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Zero Overhead Monitoring for Cloud-native Infrastructure using RDMA

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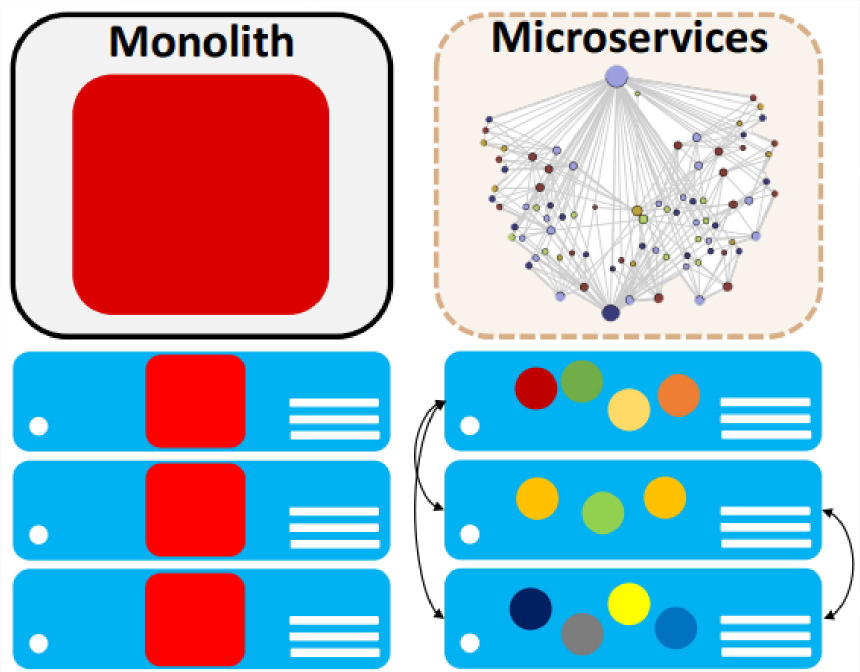
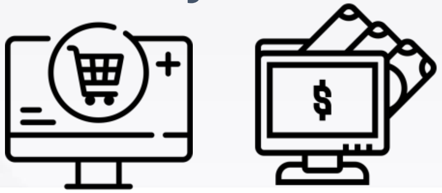
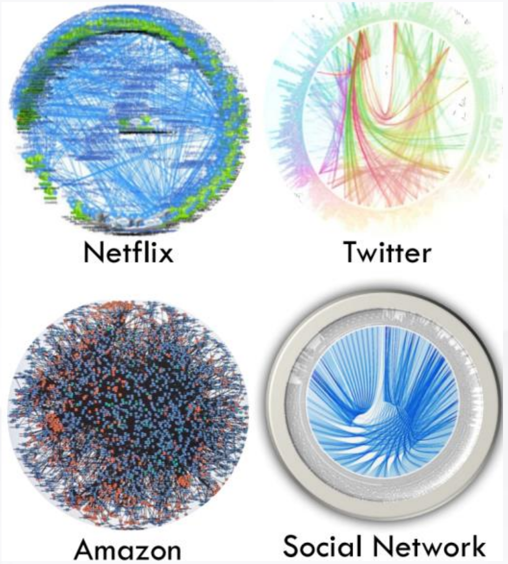


Cloud-native infrastructure:

- ✓ Monolithic design ---> microservices
- ✓ Dense deployment
- ✓ Disposable and immutable system
- ✓ Various applications

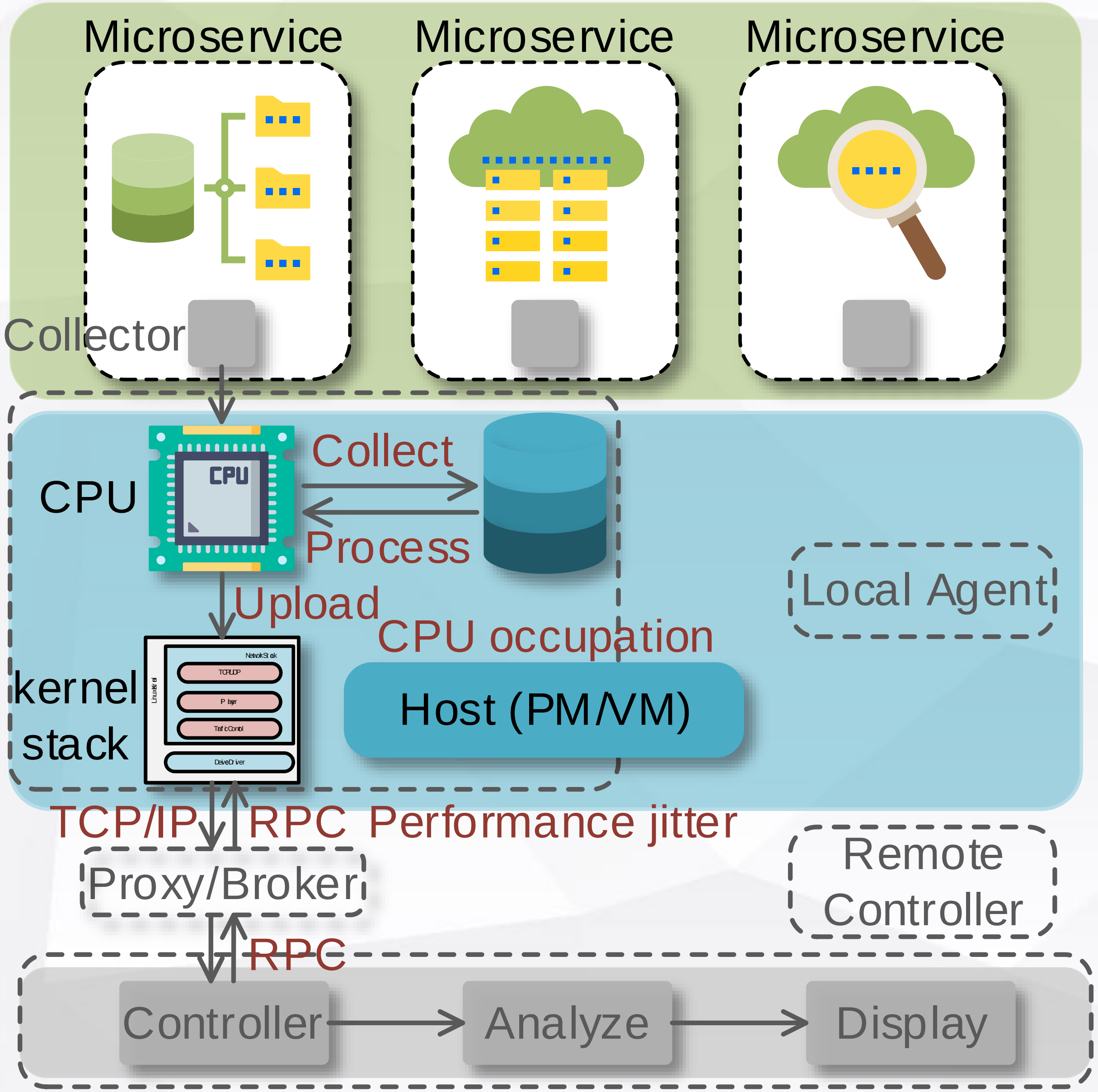


Cloud-native computing



Implications:

- ✓ Stricter QoS
- ✓ Highly resource constrained
- ✓ Massive metrics
- ✓ Rapid variations



Cloud-native monitoring

Monitor---service interference

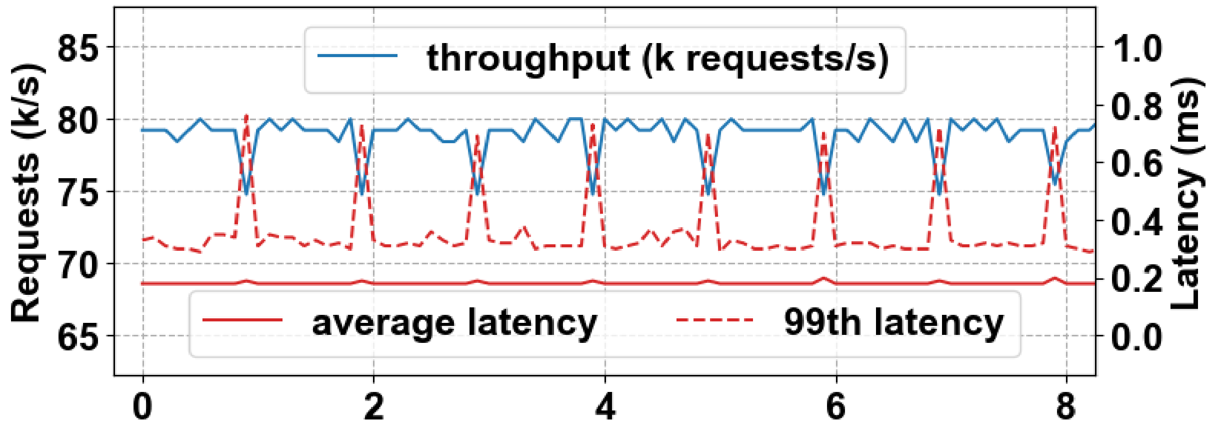
- ✓ High CPU utilization
- ✓ CPU bonding vs. default scheduling

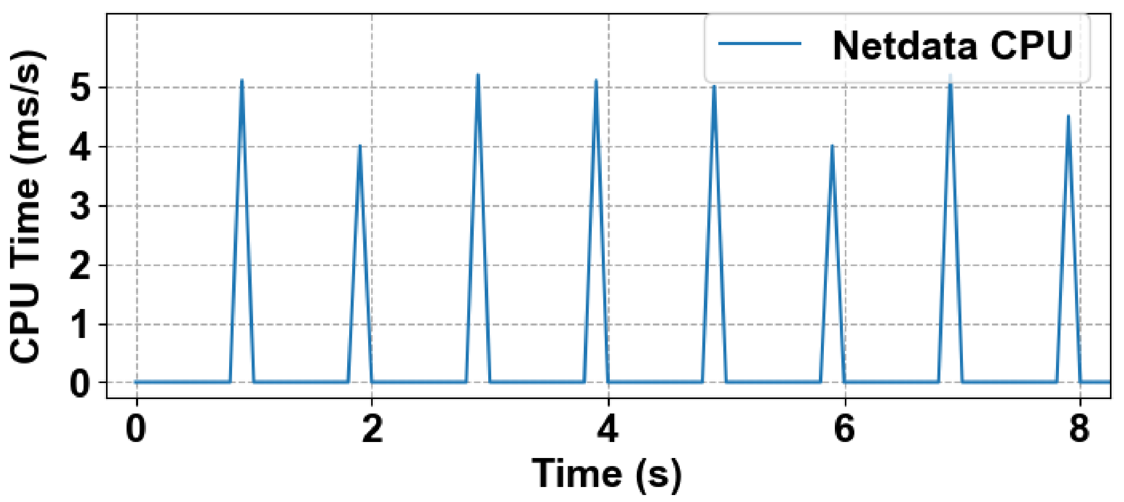
Service & monitor resource contentions

Service---monitor interference

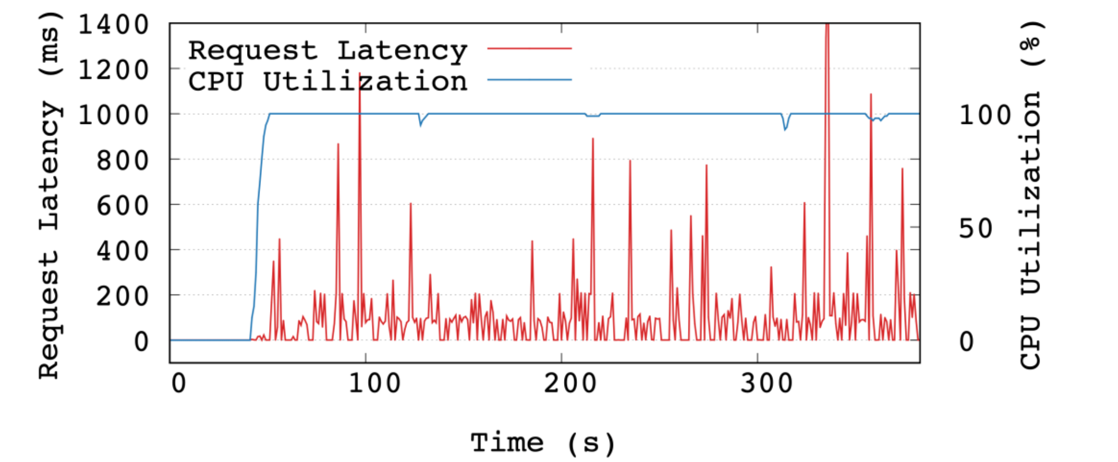
- ✓ CPU quota
- ✓ Interface reusing

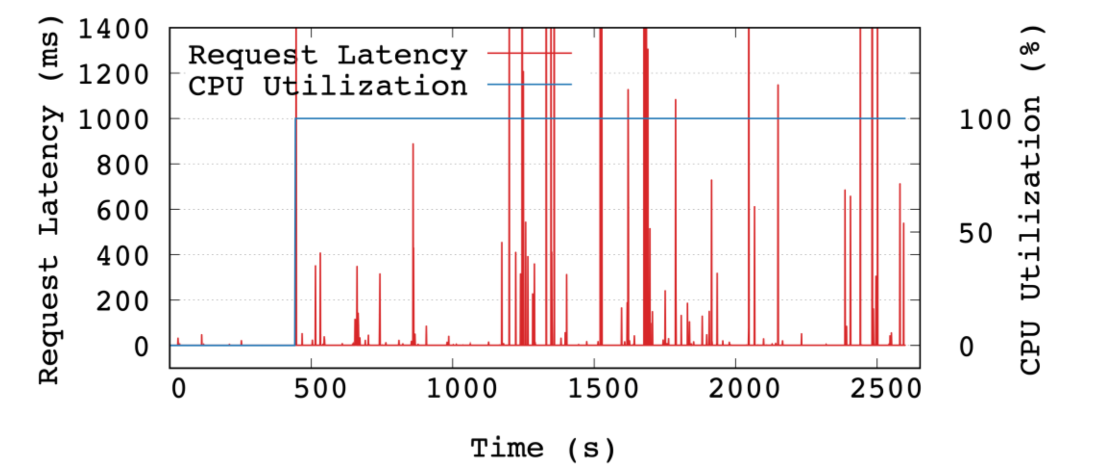
Service jitters

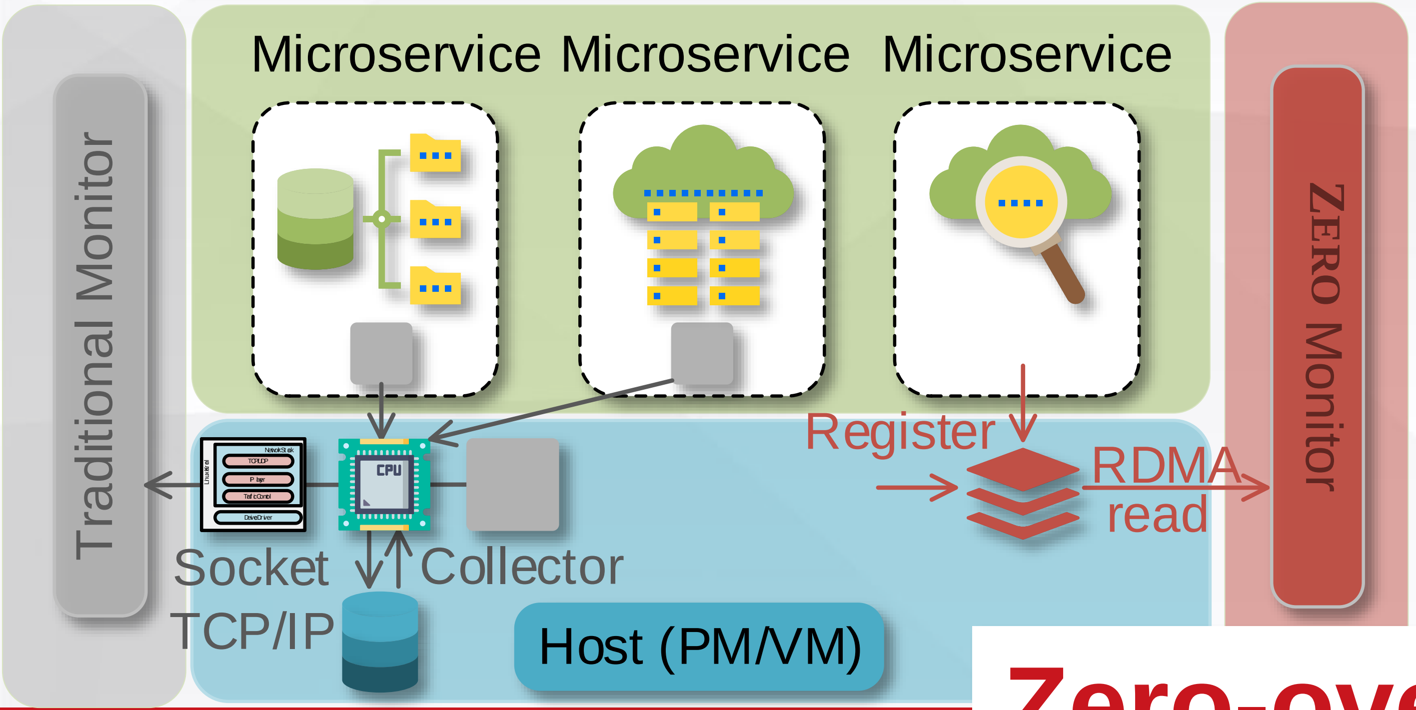




Monitor jitters







Decoupling monitor from infrastructure!

Zero-overhead monitoring

How to decouple?

Metric features

- ✓ Counters & reproducible calculation

RDMA support

- ✓ One-sided RDMA (CPU & kernel bypass)

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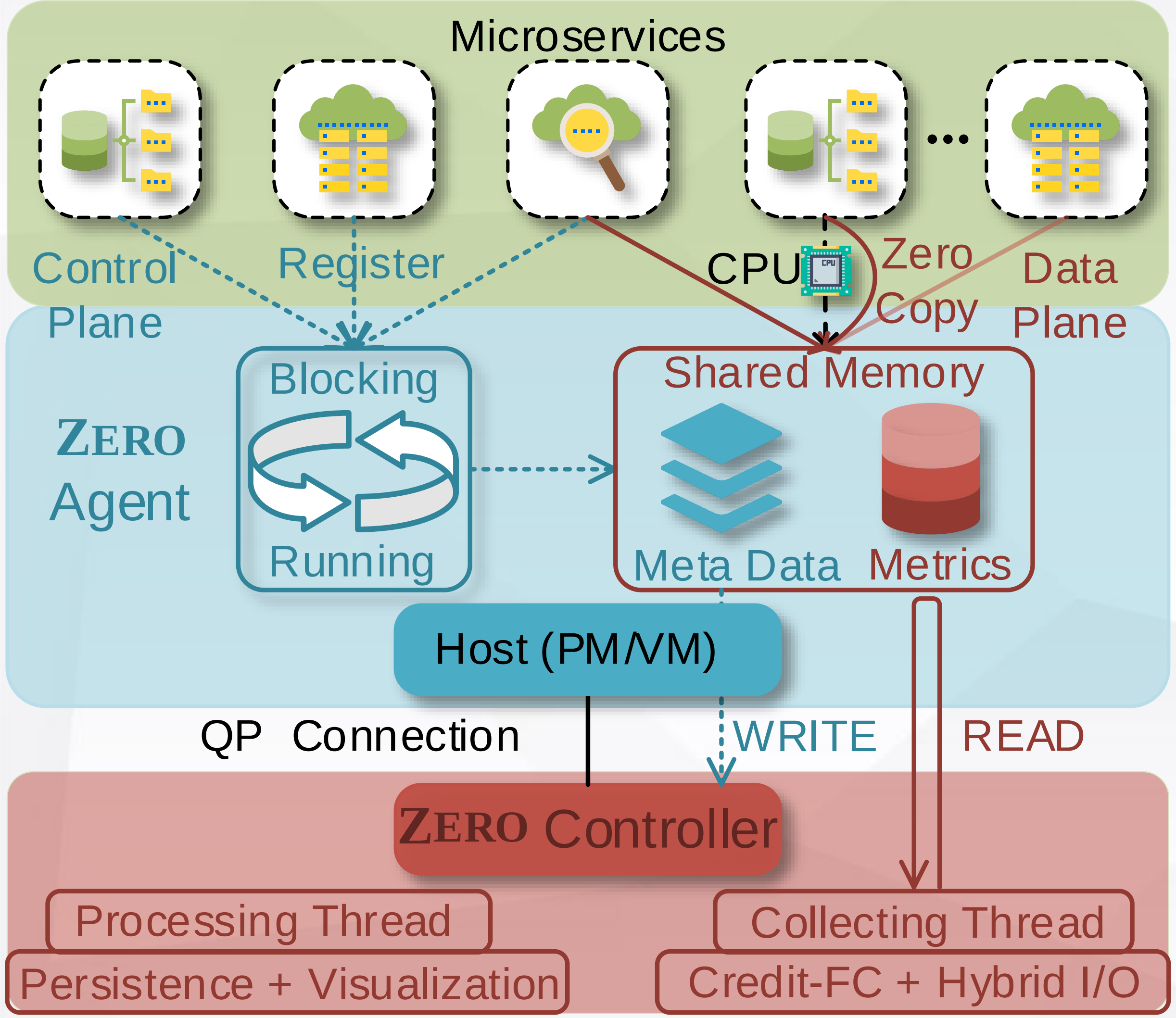
Zero Overview



Challenge 1

- ✓ Offload collect overheads besides upload overheads

Challenge 2

- ✓ Achieve high throughput while avoiding incast

Challenge 3

- ✓ Collect & process metrics from multiple connections

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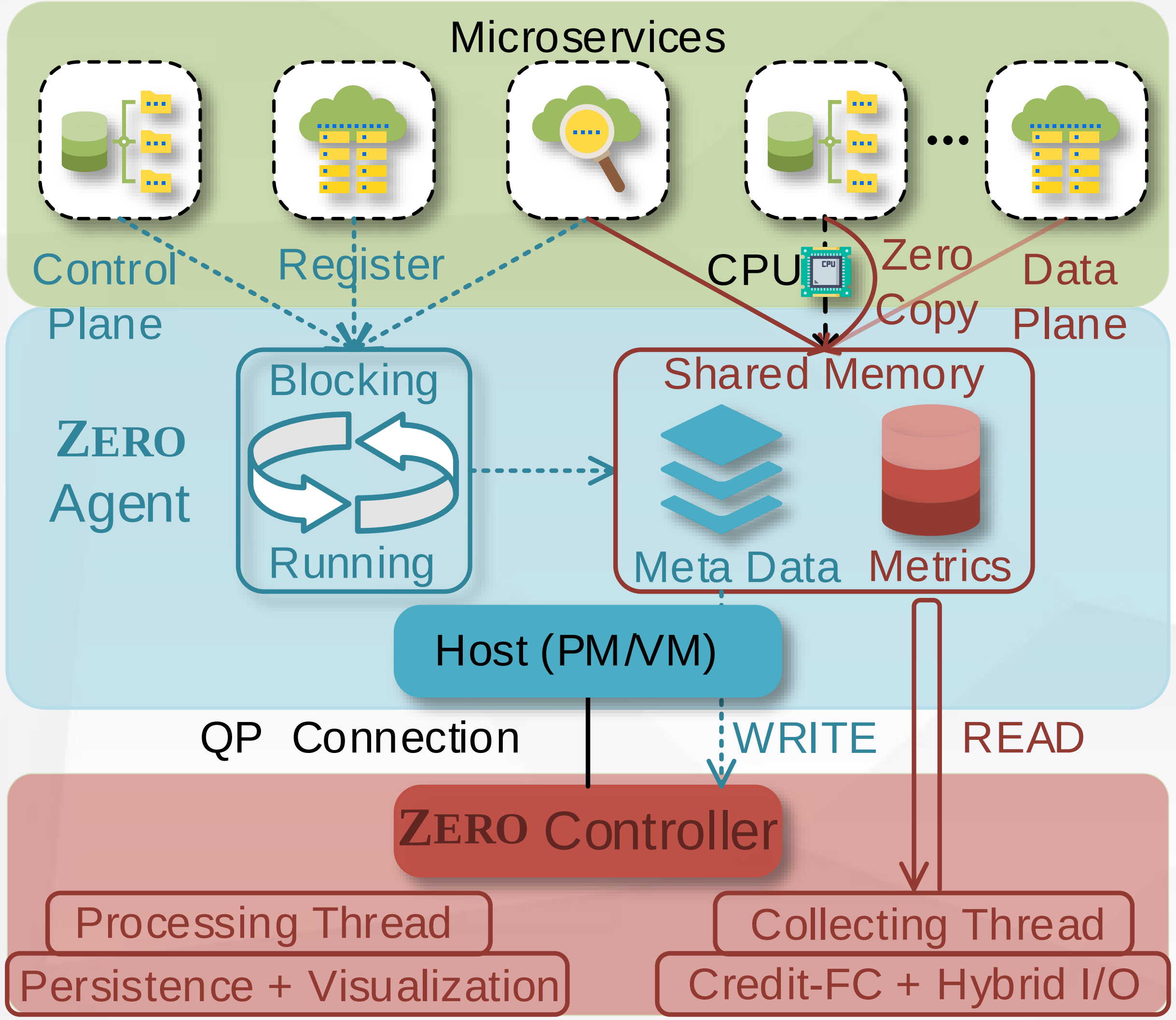
Control Plane



Universal interface

- ✓ (De)register metrics
- ✓ Update metadata in control region

Disposable overhead

- ✓ System/persistent/tidal metrics
- ✓ Serverless functions

QP connection share

- ✓ Manage & share QP connection

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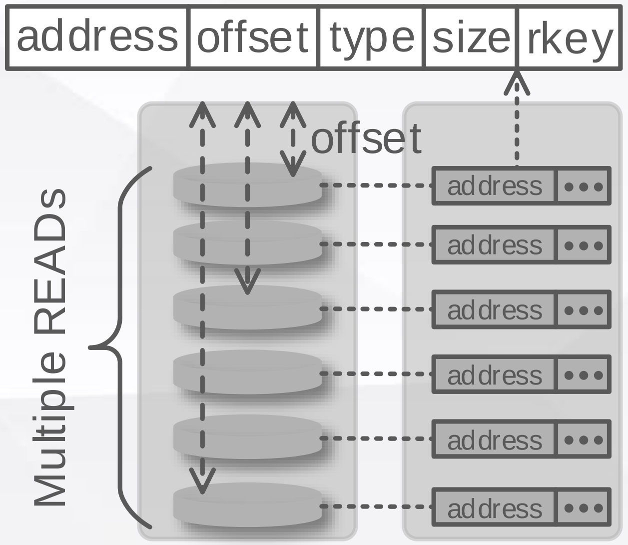
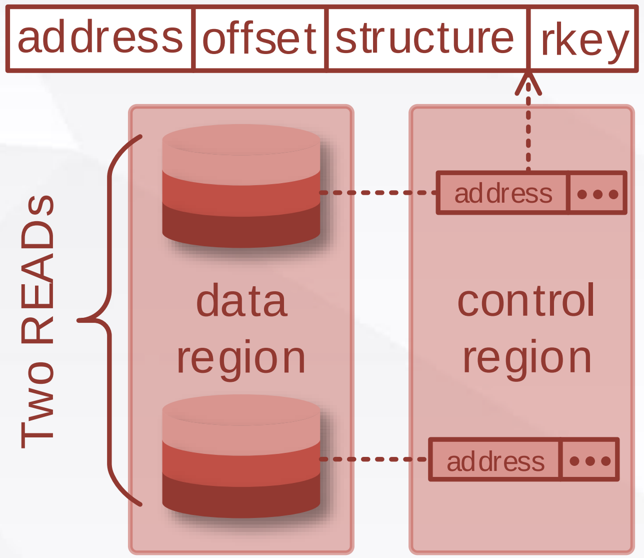
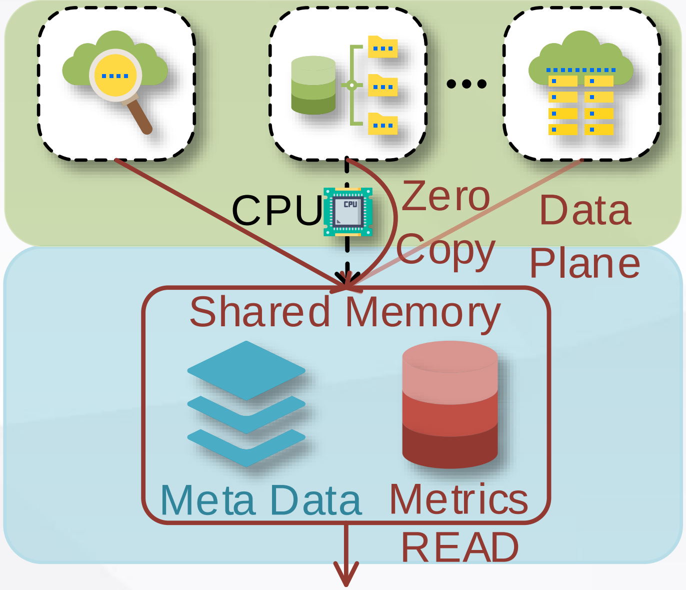


Shared memory

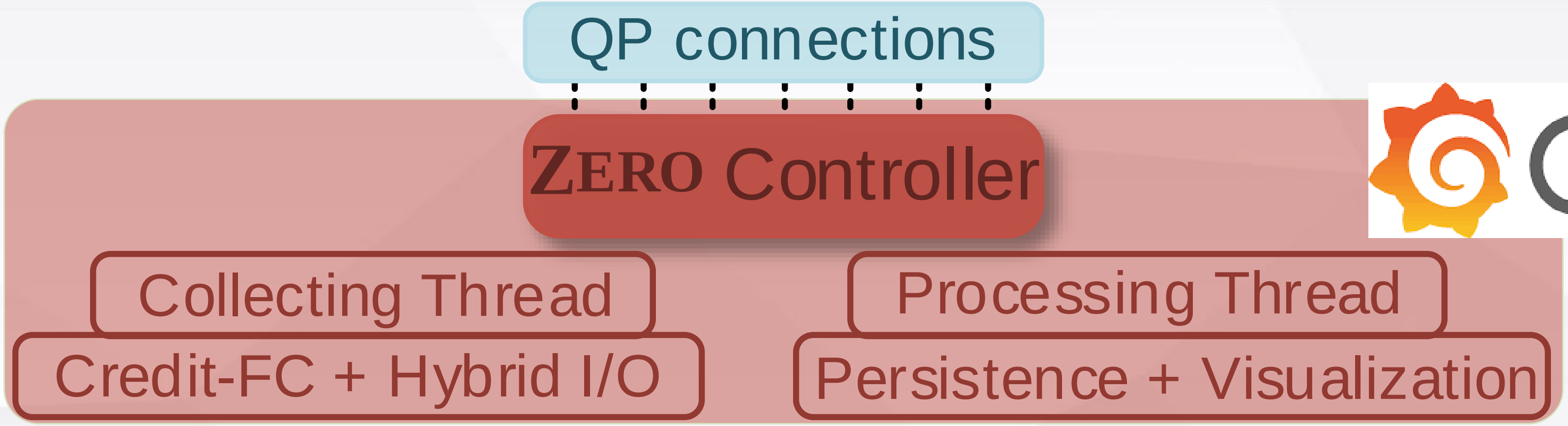
Memory management



Data Plane



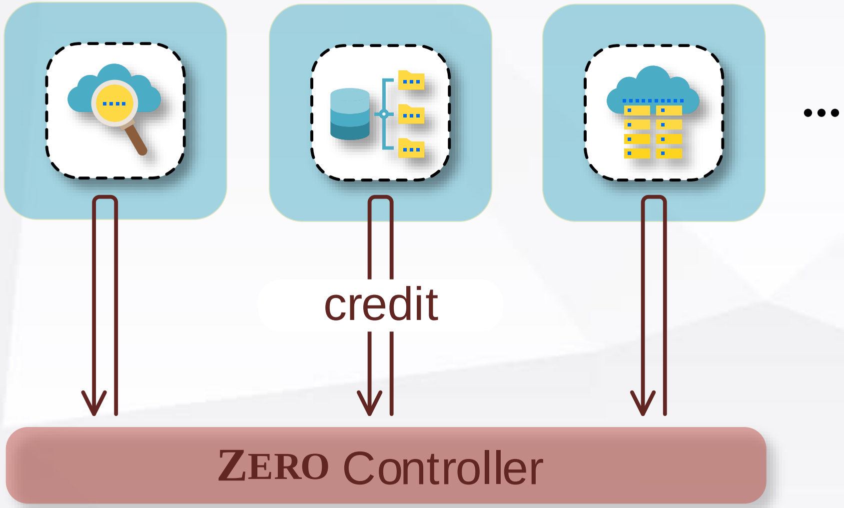
- ✓ Zero copy
- ✓ Zero CPU involvement
- ✓ Reduce MR entries and READs



Receiver-driven CC

Thread dispatch

Scale-out monitoring



- ✓ **Efficient threading and I/O model**
- ✓ **Avoid incast with many connections**
- ✓ **Guaranteed QoS level via receiver-driven model**

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Implementation & Evaluation

Implementation

- ✓ Zero framework
- ✓ Case studies

Linux redis eBPF

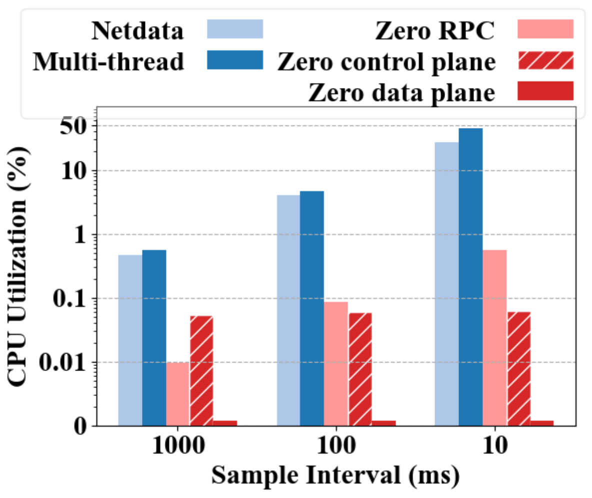
```
// type one, specifying attributes of variables
struct disk my_disk{
    .disk            = "sda",
    .hash    = 0x000f3456, ...
} __attribute__((section(".zero_init"));
//type two, using allocator
struct disk *my_disk = zero_malloc(sizeof(struct disk));
```

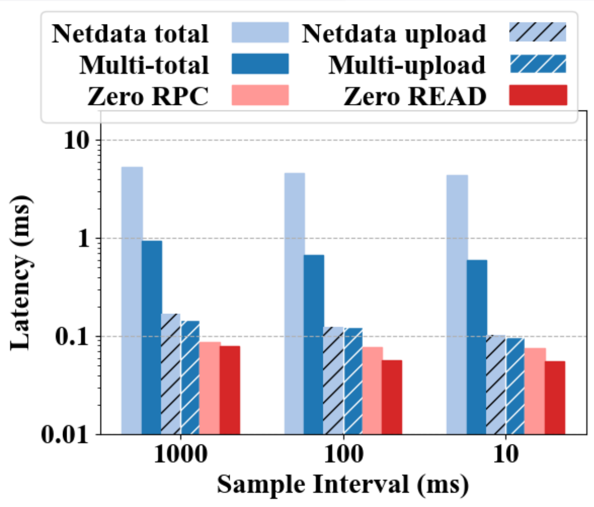
Evaluation Setup

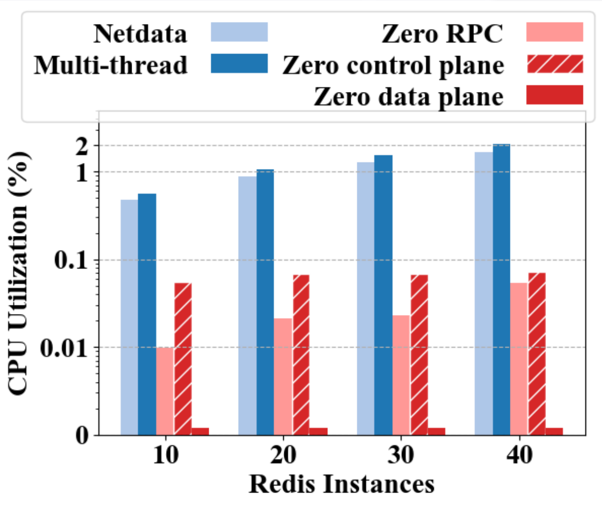
- ✓ Test Clusters

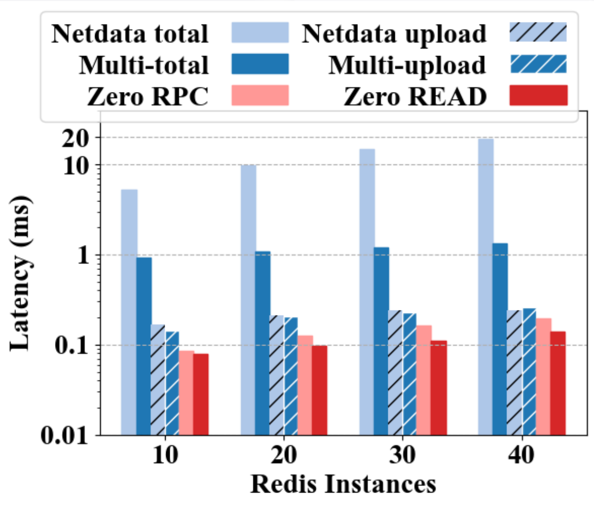
Name	Hosts	OS kernel	Intel Xeon CPU code	Mellanox NIC	Protocol	ECN	PFC
Cluster1	VMs	Linux 5.5	E5-2682 (64 cores)	2 × 25GbE ConnectX-4 Lx	RoCEv1/2	✗	✓
Cluster2	Containers	Linux 3.10	Platinum 8369B (64 cores)	200GbE ConnectX-6 Dx	RoCEv1/2	✓	✓

- ✓ Benchmarks： *CPU utilization (both sides), latency, throughput*
- ✓ Parameters： *Sampling interval (QoS), Instances (Metrics), Hosts (Connections)*
- ✓ Baselines： *Legacy tools, Netdata, Zero RPC (SEND/RECV)*





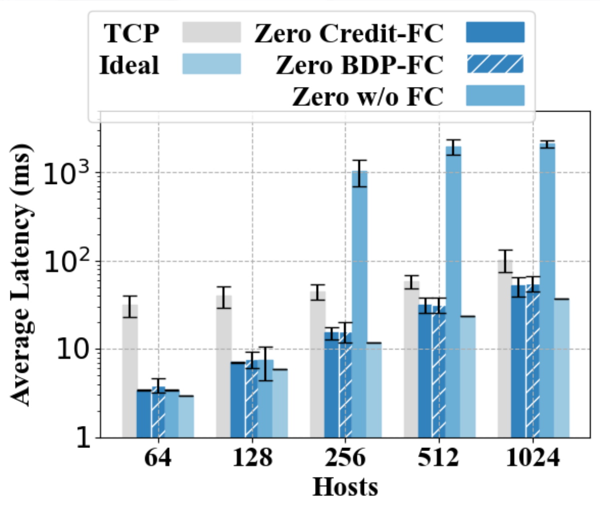


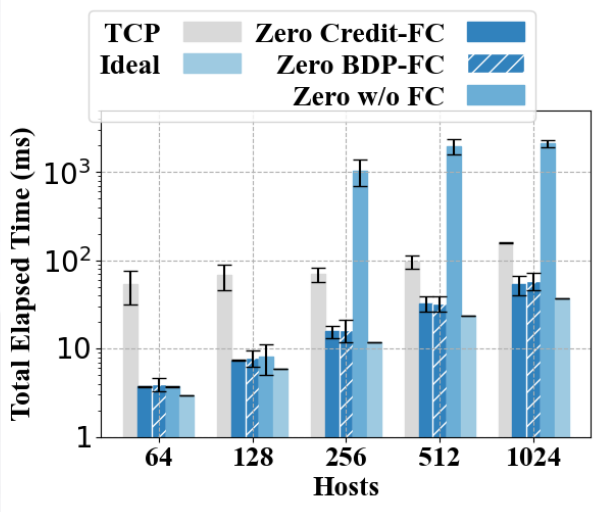


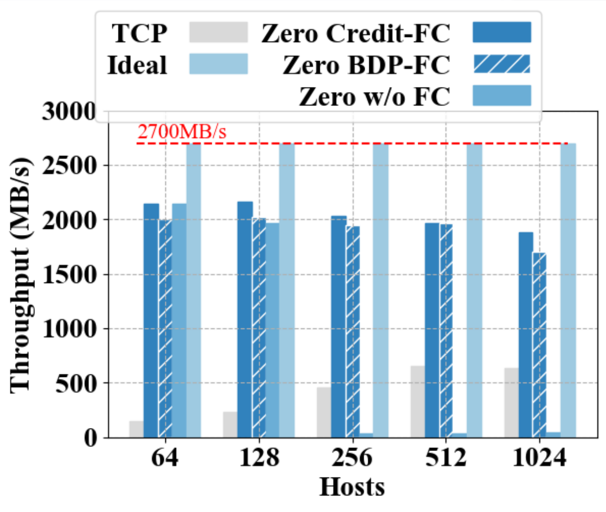
Zero Overhead

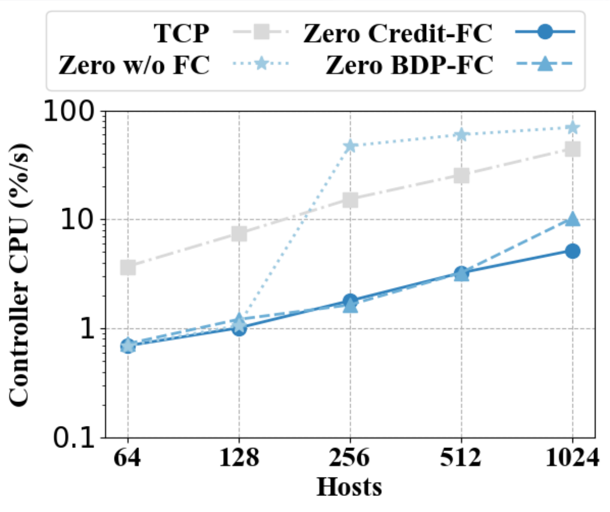
Metric	Monitor	Redis	Kernel	eBPF
Total Latency (ms)	Baseline	0.7 ~ 19.3	0.5 ~ 1.6	0.8 ~ 12.5
	ZERO RPC	0.08 ~ 0.18	0.14 ~ 0.36	0.10 ~ 1.02
	ZERO	0.05 ~ 0.14	0.07 ~ 0.23	0.08 ~ 0.87
Agent CPU Utilization (%)	Baseline	0.5 ~ 45	0.01 ~ 4	0.08 ~ 6
	ZERO RPC	0.01 ~ 0.55	0.08 ~ 0.9	0.05 ~ 0.68
	Control plane	0.05 ~ 0.07	0.8 ~ 1.5	0.04 ~ 0.05
	Data plane	0	0	0

- ✓ Disposable overhead at control plane
- ✓ Zero overhead at data plane
- ✓ Reduce latency by 1~2 order of magnitudes

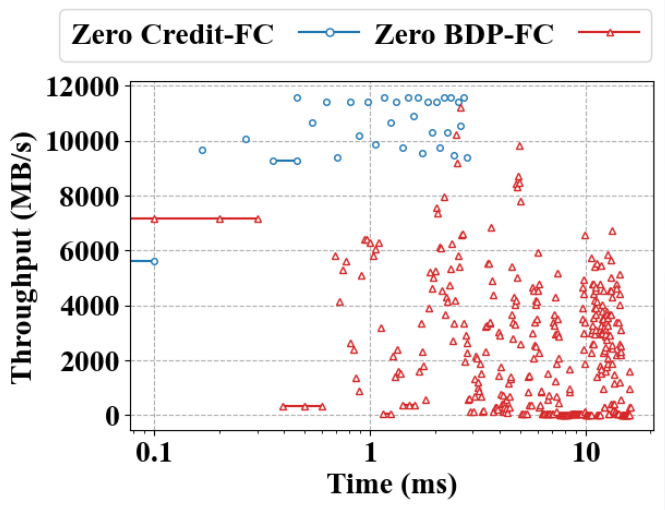








Zero Scalability



- ✓ High throughput & low CPU utilization
- ✓ Avoid incast & PFC/ECN triggering
- ✓ Stable QoS

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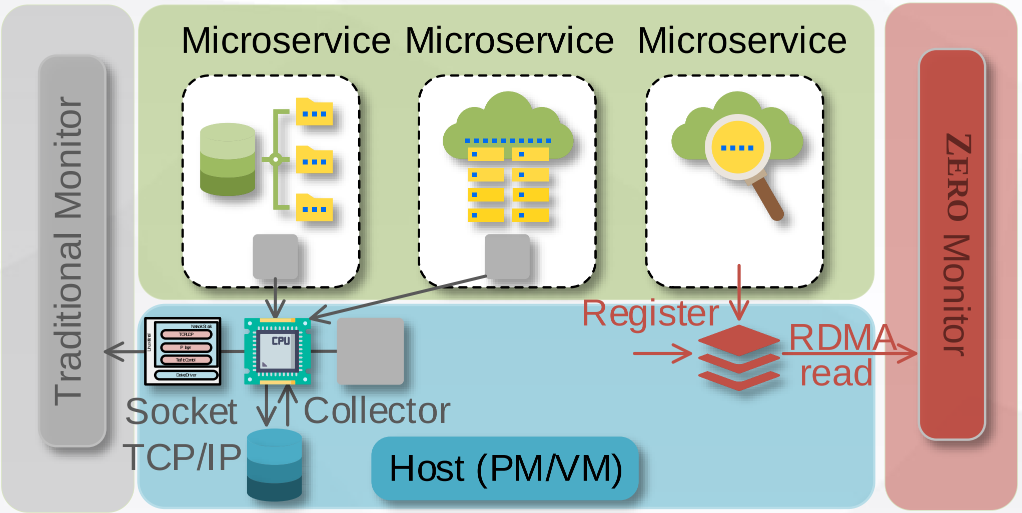
Conclusion

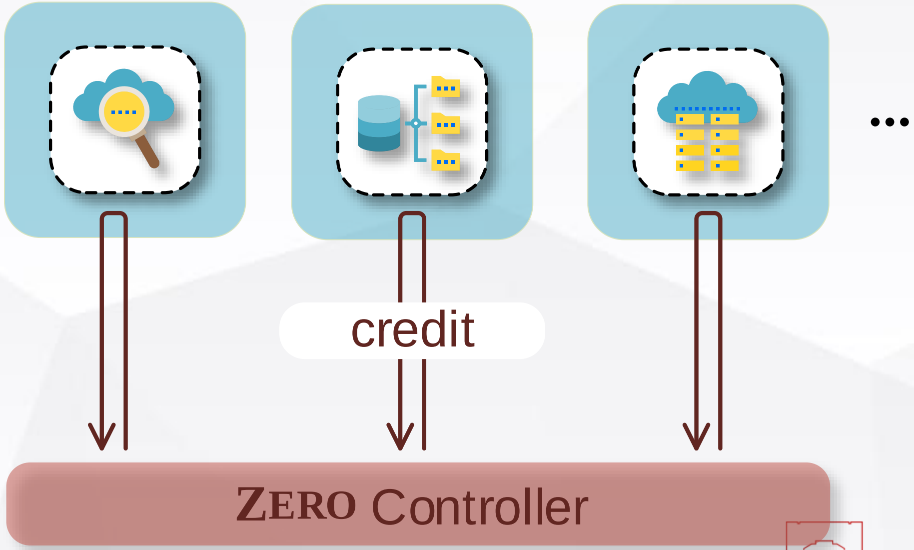
Zero-overhead monitoring

- ✓ One-sided RDMA (RDMA read)
- ✓ Novel control & data plane design



Large-scale distributed monitoring

- ✓ Receiver-driven CC
- ✓ Highly-efficient thread and I/O model



Thanks! Q&A

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Experience & Future works

Achieving high scalability and availability

- ✓ QP sharing & group switching, standby controller

Avoiding network interference

- × Physical isolation (high cost)，low priority (timeout)
- ✓ Control build-up queue (receiver-driven)

Receiver-driven CC

- × Equal bandwidth sharing, rely on ECN or INT
- ✓ Credit only (<BDP), pacing is required, general case?