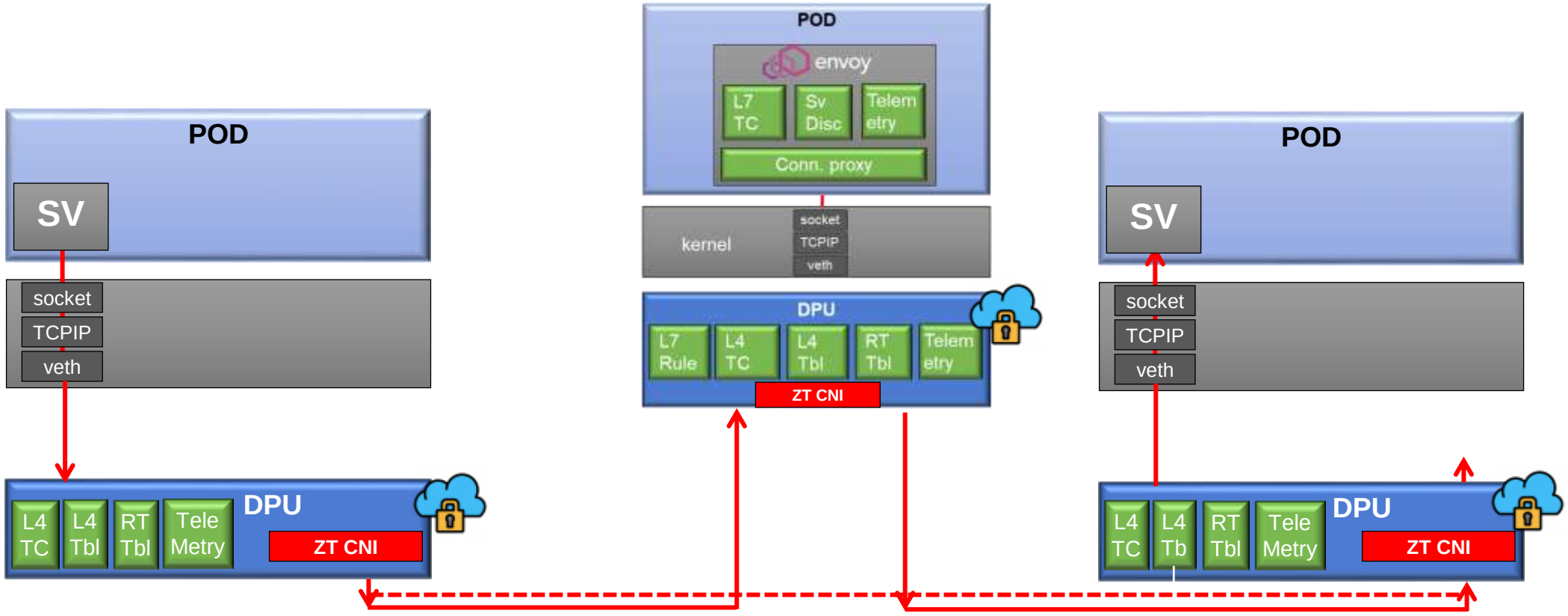
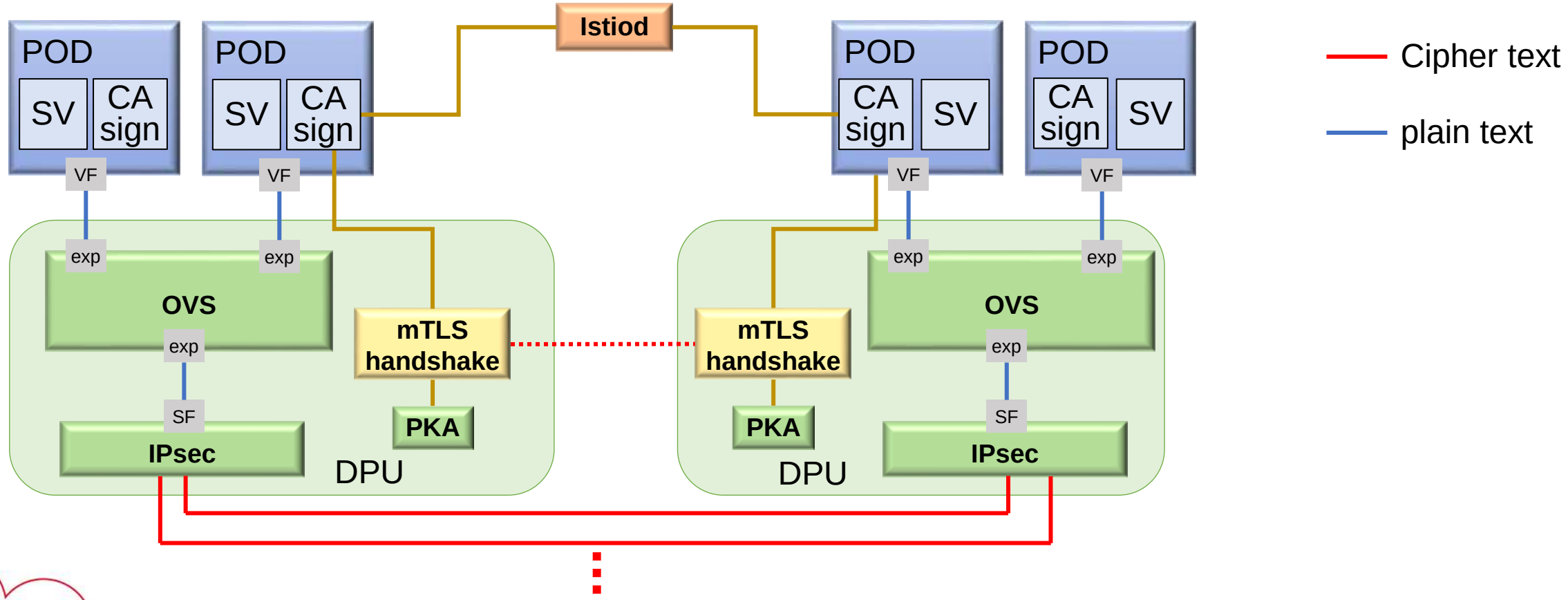


Architecture of zero trust CNI on DPU

- Per POD IPsec tunnel
- mTLS handshake for each tunnel
- Use vfid in metadata for POD identification
- Boost signature performance with larger breach radius



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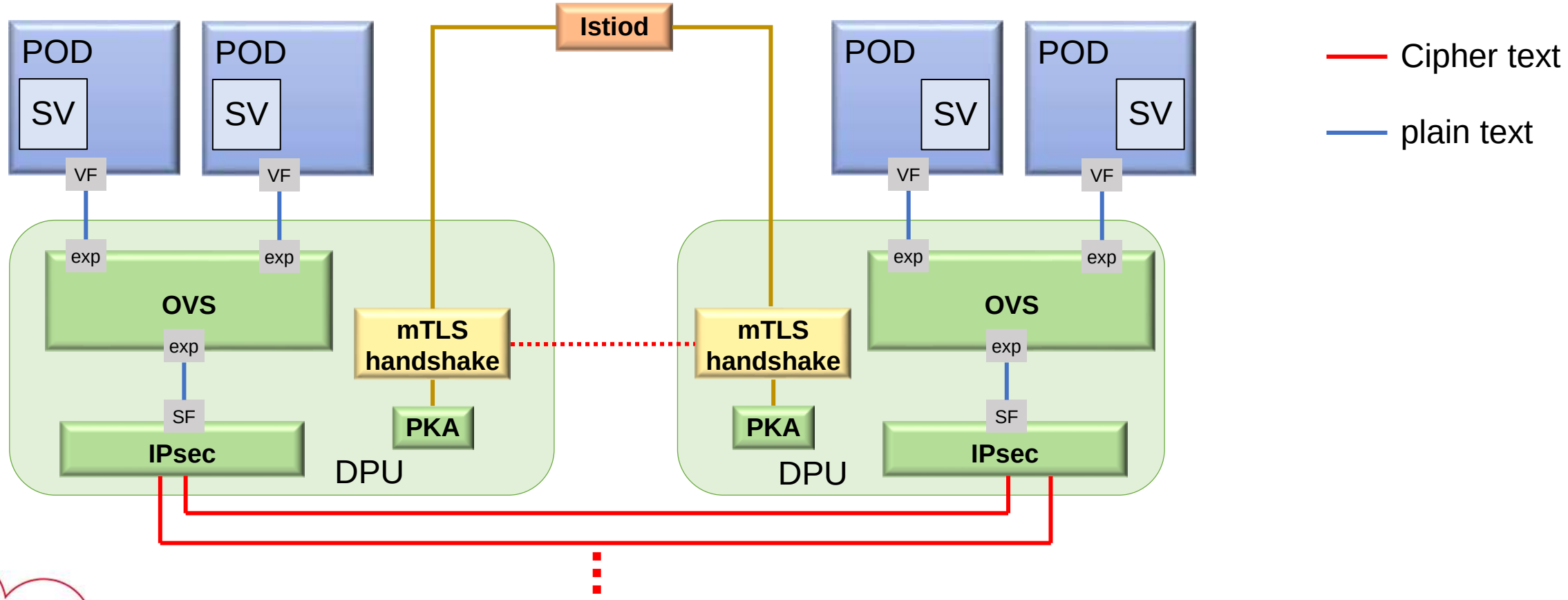
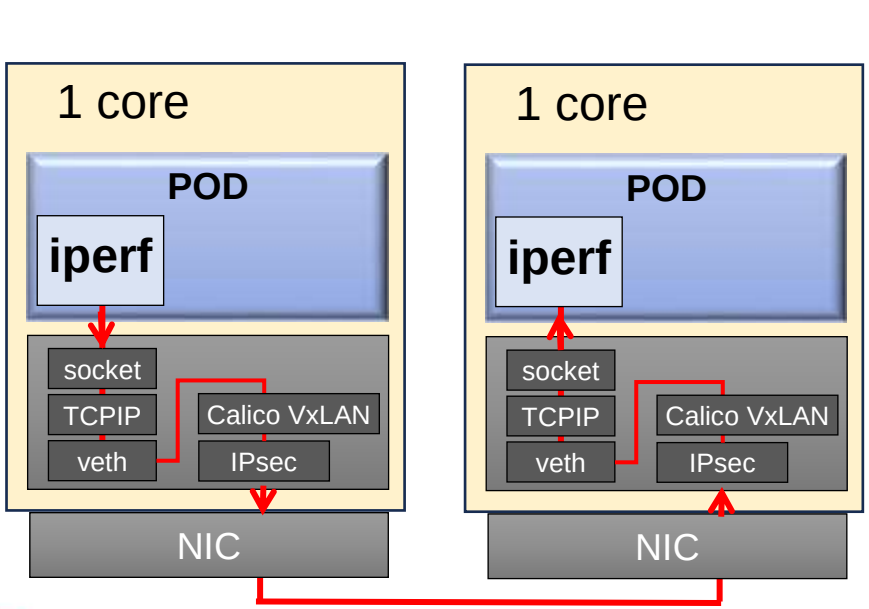


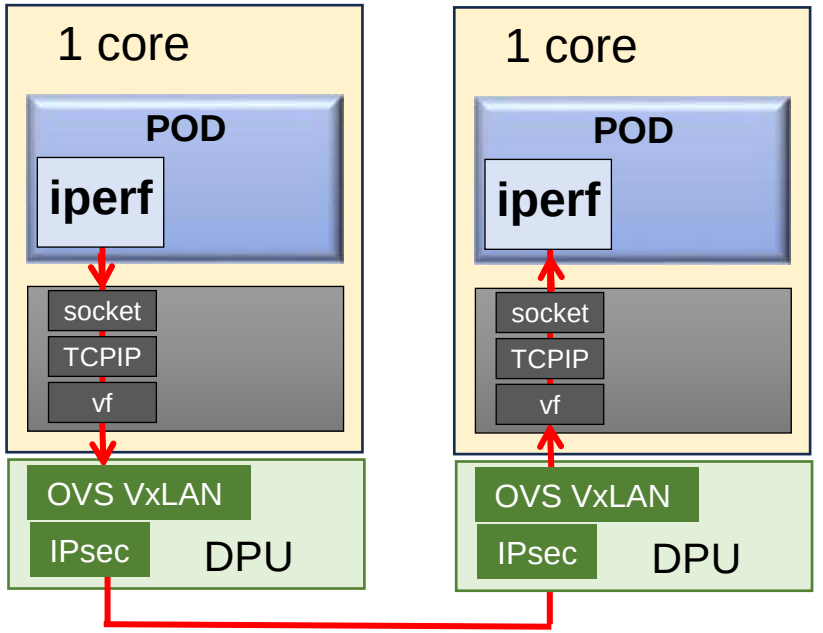
Testbed of ZT CNI w/wo DPU

- Testbed
  - server: DigitalChina KunTai 2280, CPU: KunPeng 920, 2*48 cores @2.6G
  - DPU: nVidia bluefield 2
  - TSO and Armv8 Cryptographic Extension are enabled by default
  - Iperf sending 4~8 tcp streams is bond to 1 core
- 1.8x~23.5x encrypted TCP throughput improvement @ 1 core



Calico+VxLAN+ipsec

vs



DPU ovs+VxLAN+ipsec

Performance of ZT CNI w/wo DPU

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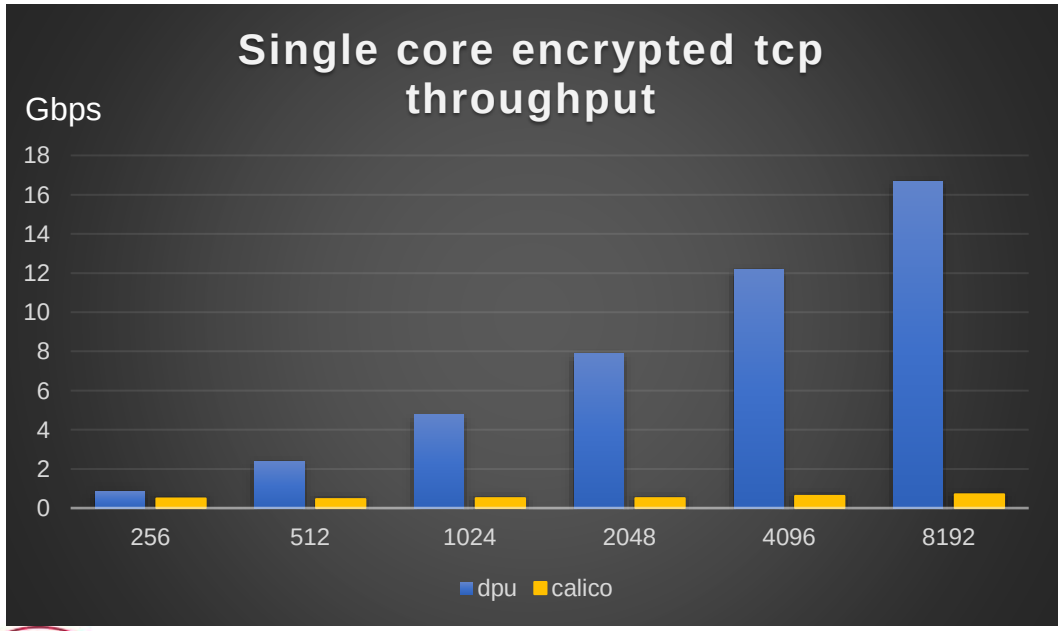
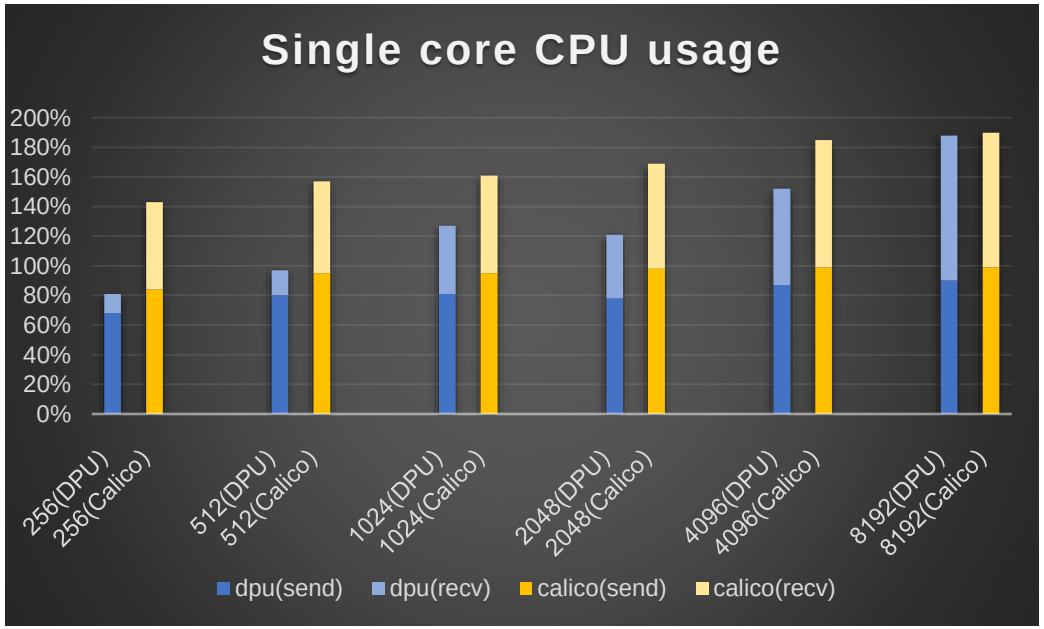
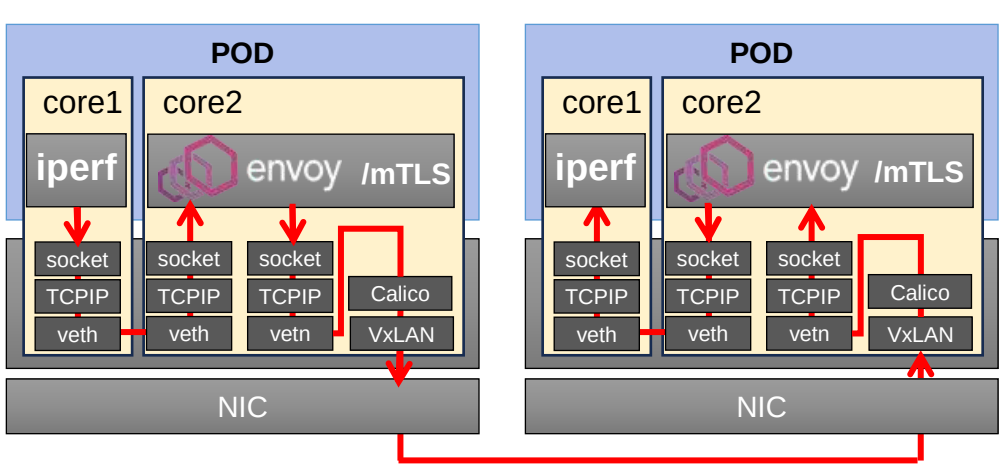
- 1.8x~23.5x encrypted tcp throughput improvement
- 40~1% CPU utilization reduce
  - Iperf uses 10~30% CPU
  - 3x~24x throughput improvement per core





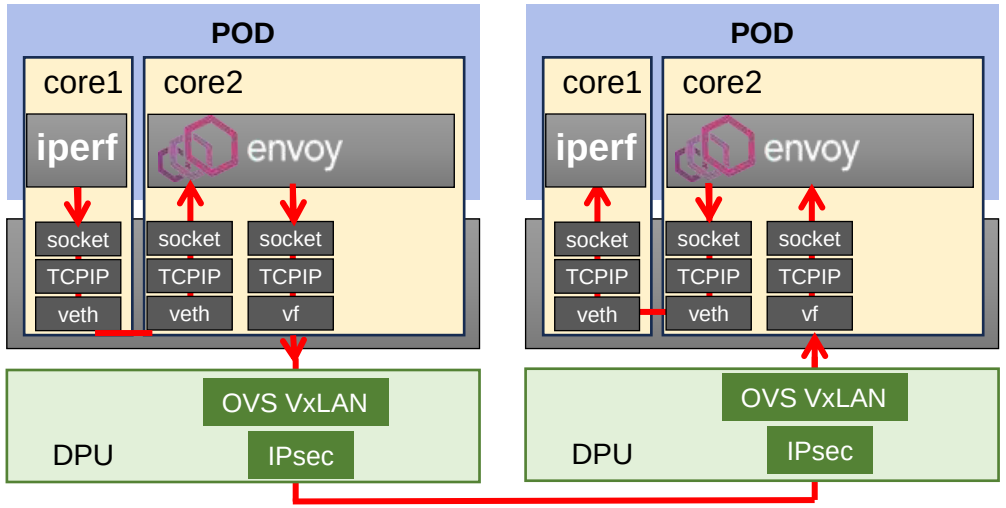
Testbed of sidecar w/wo ZT DPU CNI

- Testbed
  - server: DigitalChina KunTai 2280, CPU: KunPeng 920, 2*48 cores @2.6G
  - DPU: nVidia bluefield 2
  - TSO and Armv8 Cryptographic Extension are enabled by default
  - Iperf sending 4 tcp streams is bond to 1 core
- 3.2x~4.9x encrypted TCP throughput improvement @ 1 core
- 1.5x~4.1x encrypted TCP throughput improvement @ 4 cores



Envoy sidecar+mTLS+Calico+VxLAN

VS



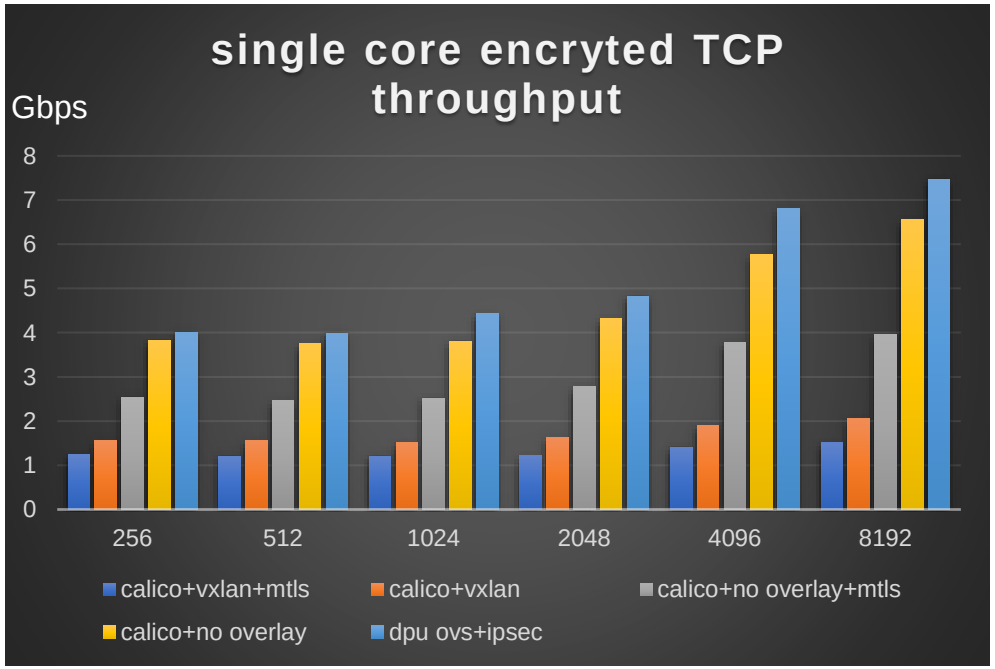
Envoy sidecar+DPU (ovs+VxLAN+ipsec)

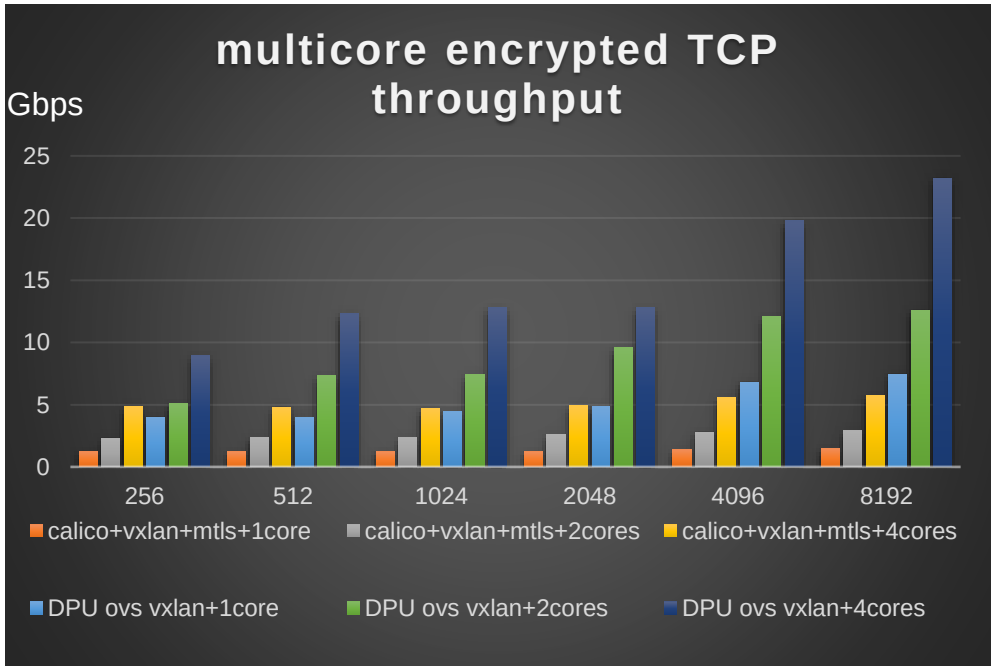
Throughput of sidecar w/wo ZT DPU CNI

- vxlan reduces throughput by 60~70%
- mtls reduces throughput by 30~40%

- 3.2x~4.9x improvement @ 1 core
- 1.5x~4.1x improvement @ 4 cores

TSO(vxlan) has greater impact than mtls
Kernel network stack locks have impact on multicore

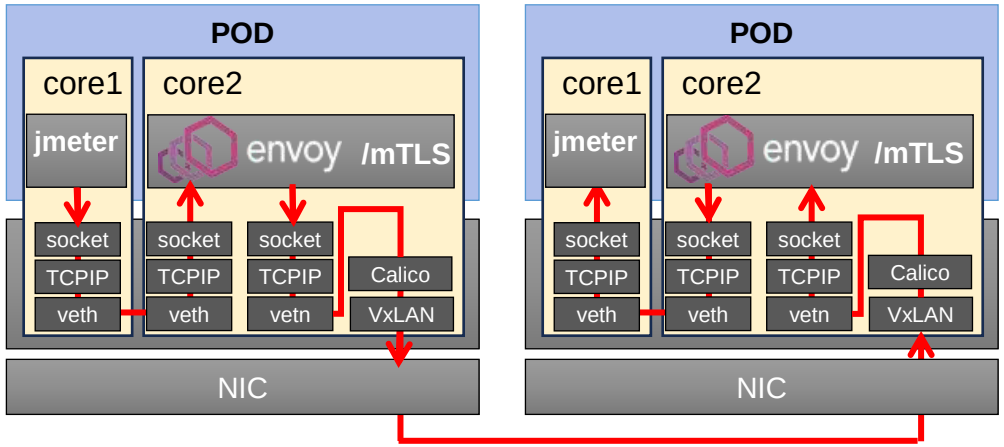




Higher is better

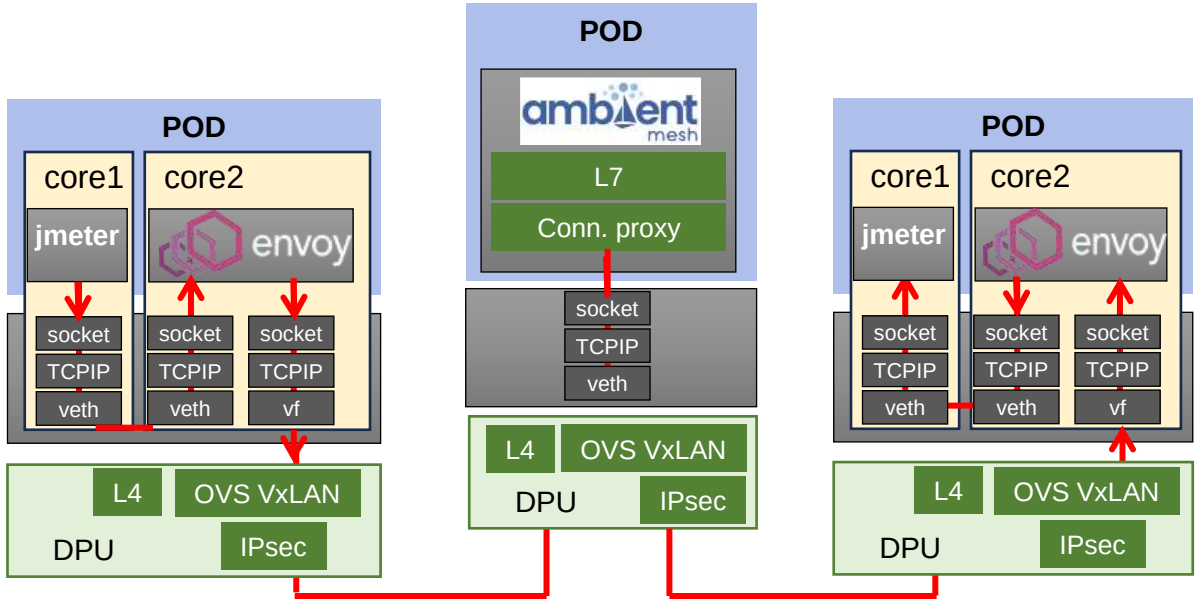
Testbed of service mesh w/wo sidecar

- Testbed
  - server: DigitalChina KunTai 2280, CPU: KunPeng 920, 2*48 cores @2.6G
  - DPU: nVidia bluefield 2
  - TSO and Armv8 Cryptographic Extension are enabled by default
  - Jmeter sends 50 concurrent http streams
- 4x encrypted http QPS improvement per 1 core
- 50% encrypted http latency reduce



envoy+mTLS+Calico+VxLAN

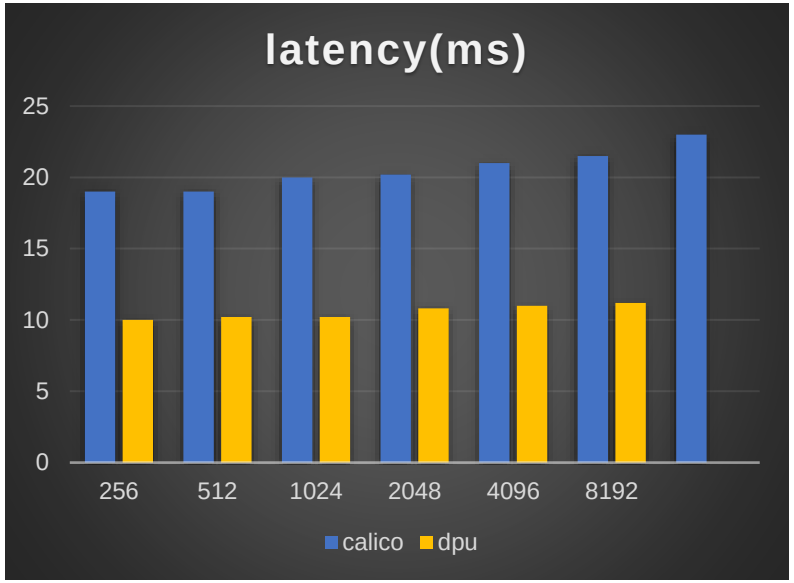
VS

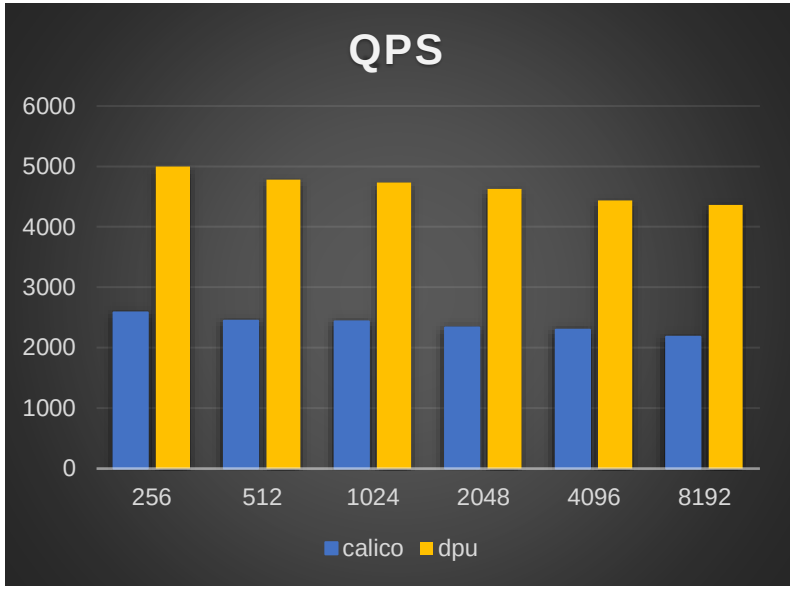


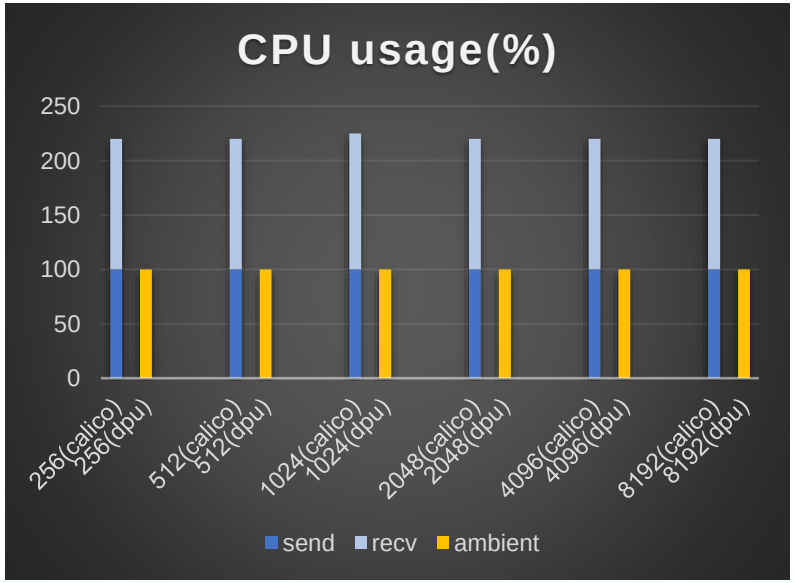
ambient+DPU ovs+VxLAN+ipsec

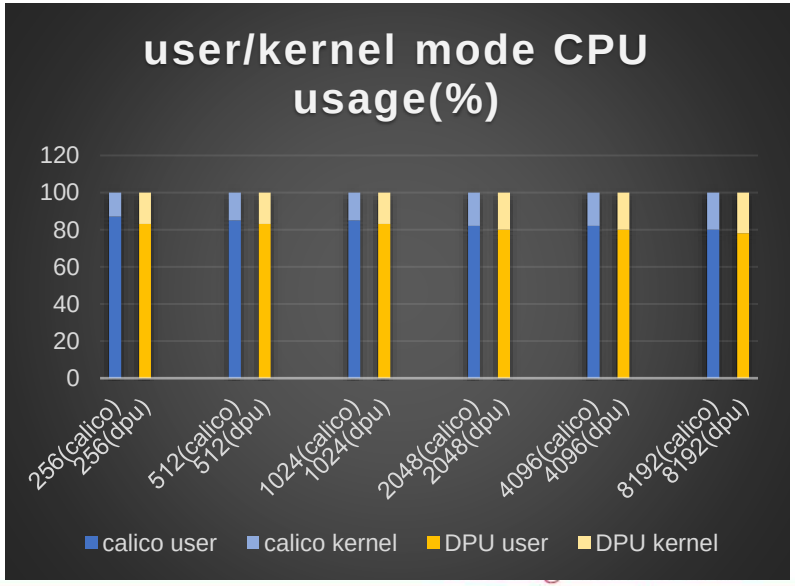
Performance of service mesh w/wo sidecar

- 2x encrypted http QPS improvement
- 54% CPU usage reduce
  - 4x QPS improvement per core
- 50% latency reduce
- 80% CPU is used by envoy L7
  - L7 parse
  - Rule match
  - Further improvement direction









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