Dissecting Overheads of Service Mesh Sidecars

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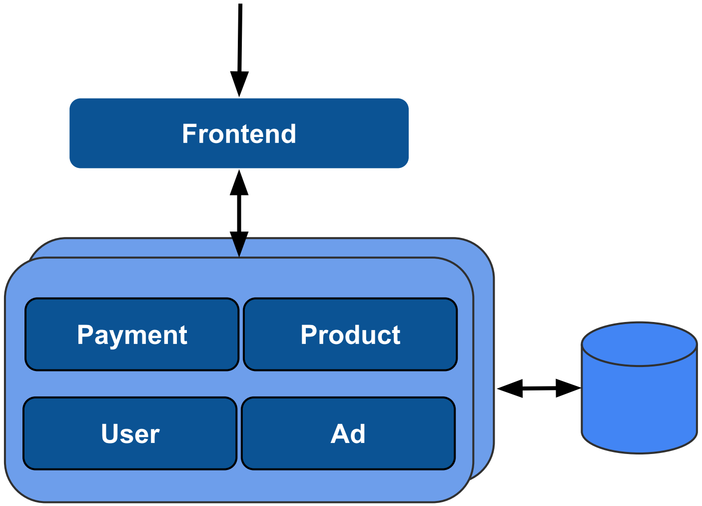
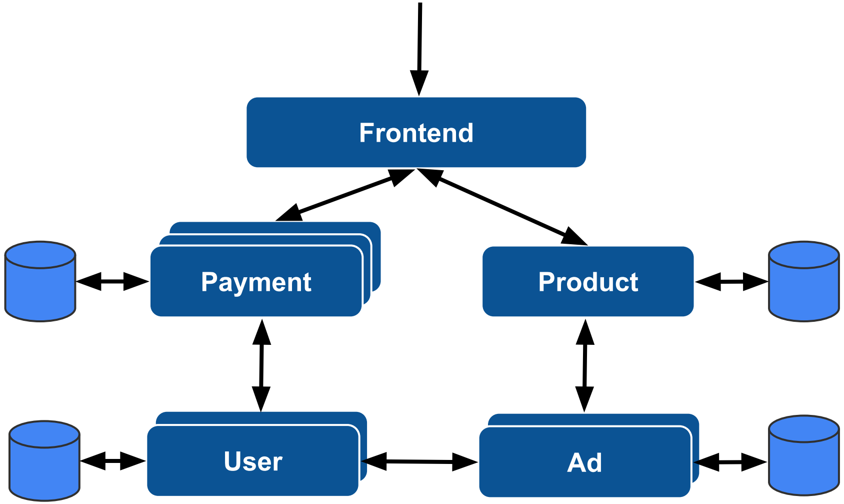
From Monolith to Microservices

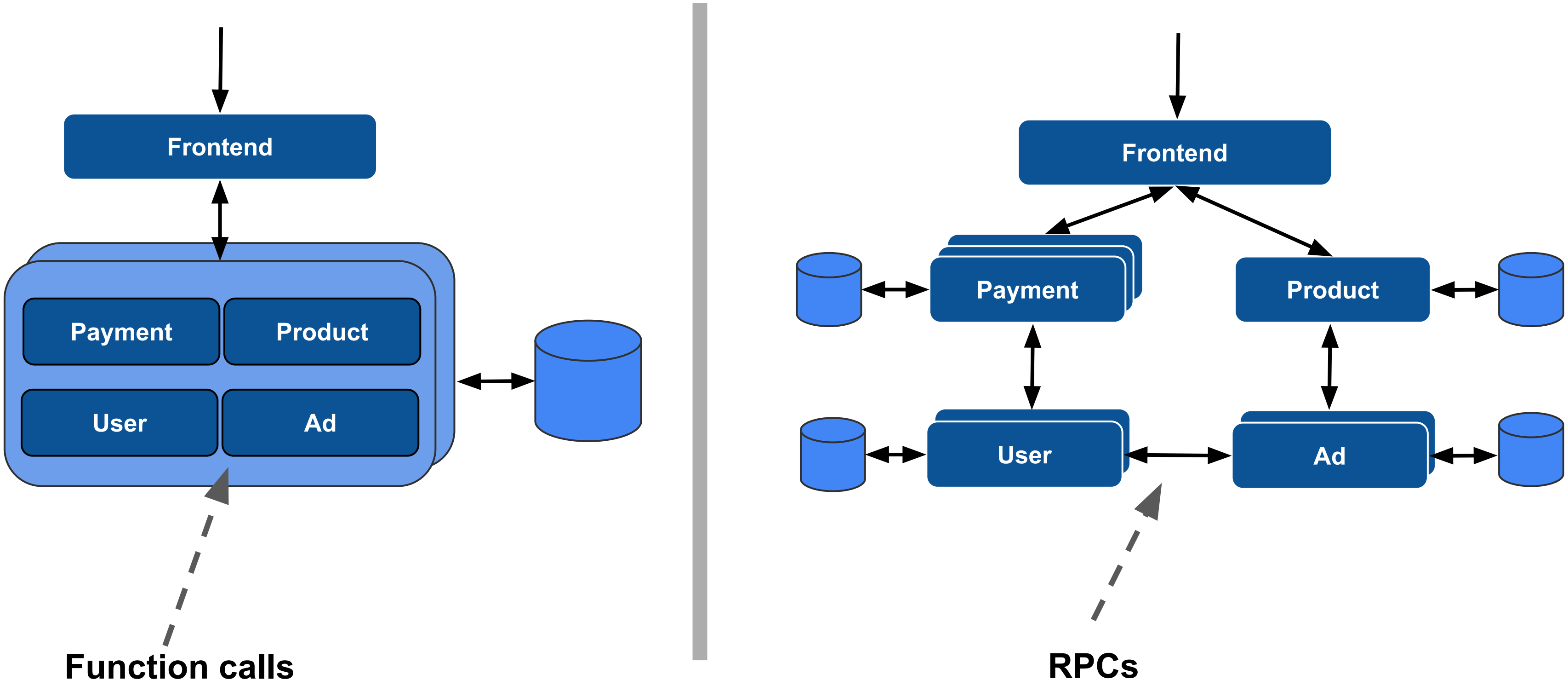


Monolithic Application



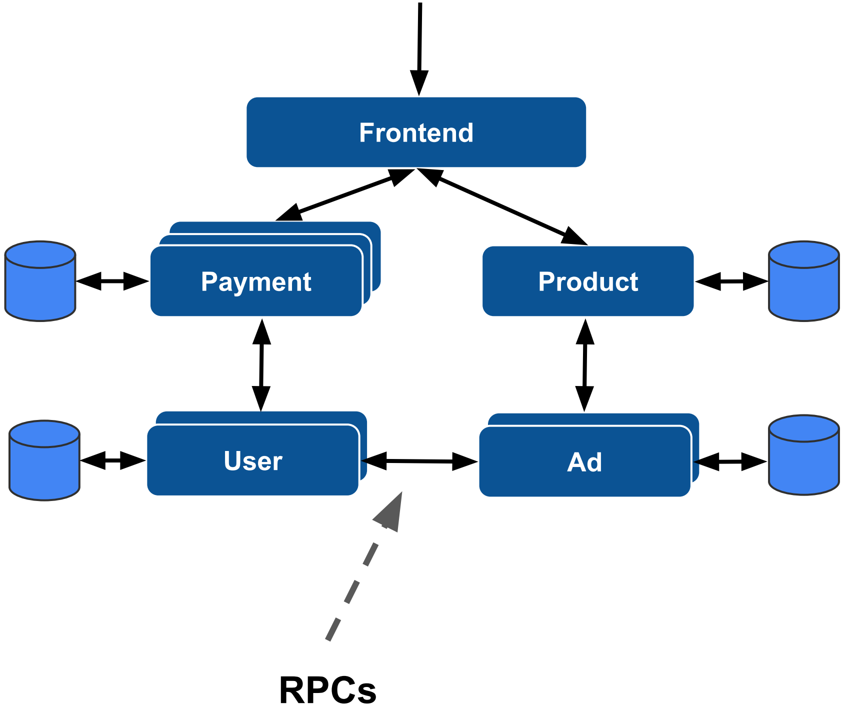
Microservices

From Monolith to Microservices



Microservices need rich message processing

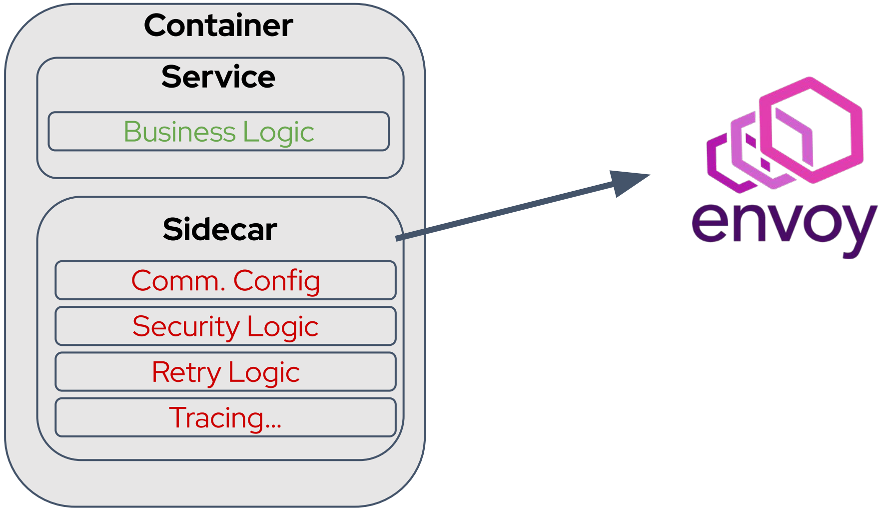
- Service discovery
- Access control
- Load balancing
- Observability
- Encryption
- Fault tolerance



Solution: Service Mesh with Sidecar Pattern

90% of the organizations either using or evaluating service mesh

- From a 2022 CNCF Survey[1]



[1]Service meshes are on the rise - CNCF '22

Performance Overhead vs. Functionality

"We are frequently asked how fast is Envoy? ... The answer is: it depends. Performance depends a great deal on which Envoy features are being used and the environment in which Envoy is run...."

- From Envoy FAQ

- Balancing performance and functionality
  - What is the latency and CPU usage impact with a given configuration
- Evaluating the impact of optimizations
  - What are the primary sources of overhead of a given configuration?
  - What if I use an alternative the IPC mechanism between application and sidecars?

Ad-hoc Configuration Tuning is inefficient

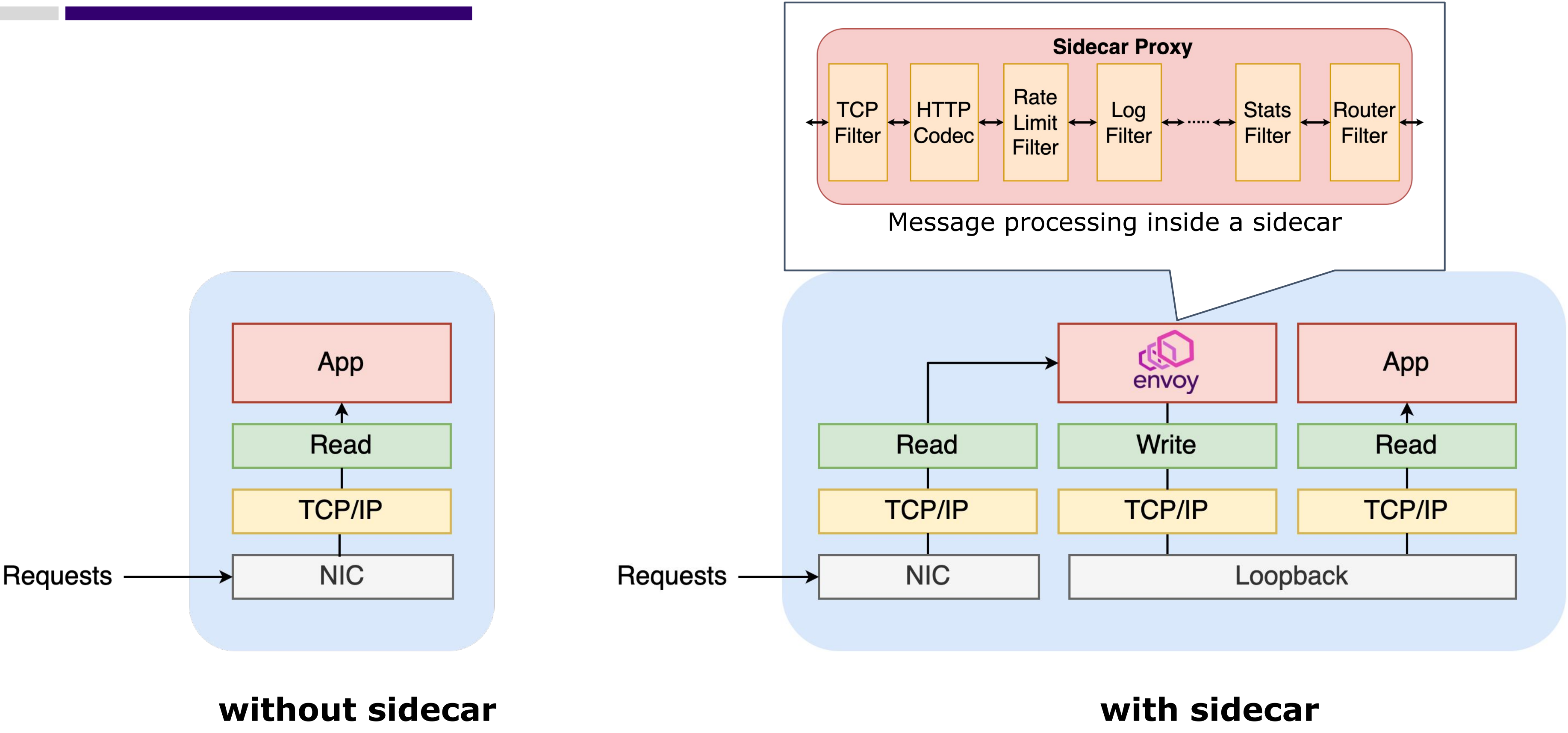
- Black-box measurement of different configurations and workloads
- Key limitation:
  - Combinatorial configuration space
    - Protocol
    - Envoy features
    - Workload (Request size and rate)
    - …

MeshInsight: Dissecting Sidecar Overheads

Goal: systematically quantify the service mesh sidecar overheads for developers to

- Navigate the performance and functionality tradeoff
- Estimate the impact of their optimizations

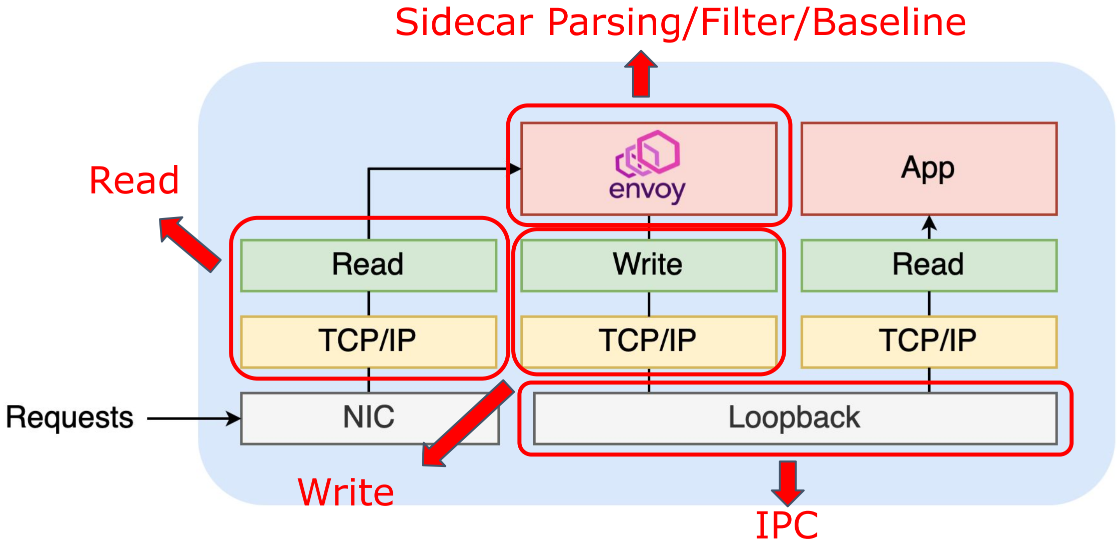
Service Mesh Data Path



Modeling per-Sidecar Overheads

- Breakdown the overhead into fine-grained components
  - Independent from each other
  - Total overhead = Sum (overhead of each component)

- Metrics
  - Latency (service time)
  - CPU usage



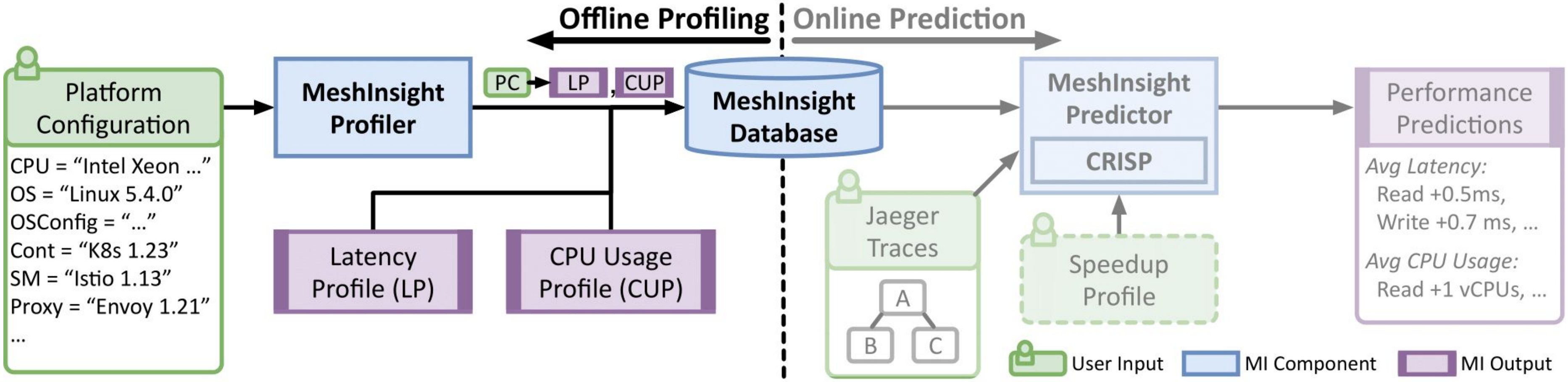
Building Component Profiles

- Component profile is a linear function of message size and rate
  - Latency: $L_x + message\_size \times l_x$
  - CPU: $message\_rate \times (C_x + message\_size \times c_x)$

Predicting the End-to-end the Overhead

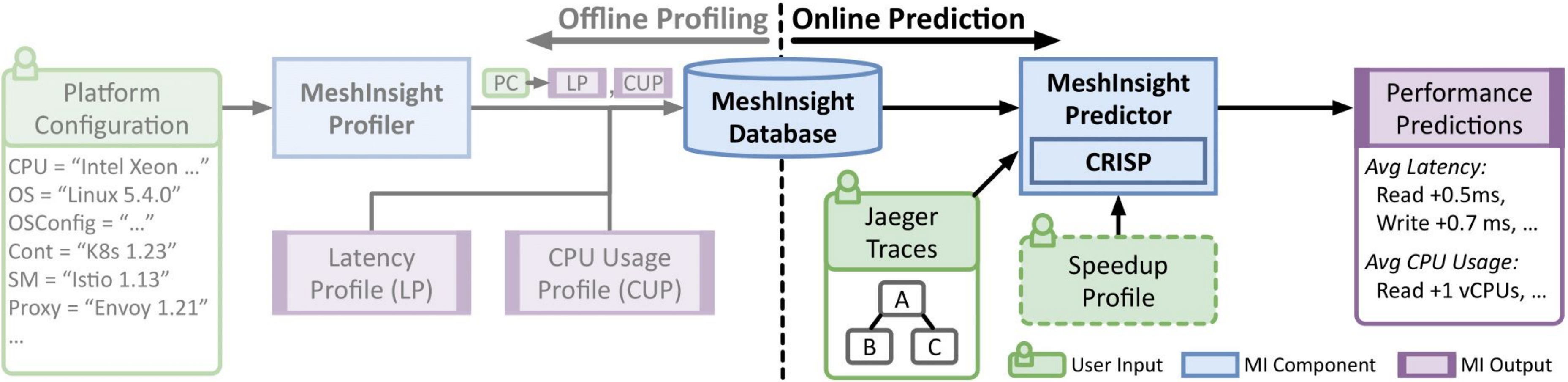
- Extended Call Graph (ECG)
  - Captures service communication patterns, platform specs, sidecar configurations, and workload information
- E2E overhead = sum of all sidecar-level overheads in ECG
  - Latency overhead requires critical path analysis

MeshInsight Architecture



https://github.com/UWNetworksLab/meshinsight

MeshInsight Architecture



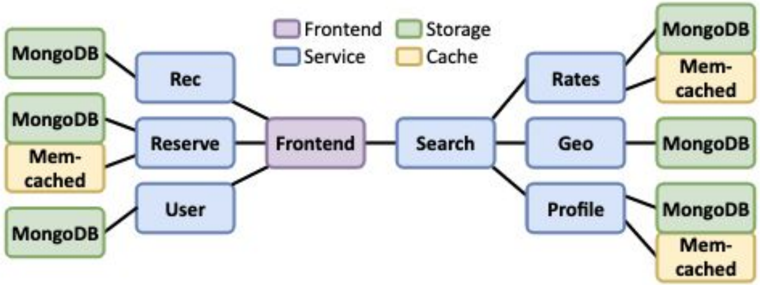
https://github.com/UWNetworksLab/meshinsight

Implementation

- Implementation:
  - Istio v1.13 and Envoy v1.21
  - Each component is profiled using an echo server
    - *eBPF* for latency
    - *perf* for CPU usage

Evaluation

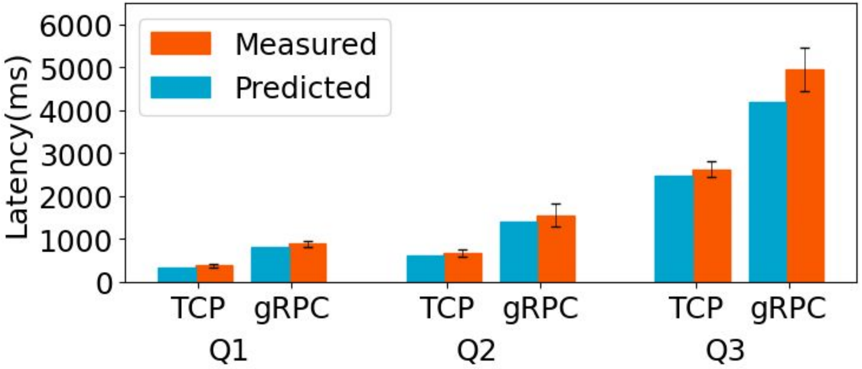
- Synthetic benchmark
  - Hotel Reservation
- Real-world microservice traces
  - Alibaba microservice trace (~20K services, >20M call graphs)

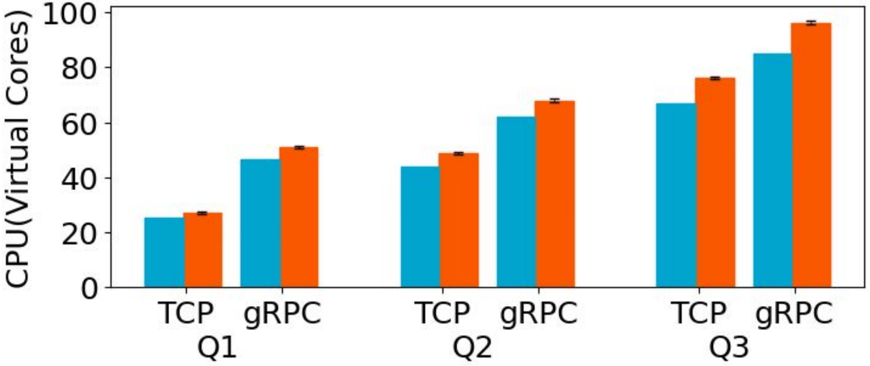


Hotel Reservation Architecture

How Well Can MeshInsight Predict Overhead?

- MeshInsight provides accurate prediction of latency and CPU usage overhead

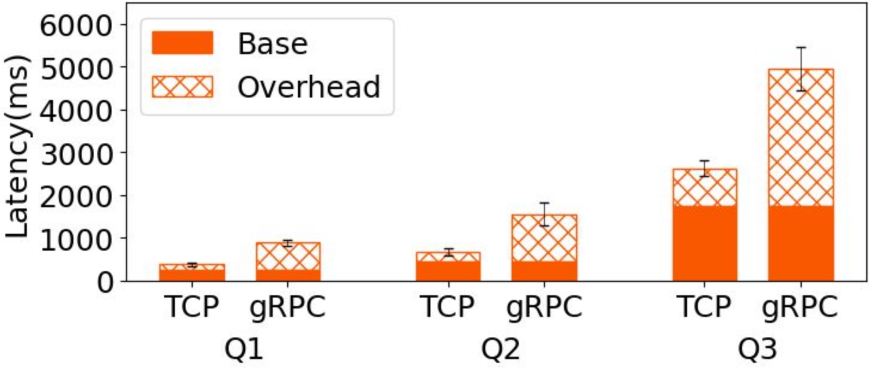


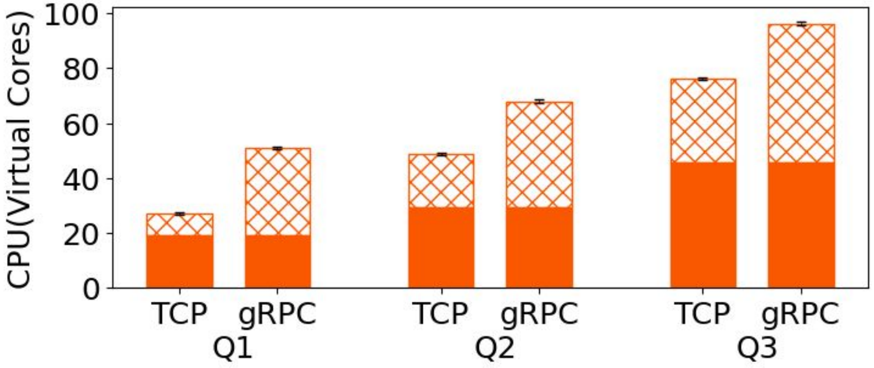


Latency and CPU usage of Hotel Reservation Benchmark

How Much Overhead Do Sidecars add?

- gRPC mode can increase the latency by up to 2.7X and CPU usage by up to 1.6X
- TCP mode overhead are lower but still noticeable

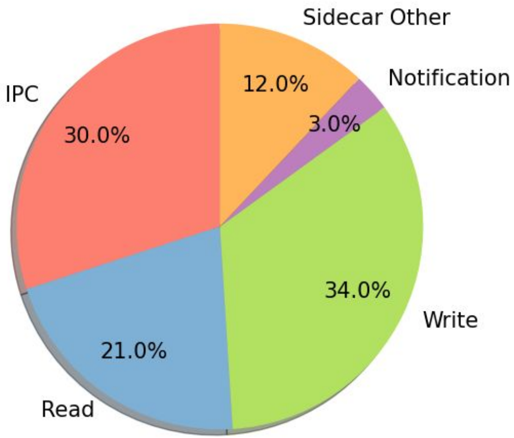




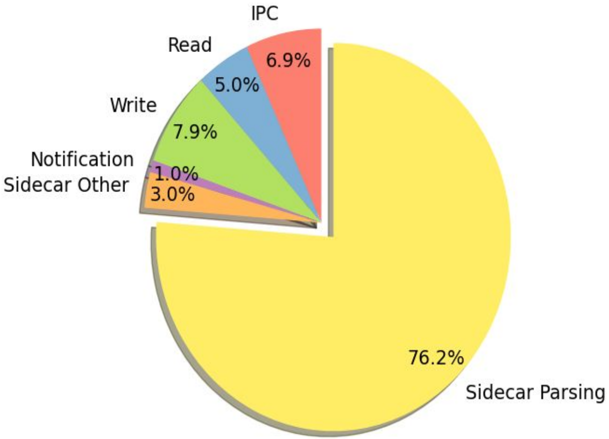
Latency and CPU usage of Hotel Reservation Benchmark

What Are the Primary Contributors of Latency Overhead?

- IPC, Read, and Write are the major sources of overhead in TCP mode
- Parsing dominates in HTTP mode



TCP Mode (+41μs)

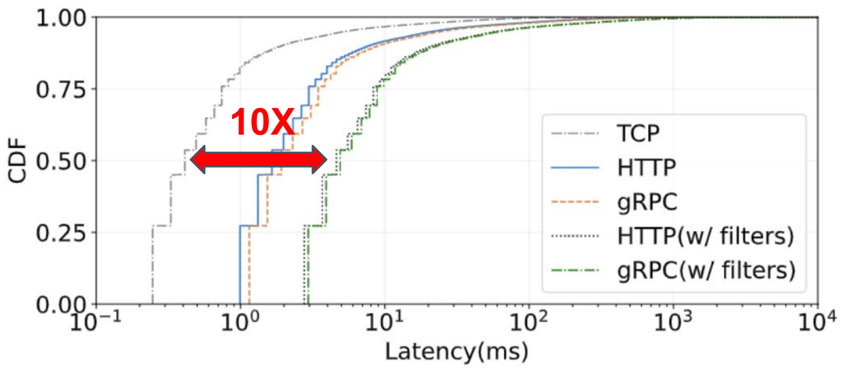


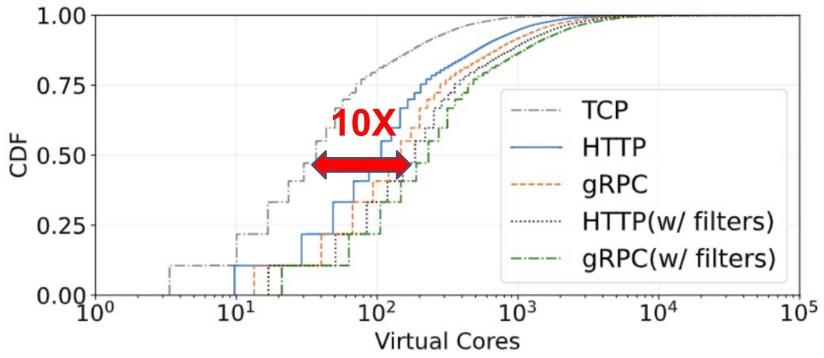
HTTP Mode (+165μs)

Message size is set to 100B

How Do Overheads Vary Across Configurations/workloads?

- Performance overhead varies by orders of magnitude for
  - Different configurations





CDF of Latency and CPU usage overhead for Alibaba Microservice Trace

Characterizing Microservice Dependency and Performance: Alibaba Trace Analysis - SoCC' 21

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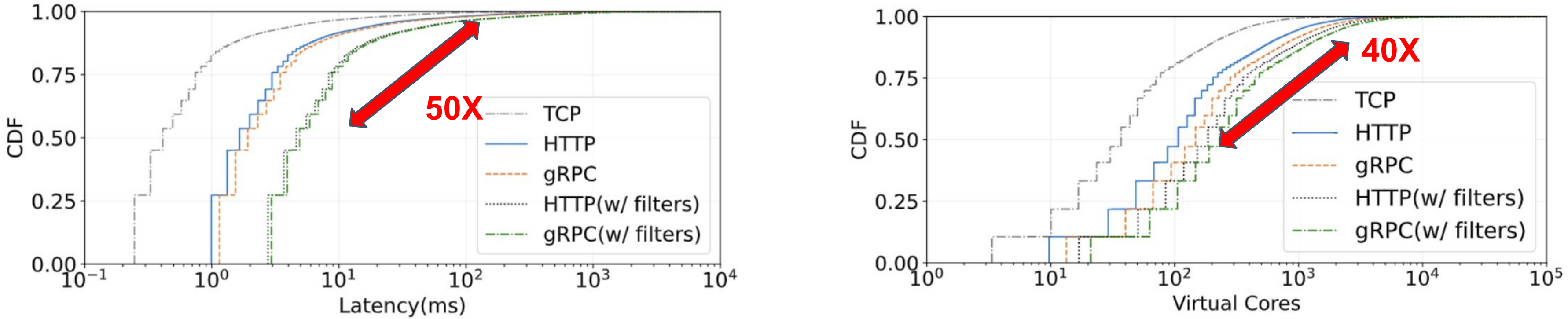
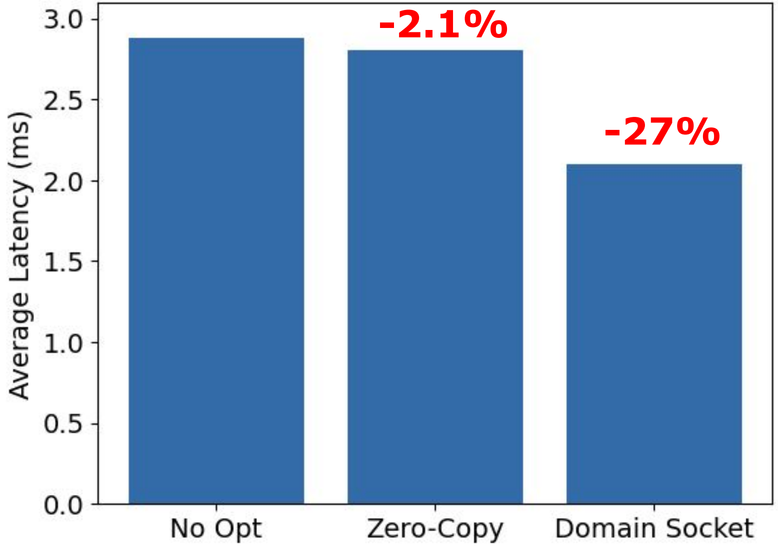


Absolute Latency and CPU usage overhead for Alibaba Microservice Trace

Characterizing Microservice Dependency and Performance: Alibaba Trace Analysis - SoCC' 21

What Are the Impacts of Common Linux Features?

- Different optimizations have different impacts
  - Zero-copy write offers negligible improvement
  - Unix Domain socket can provide notable benefits



Conclusion

- Present MeshInsight, a tool to systematically quantify overhead of service mesh sidecars
  - Breaks down the data path into independent components
  - Predict the overhead based on extended call graphs
- Total Overhead and components' contribution varies substantially in different settings
- Some optimizations can help reduce overhead others do not
- MeshInsight is available at: **github.com/UWNetworksLab/meshinsight**