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CRISP: Critical Path Analysis of Large-Scale Microservice Architectures

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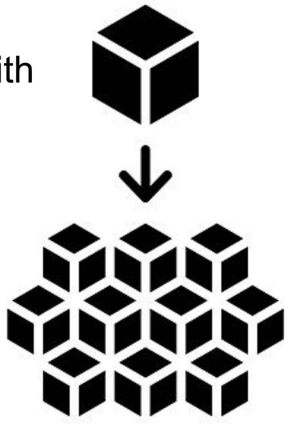
Uber

What is microservice architecture?

- Distributed system
- Independent business logic -> independent programs
- Communicate over well-defined APIs
- Loosely coupled
- Owned by small, self-contained team

Monolith



Microservice

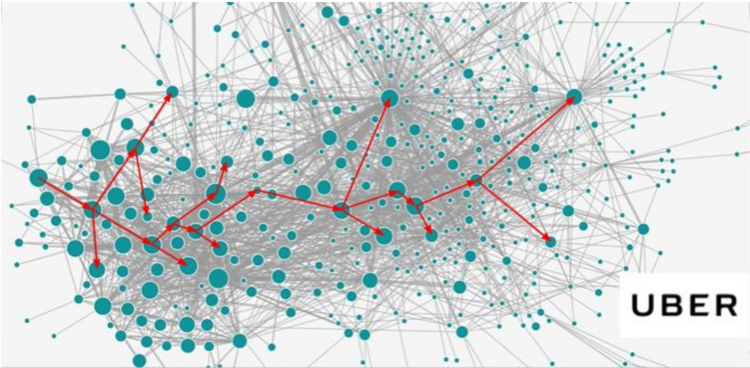
https://tinyurl.com/4zxbynt8

Why microservices?

- Scalable development
- Independent development
- Easier deployment
- 71% organizations adopted microservices in 2021

Microservice Challenges: Complexity

- Evolution of microservices often leads to complex interactions
- Extremely complicated to analyze
- Deeply nested
- Asynchronous
- Tens of thousands of endpoints interact with each other



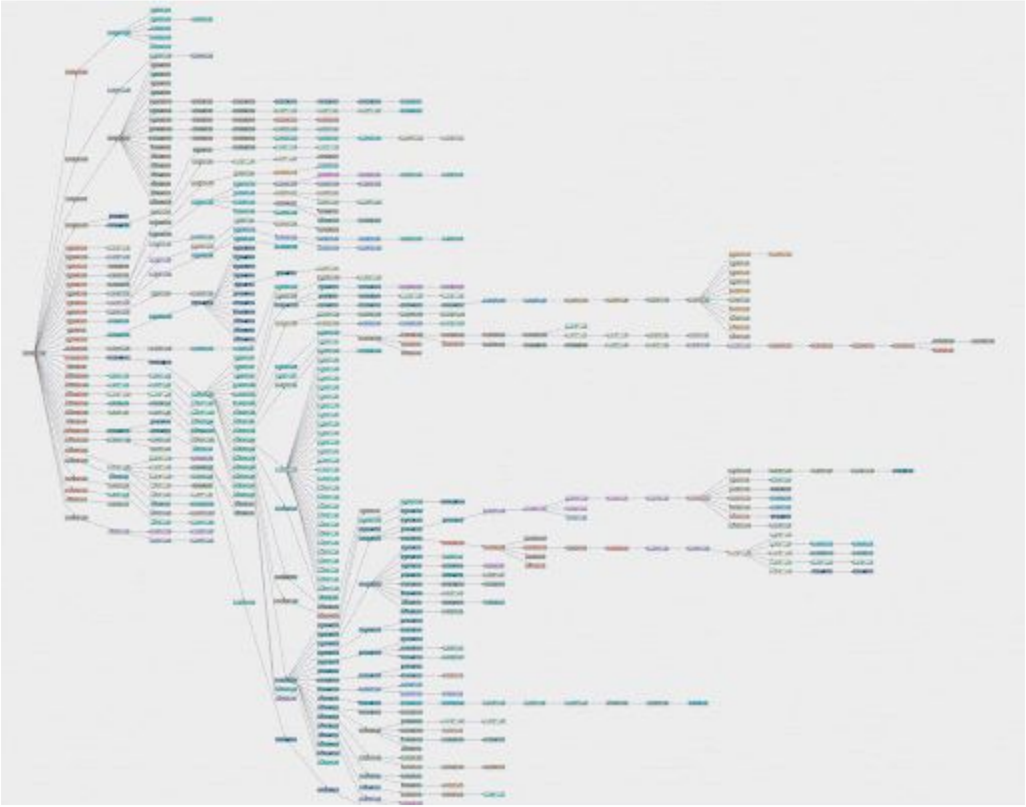
Distributed tracing

- Jaeger: System for capturing RPC caller-callee relationships among services
- Widely deployed at Uber
- Supports multiple languages: Go, Java, Python…
- Collect trace on sampling basis
- Retains in different storage systems
  - Cassandra, Elasticsearch, memory

https://www.jaegertracing.io/

How to **pinpoint** and **quantify** the root cause of end-to-end latency of a request?

Gives example visualize



Our solution

Critical Path Analysis (CPA) on distributed traces

It supports:

- Top-down: service owner debuggings and optimizations
- Bottom-up: systemic analysis and optimizations
- Anomaly detection: for building automatic alerting system

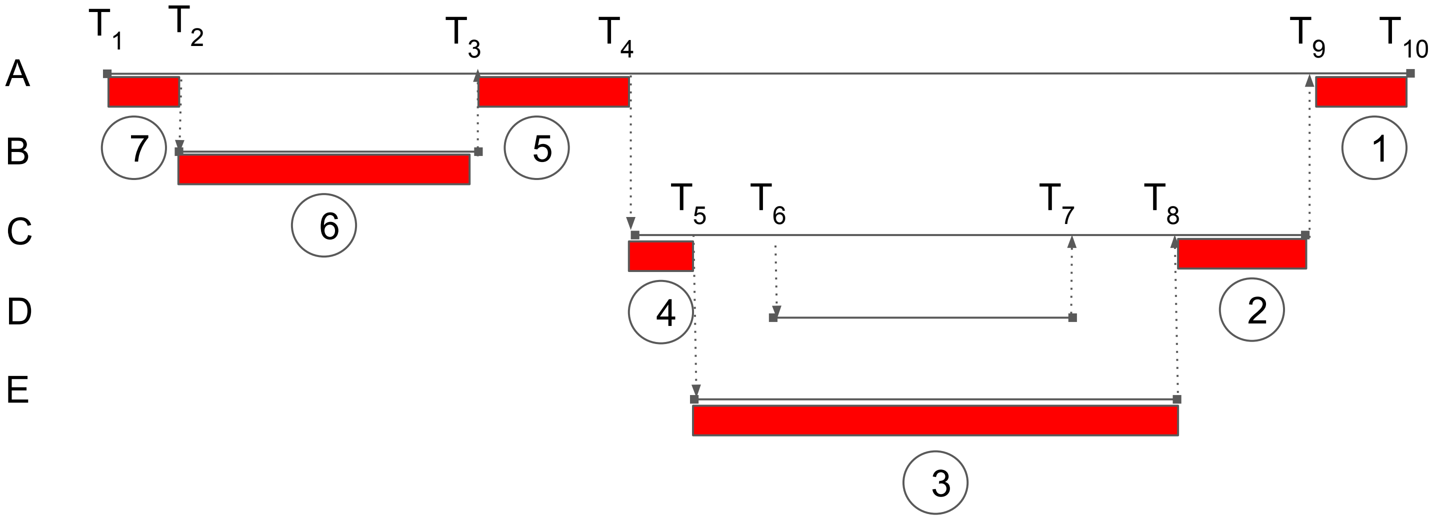
Outline

- Intro
- What is Critical Path Analysis
- Challenges applying CPA in real data center
- CRISP design
- Top-down analysis
- Bottom-up analysis
- Anomaly detection

Critical Path Analysis (CPA)

- Technique to identify longest stretch of dependent tasks
- End-to-end latency = length (CP)
- ↓length (CP) ⇒ ↓end-to-end latency
- Naturally simplifies the complex dependency graph from distributed tracing
- How to compute: iterate backwards and recursively

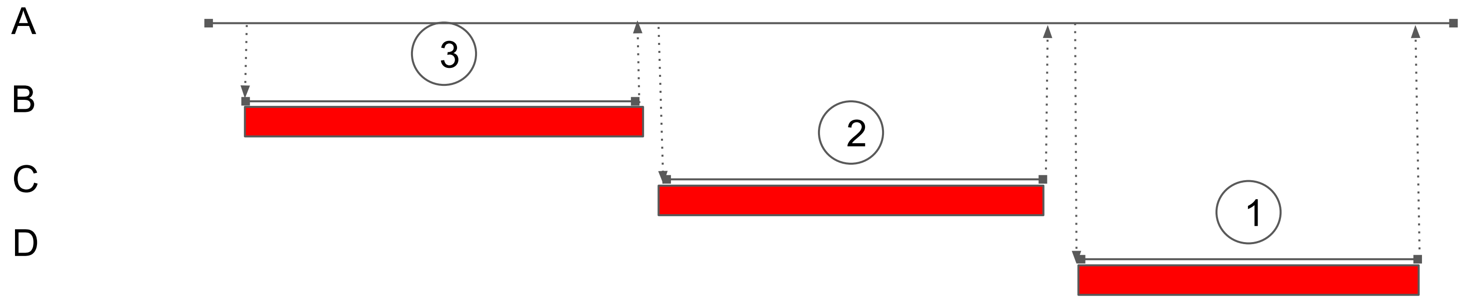
CPA example



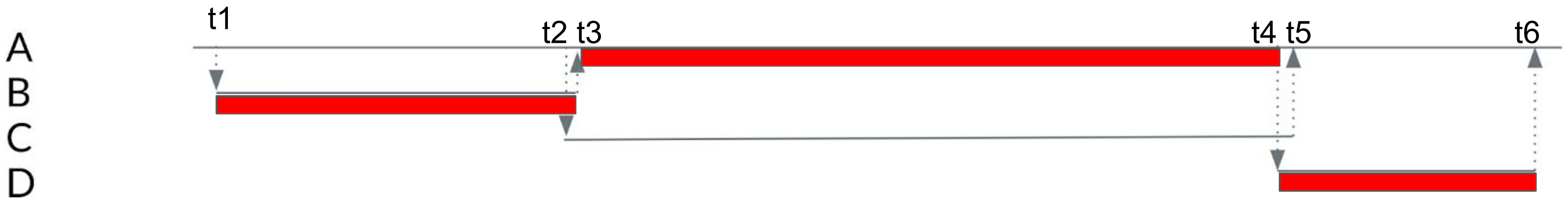
Challenges applying CPA on real-world traces

- “sync” (last arriver) are NOT designated events in Jaeger traces
  - “Sync” needs to be inferred via timestamp
- Machine clocks are not synchronized
- Missing spans

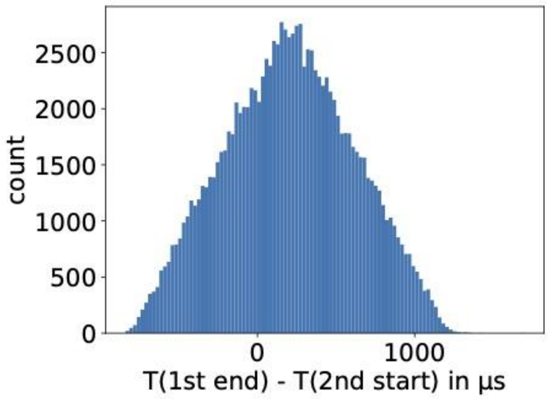
Critical Path on Perfect Traces



Critical Path on Real Traces

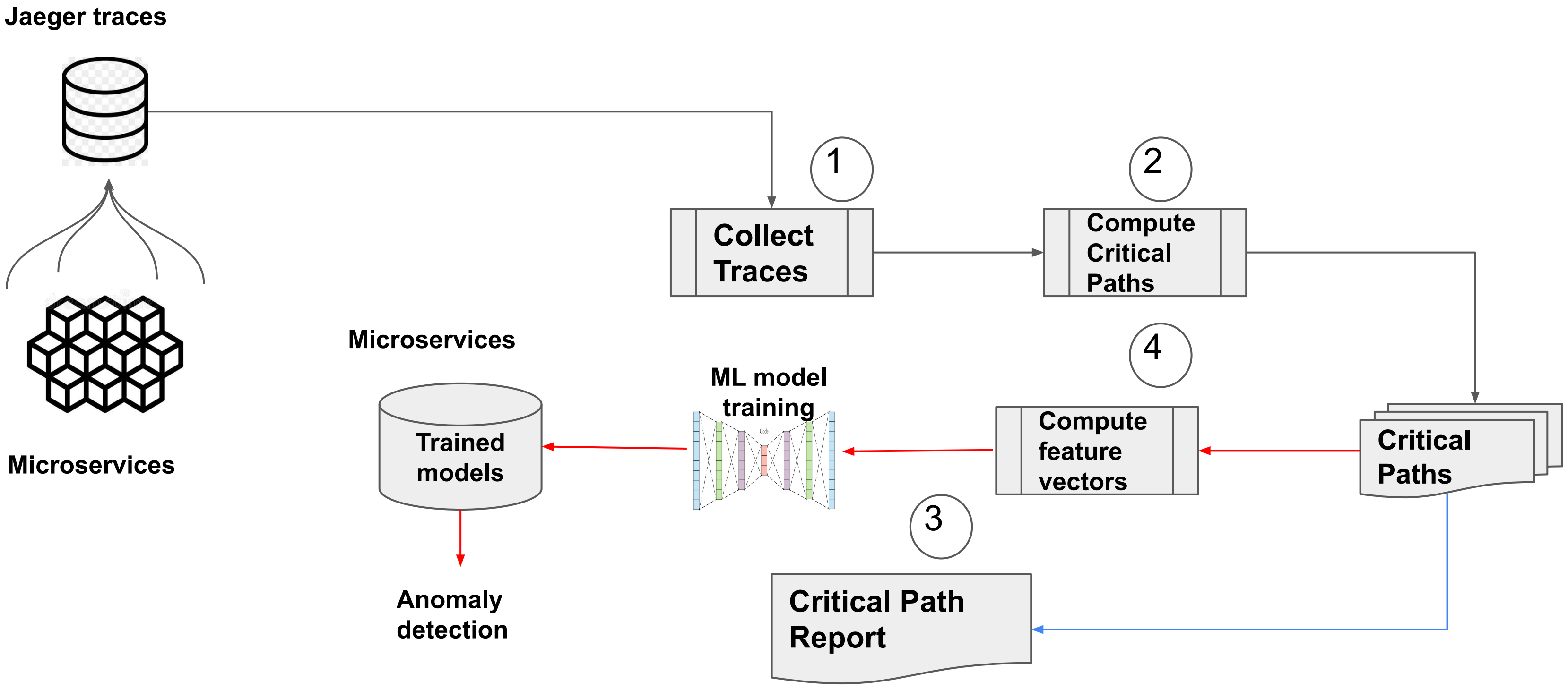


C is **<u>NOT</u>** on critical path!

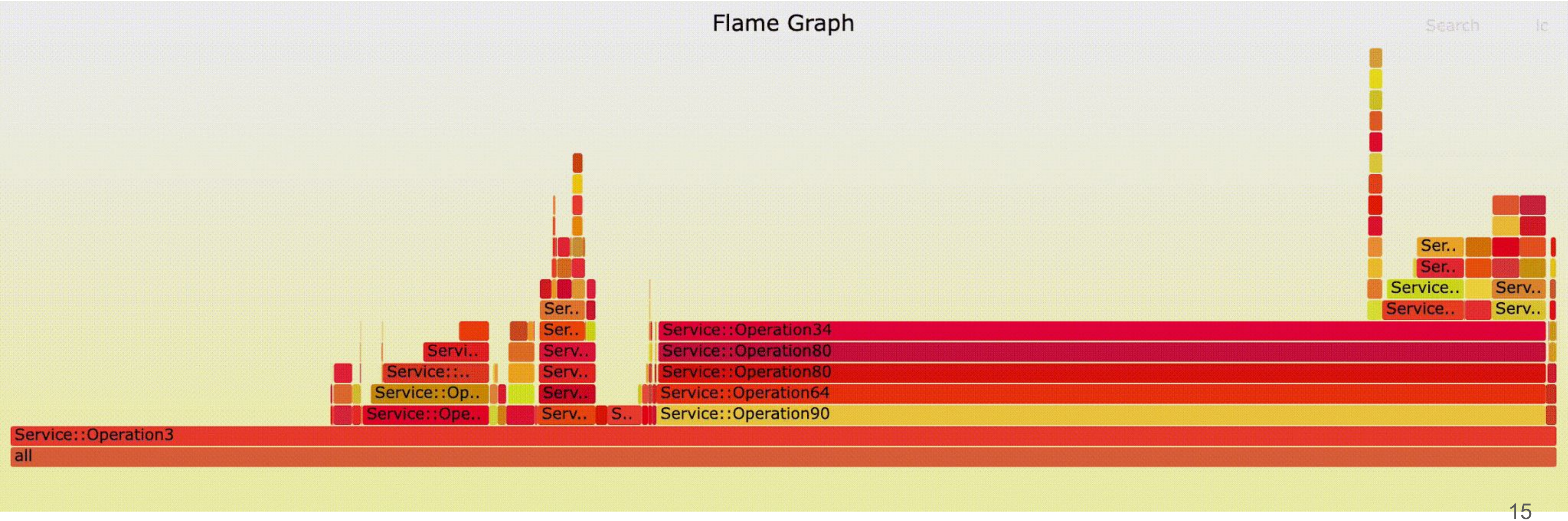


- Solution: allow some degree of overlap between child endpoints

Design of CRISP (Critical path and Span)



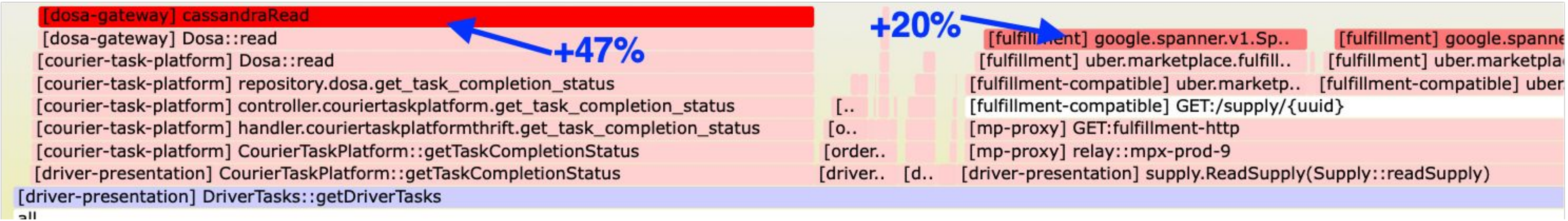
Top-Down Analysis



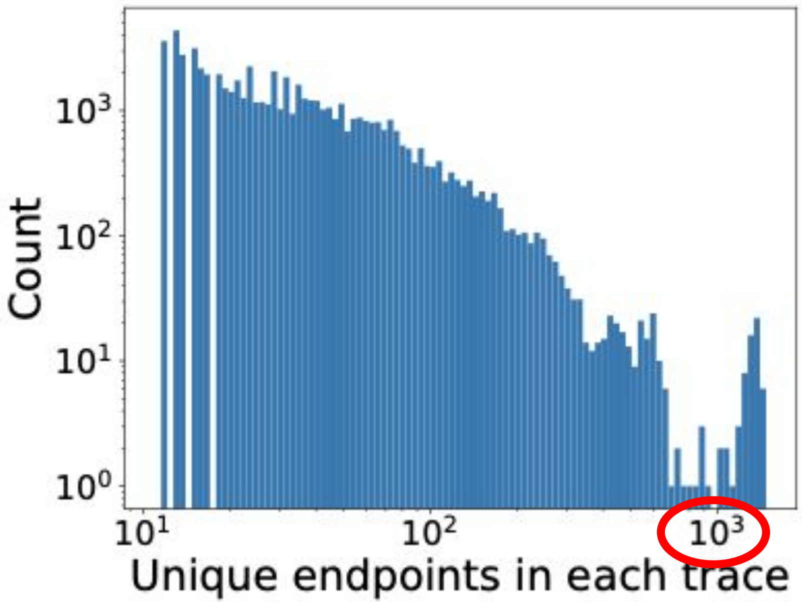
Differential Analysis

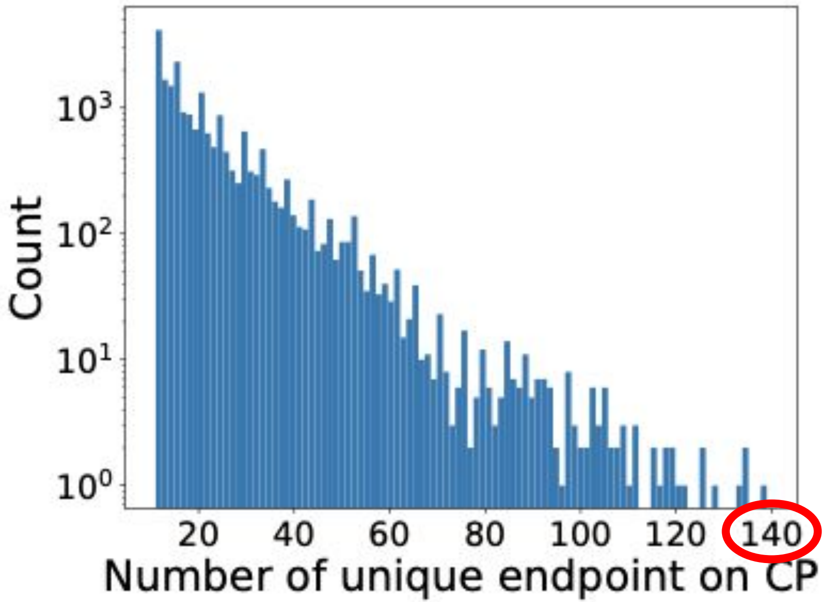
Root cause the tail latency by diffing P50 vs. P95

Recommend developer to cache the result instead of query database



Bottom-Up Analysis





Almost 10X difference!

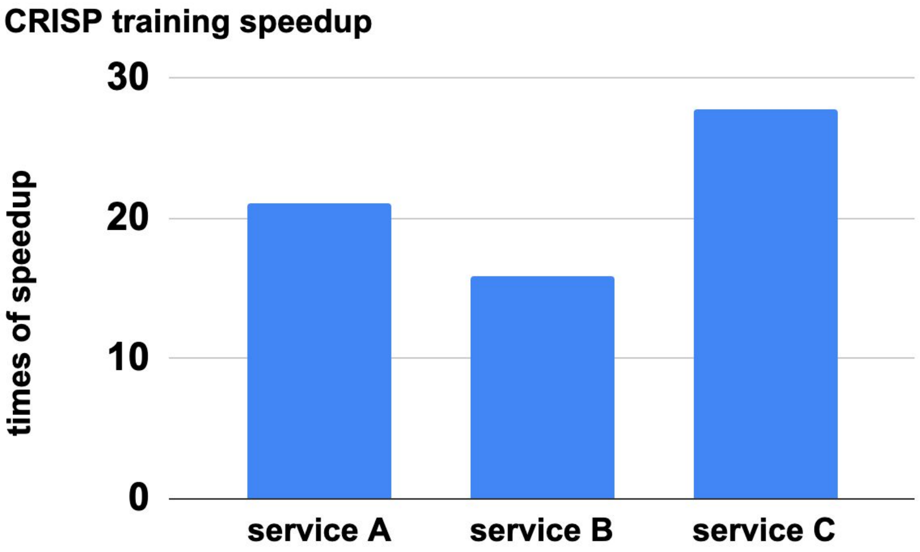
Anomaly detection

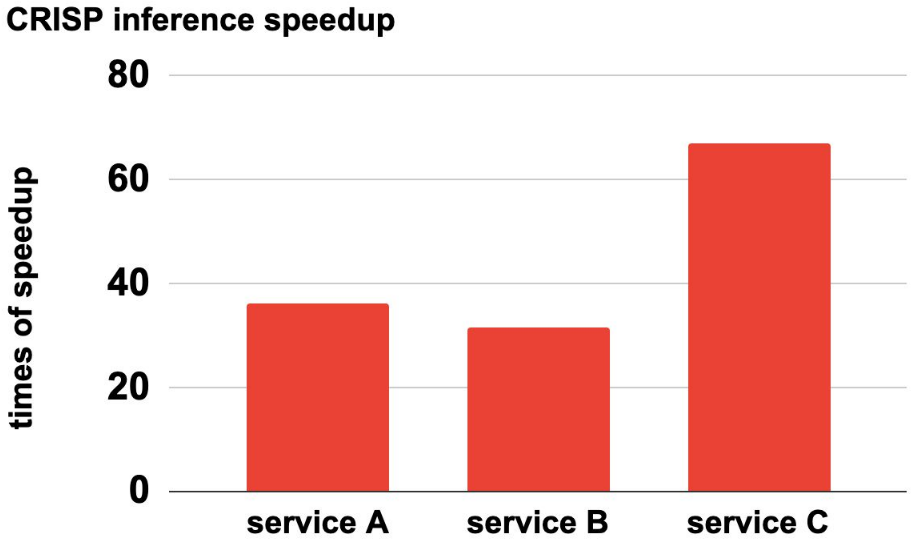
- Important to detect anomaly to debug
- Auto-encoder decoder (Liu et al. ISSRE 2020)
- Use critical path as the training data instead of full graph
- Run on numerous real important services from Uber
  - 200~1500 unique endpoints on each service
  - 1500~11000 spans in the trace

Recall Improvement

	recall	
	Liu et al. (SOTA)	CRISP
service 1	0.986	0.992
service 2	0.958	0.984
service 3	0.5	0.982
service 4	0.928	0.978
service 5	0.5	0.982
service 6	0.912	0.977

Training and Inferencing Speedup





Conclusion

- CRISP: critical path to analyze complex microservice traces
- Top-down for service-level insights
- Bottom-up for system-wide insights
- Anomaly detection to aid alerting systems

Available at: https://github.com/uber-research/CRISP

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Thanks!

Questions?