
KubeCon
CloudNativeCon
OPEN SOURCE SUMMIT
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Balancing Cost and Quality in OpenTelemetry

An Evaluation of Sampling Policies

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About Me

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Quwan

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Former End User

Current Maintainer

Agenda

01. Quwan’s Distributed Tracing Journey

02. Sampling in OpenTelemetry: Classic Approaches

03. Quantifying Sampling Costs and Quality

04. Tracing Edge Cases: Potential Solutions

05. Build the Future with OpenTelemetry

Drop Your Question

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01. Quwan’s Distributed Tracing Journey

分布式追踪在趣丸现状

About Quwan

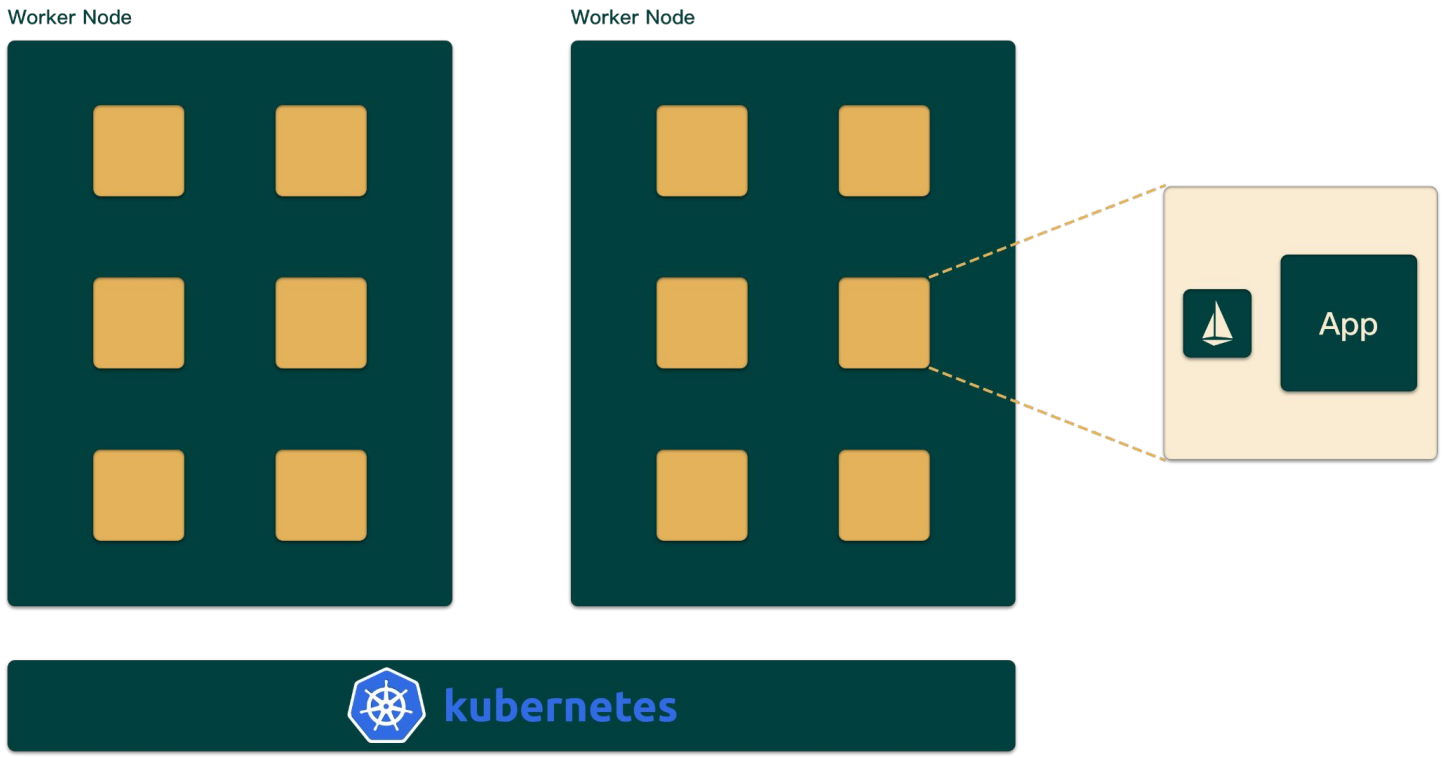
Quwan 趣丸

TT语音

TT电竞

唱鸭

Current Situation

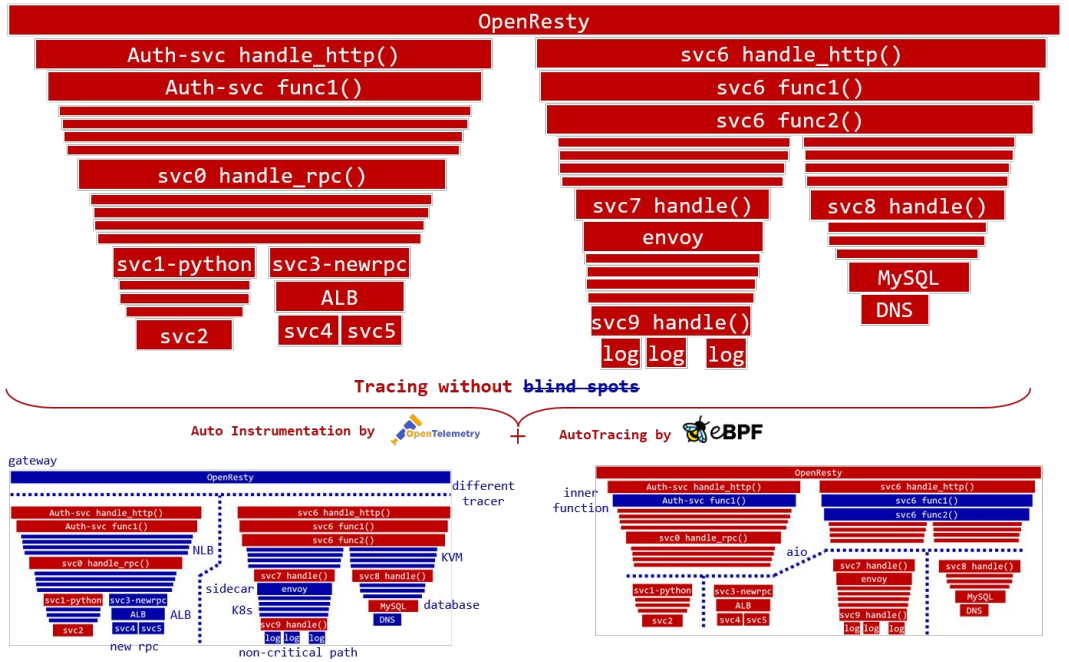


Keypoint

- Build on Kubernetes accompanied by Istio.
  构建在 Kubernetes 之上，搭配 Istio。
- 40+ Billion Spans per Day.
  每日有超过 400 亿 Span 被上报。

What's Next

- Covering Out-of-scope Areas.
  eBPF + DeepFlow 用于覆盖更多场景。



eBPF × DeepFlow®

Questions

- Are all trace data helpful for troubleshooting?
  有多少 Trace 数据对问题排查有帮助？
- How to reduce trace data?
  如何减少 Trace 数据呢？

02. Sampling in OpenTelemetry: Classic Approaches

OpenTelemetry 中的采样方案

How is a Trace Generated

Trace [treɪs]

A Trace represents a call-chain.

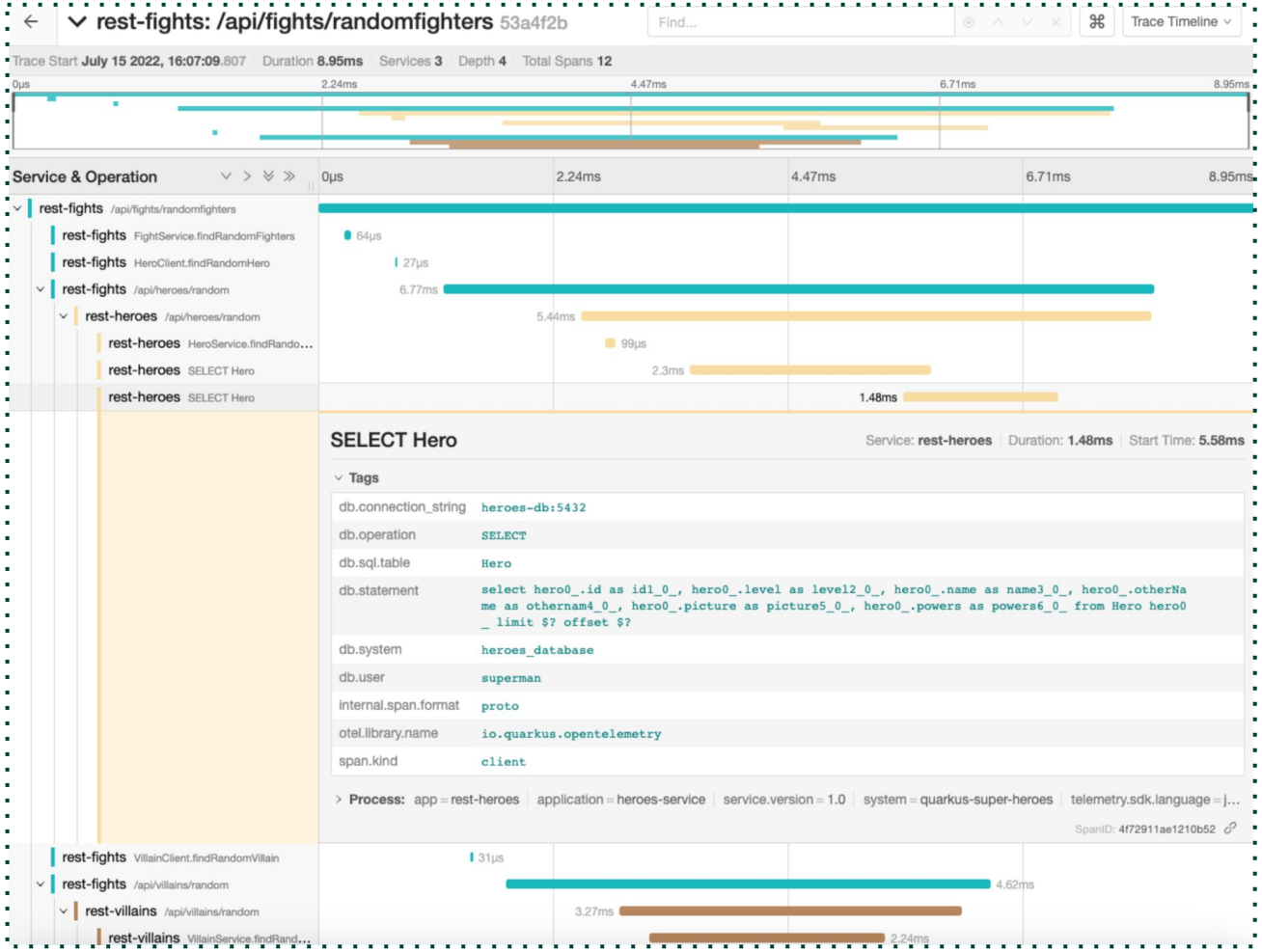
Trace 代表一条调用链路。

Span [spæn]

A Span represents a procedure within a process.

Span 代表一个进程内的的一个过程。

How is a Trace Look Like



Duration (Trace / Span)

span 耗时

Flags (Error / Debug /...)

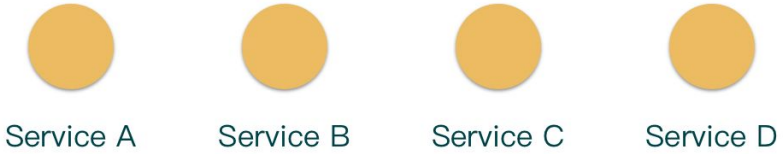
各种标记位

Custom Attributions

自定义属性

Head-based Sampling

Head-based Sampling



Keypoint

- Early decision.

  由**根 Span 决策**，传播至其他 Span。

Pros and Cons

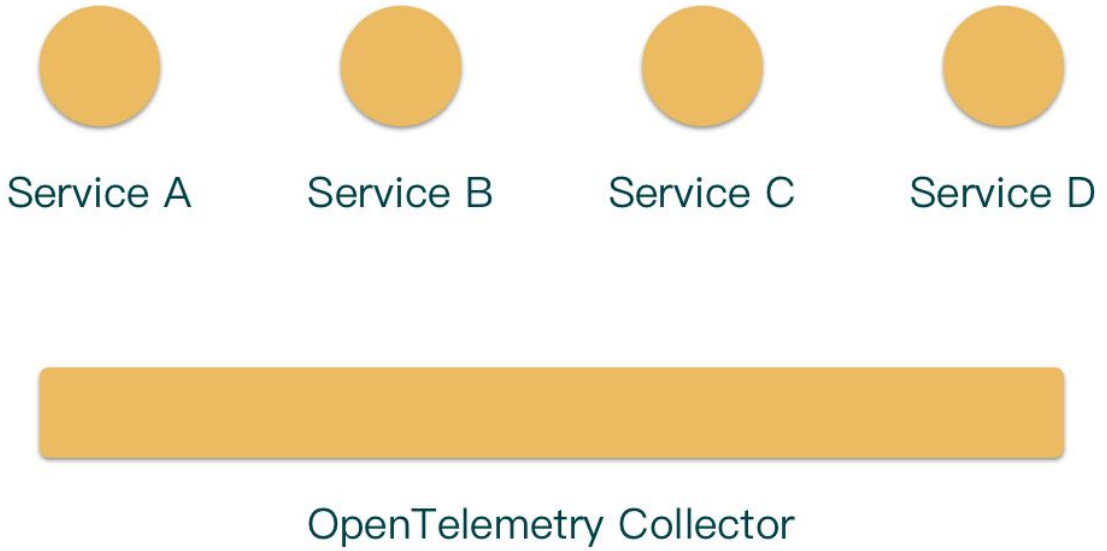
- Lightweight.

  由**应用进行采样**，Trace 平台仅收到少量数据。

- Missing abnormal traces.

  决策时视野有限，错过很多异常情况。

Tail-based Sampling



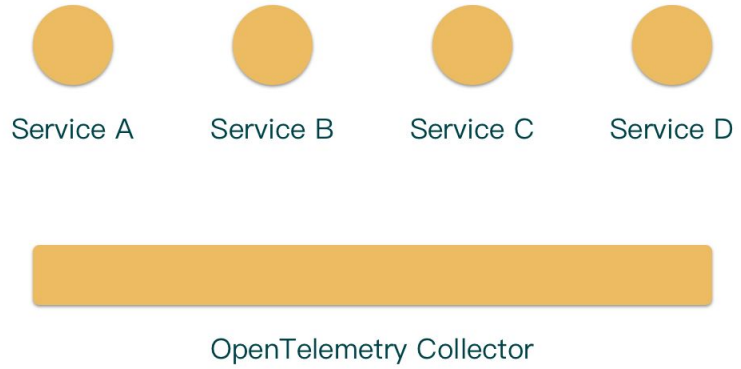
Tail-based Sampling

Keypoint

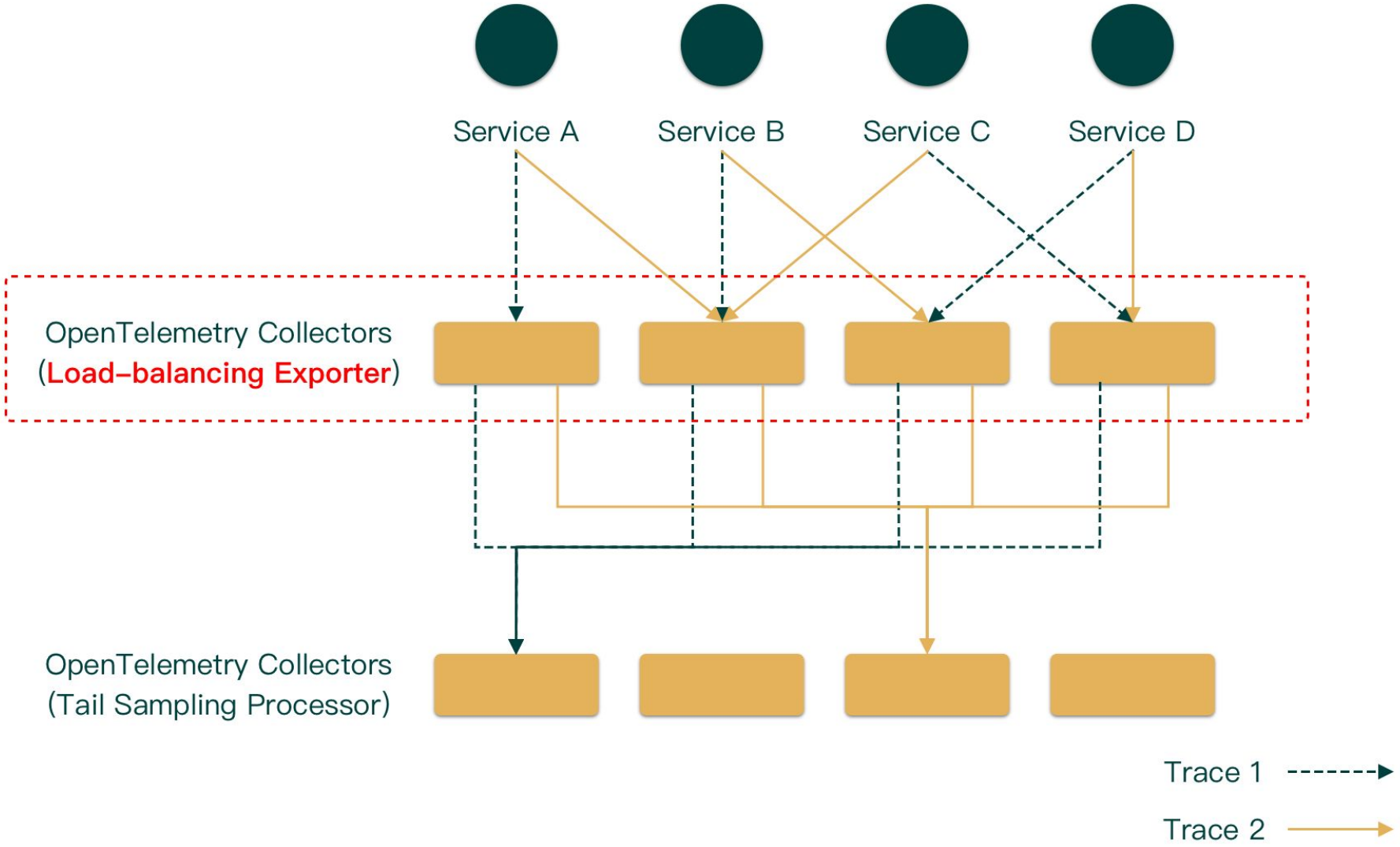
- Postponed decision.
  延迟决策，先收集Trace 信息再判定。

Pros and Cons

- Save disk space while preserving abnormal cases.
  既保留异常情况，又不需要海量的存储资源。
- Require large memory to store tmp data.
  暂存数据多，对基础设施要求高。



Tail-based Sampling: Scaling



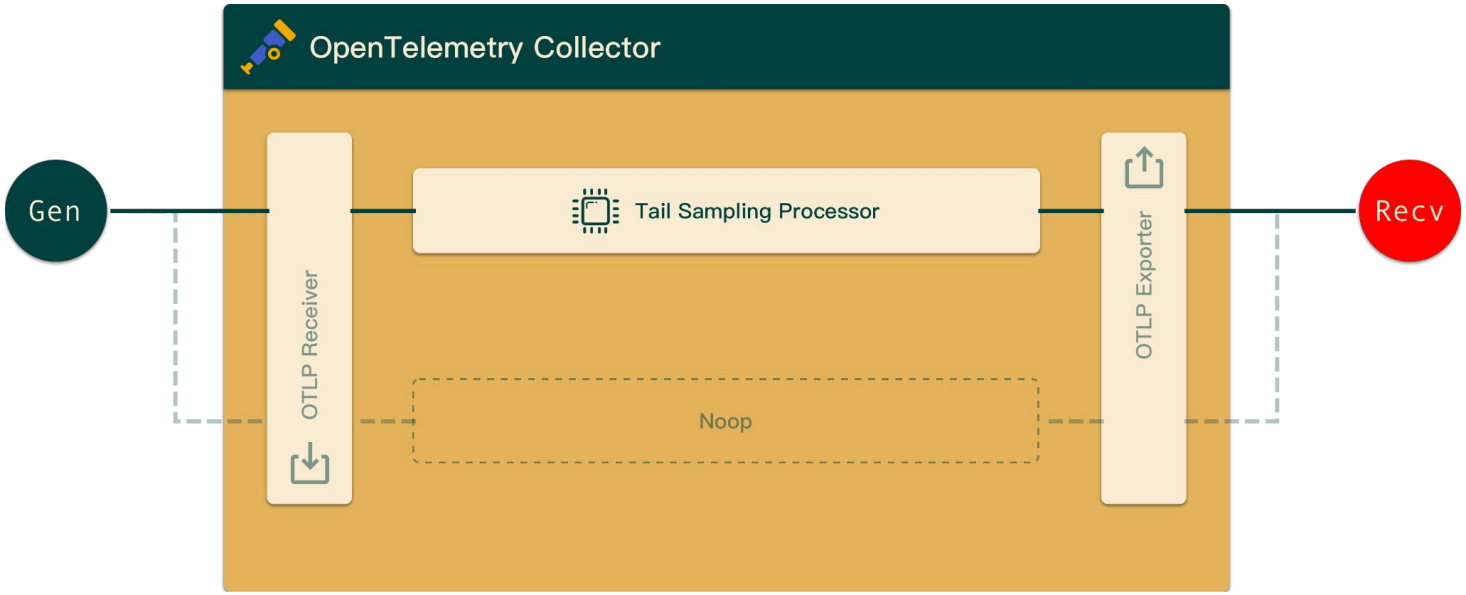
03. Quantifying Sampling Costs and Quality

量化采样成本和效果

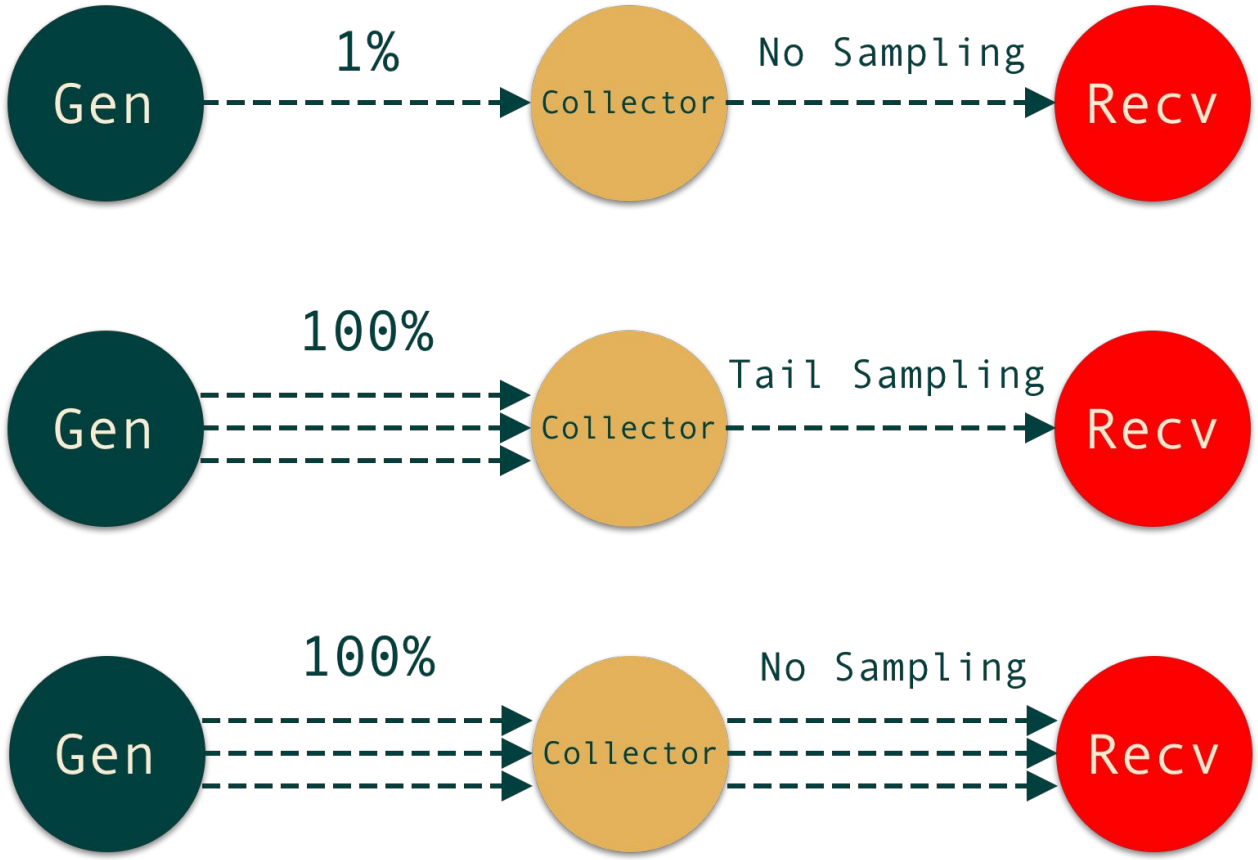
Preparation

Components of the System

- Configurable Trace Generator.
  可配置的 Trace 生成器。
- OpenTelemetry Collector.
  OpenTelemetry Collector 用于数据处理。
- Trace Receiver.
  接收 OTLP 协议 Trace 的 Receiver。
- 4 CPU / 8 GiB Memory.
  Collector 资源使用限制为 4 CPU 和 8 GiB 内存。



Preparation



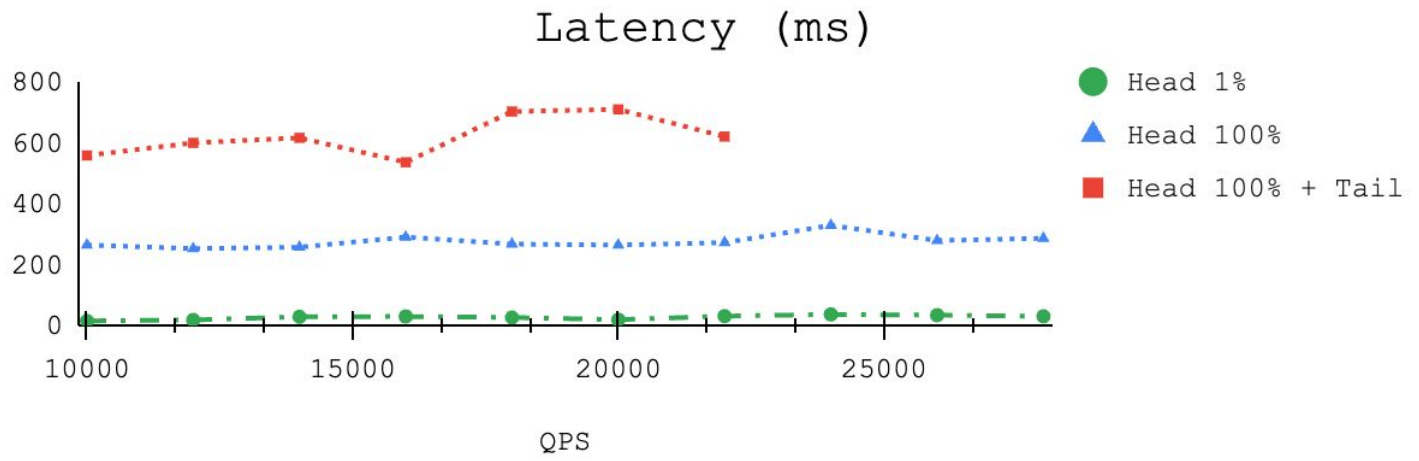
Dataset and Sampling Policies

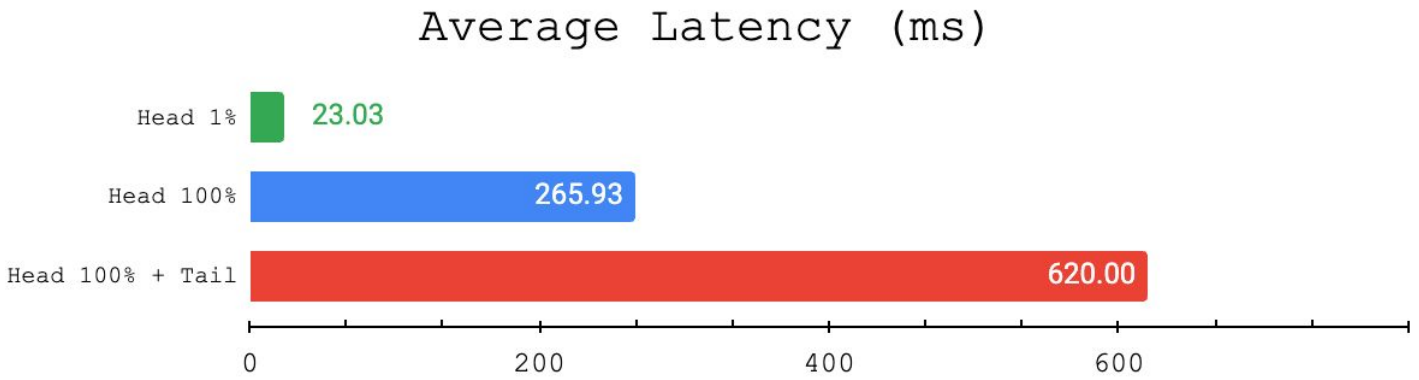
- 400000+ Spans / 20000+ traces.
  平均每组处理 40 万+ Spans / 2 万+ Traces。
- 1% / 100% Head-sampling.
  由 Trace Generator 模拟头部采样，采样率 1% / 100%。
- Tail-sampling by Latency / Error.
  针对长耗时和包含错误的 Trace 进行尾部采样。
- decision_wait: 5s.
  首个 Span 抵达后等待 5 秒评估所属的 Trace。

Benchmark Result

Keypoint

- Significant increase in latency.
  显著处理耗时提升。

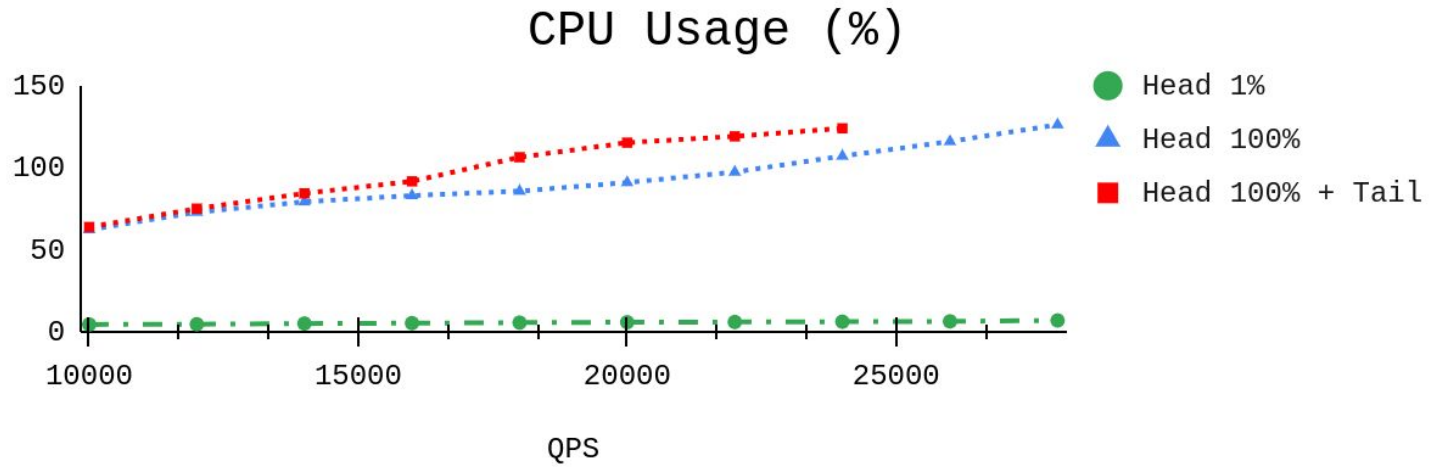


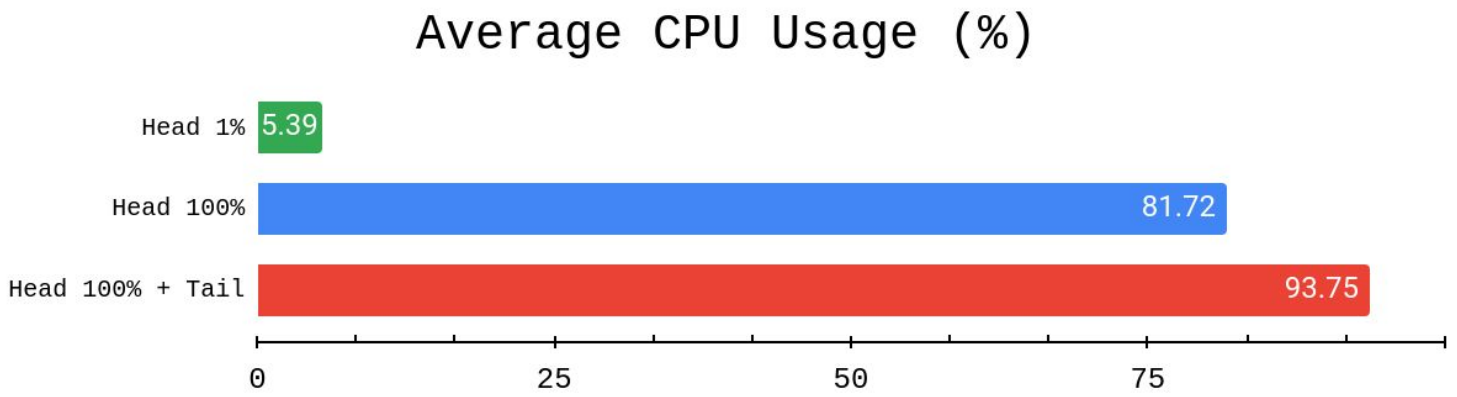


Benchmark Result

Keypoint

- Stronger correlation with the Span number.
  CPU 开销与 Span 上报数量关联更大。
- Weaker correlation with the Collector Processor.
  尾部采样带来 10% 的额外 CPU 开销。

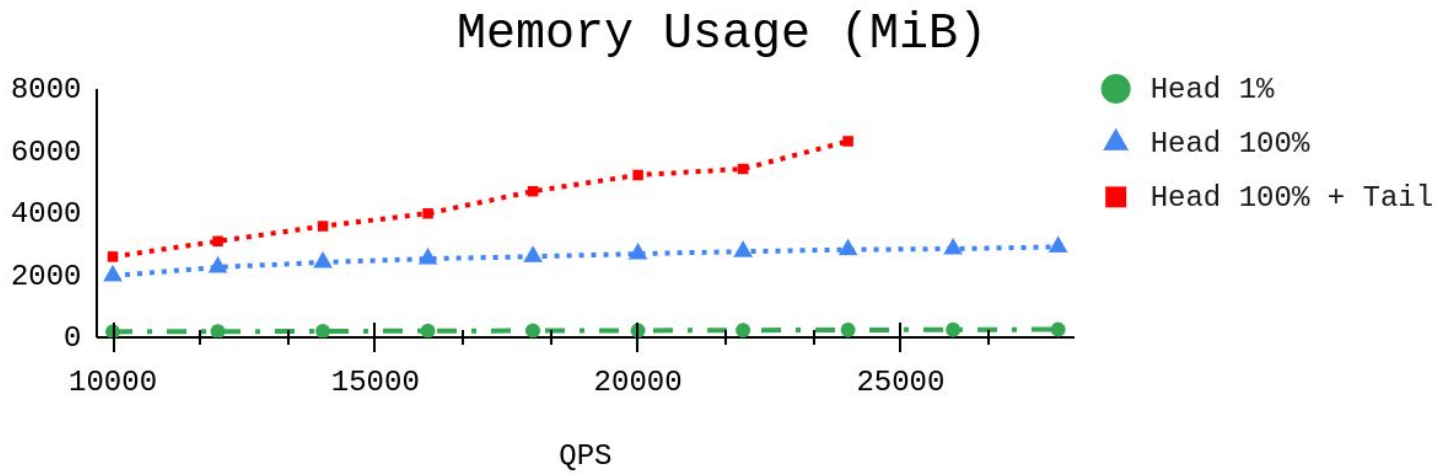


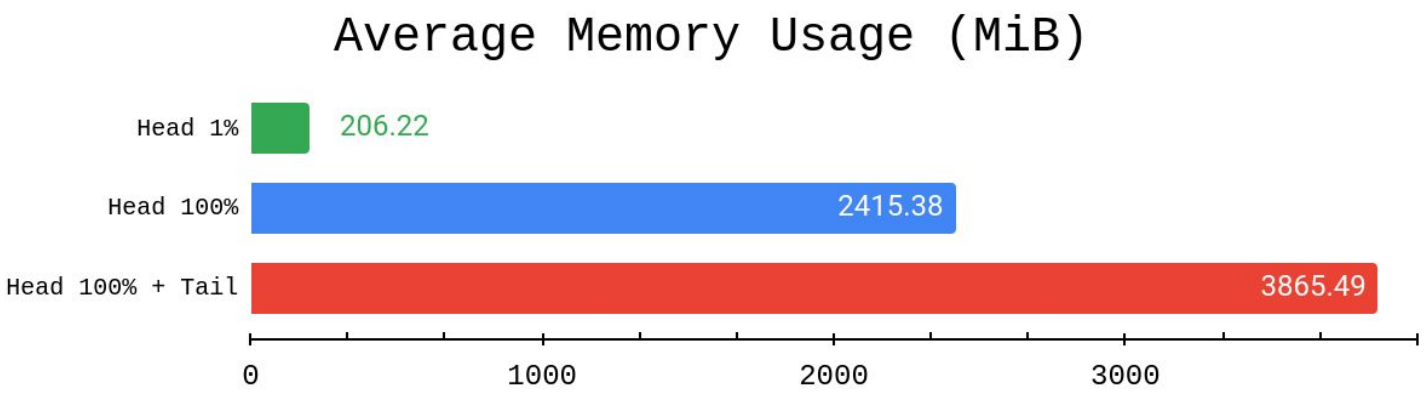


Benchmark Result

Keypoint

- Requiring Infrastructure with large memory.
  尾部采样更青睐于大内存容量的基础设施。
- 20x Mem increment versus Head-Sampling.
  相比头部采样，尾部采样面对 20000 QPS 输入时增加了 20 倍内存使用量。



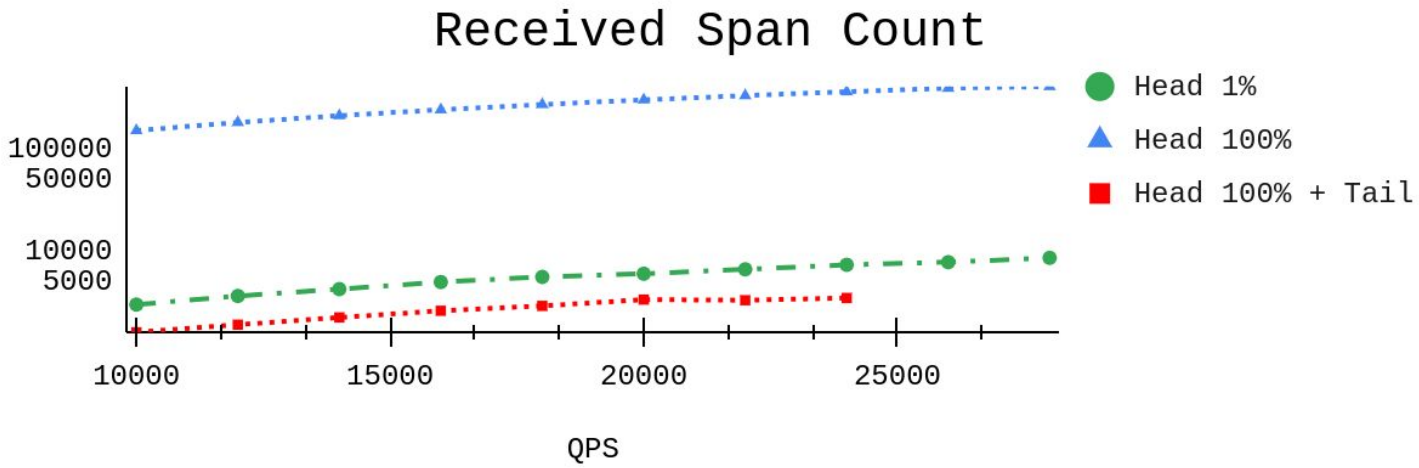


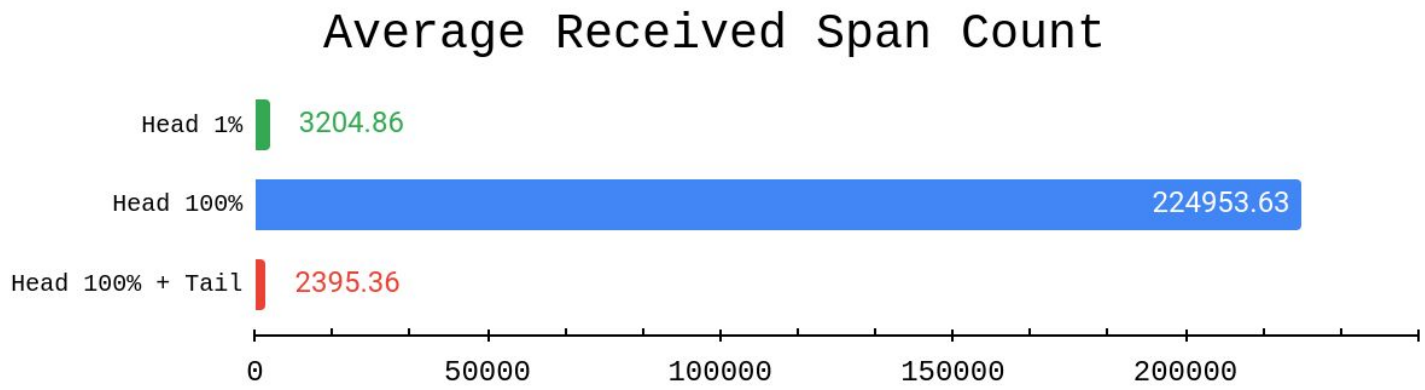
Benchmark Result

Keypoint

- The output data volume of Tail-sampling is highly competitive.

  尾部采样得到的数据量对比 1% 头部采样依然有竞争力及调整空间。





Advices

Recommend

- 1 CPU / 2 GiB for 8000 span per second.
  为每 8000 Span / Sec 的数据压力准备 1 CPU / 2 GiB 内存资源。

Advices

- Provide client SDK with dynamic configuration.
  使用可以由平台方动态调控的 Client SDK。

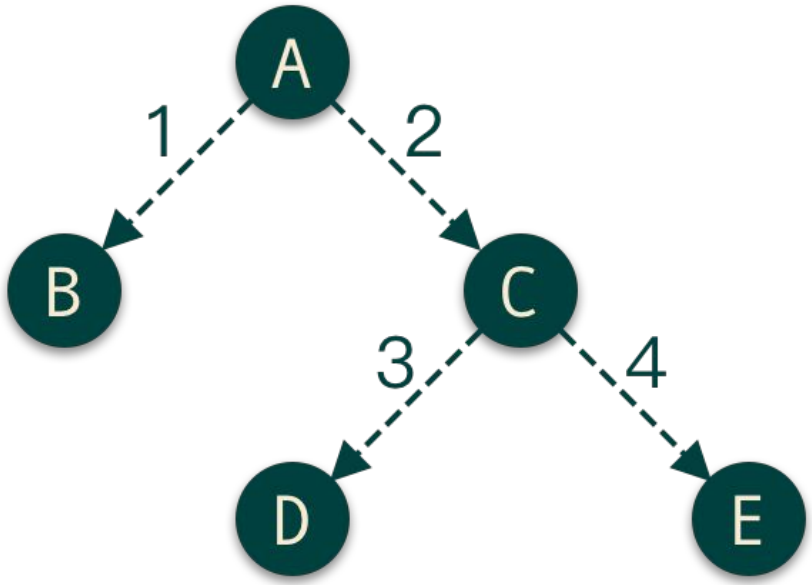
Benefits

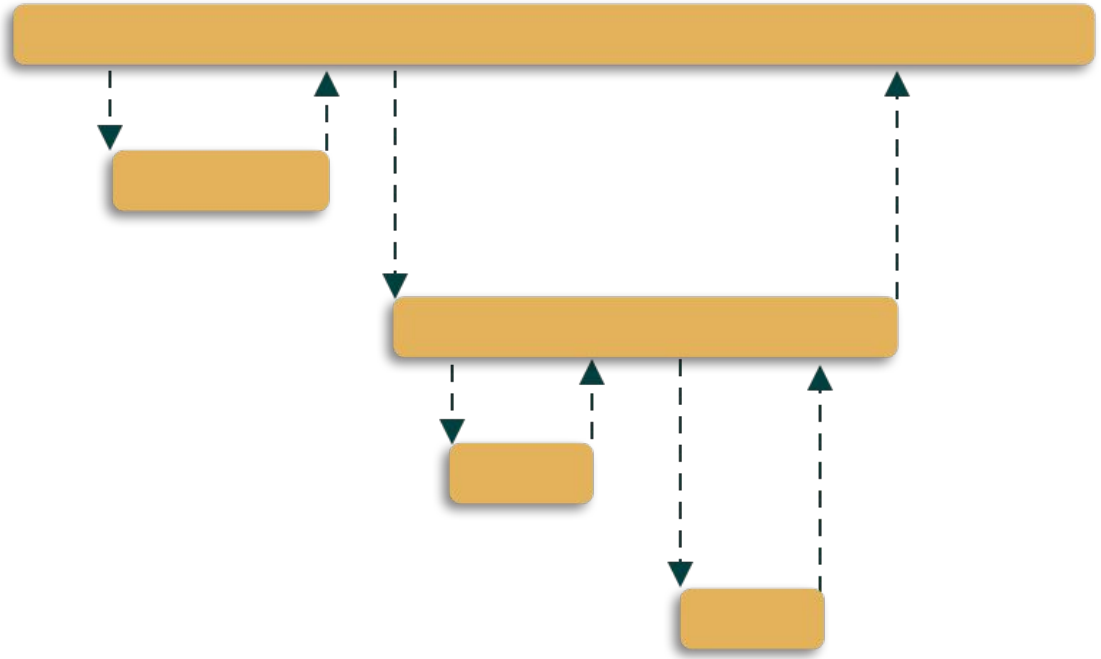
- Real-time awareness.
  对采样率的实时感知，控制风险。
- Dynamic adjustment.
  根据错误率等情况实时动态调整采样率。

04. Tracing Edge Case: Potential Solutions

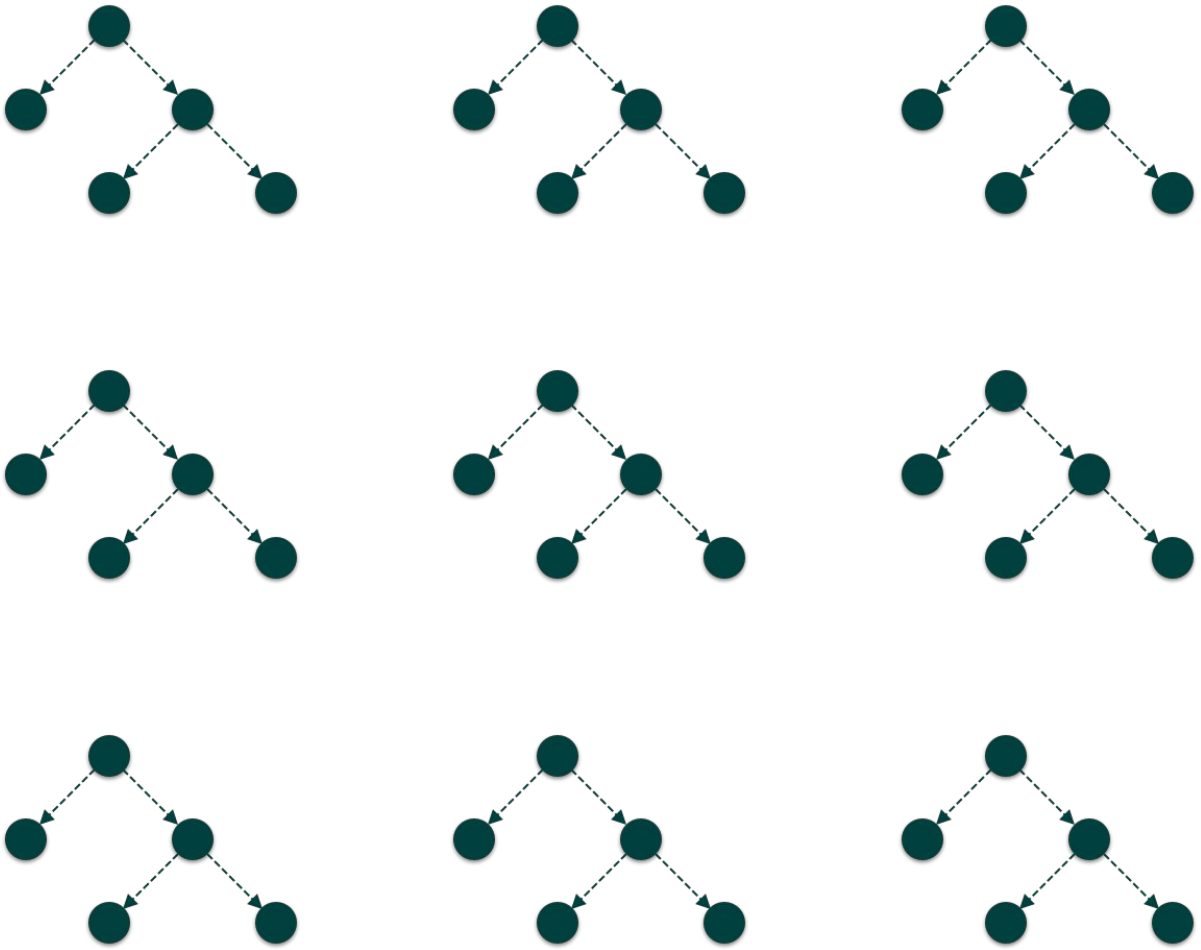
让采样覆盖更多场景

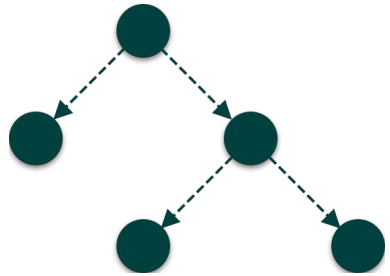
A Trace Example





The Chaos of Trace Data

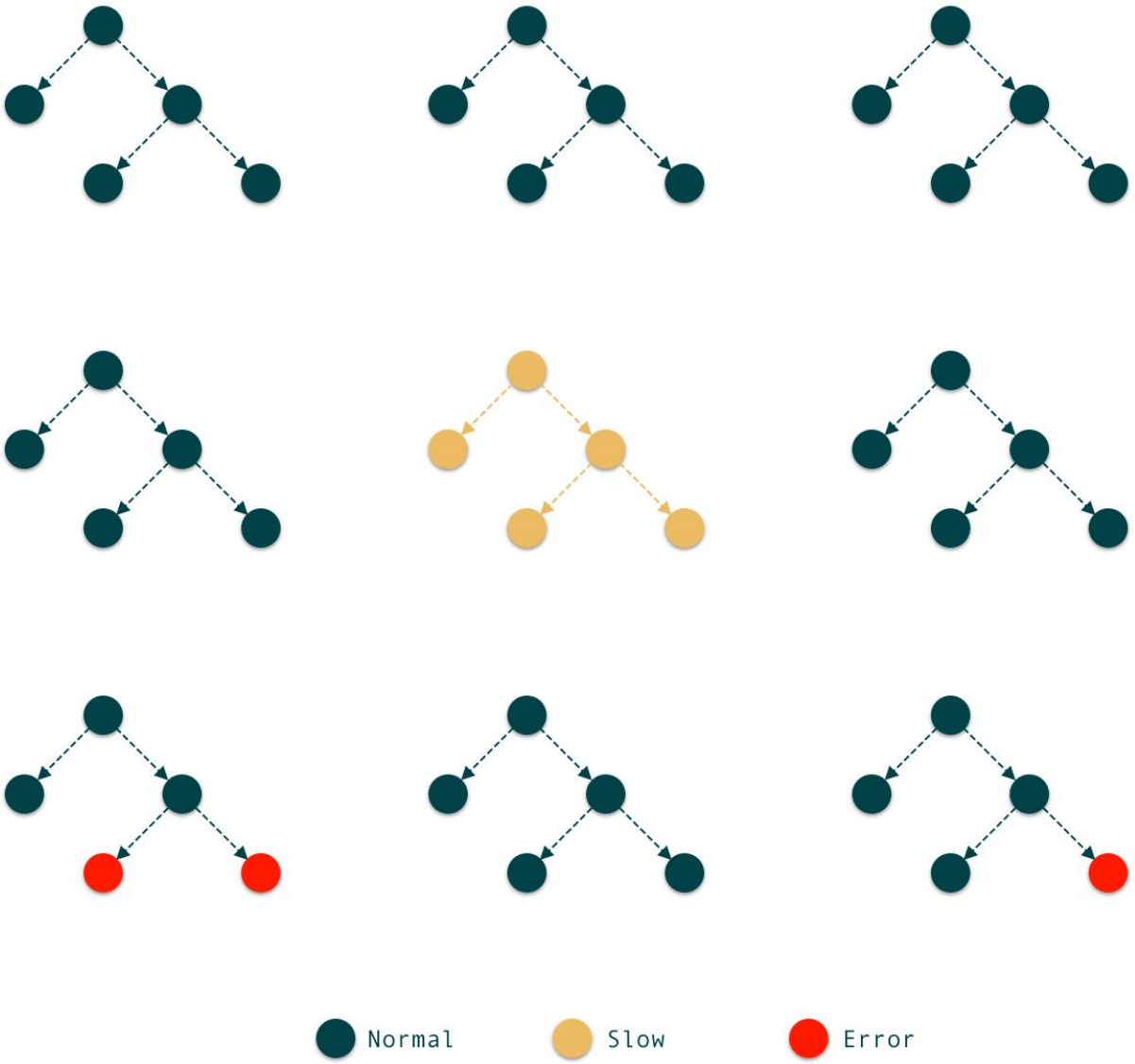


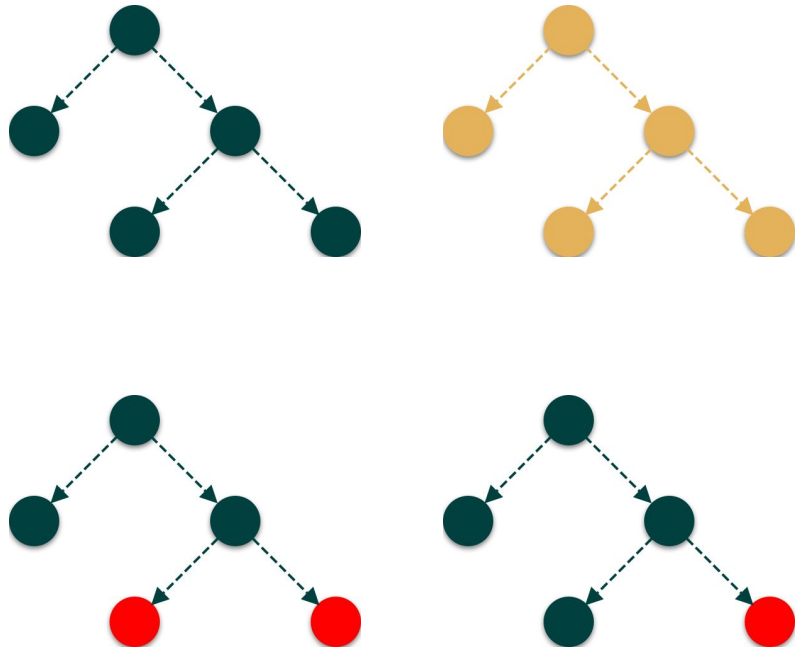


Head-based Sampling Result

头部采样结果

The Chaos of Trace Data



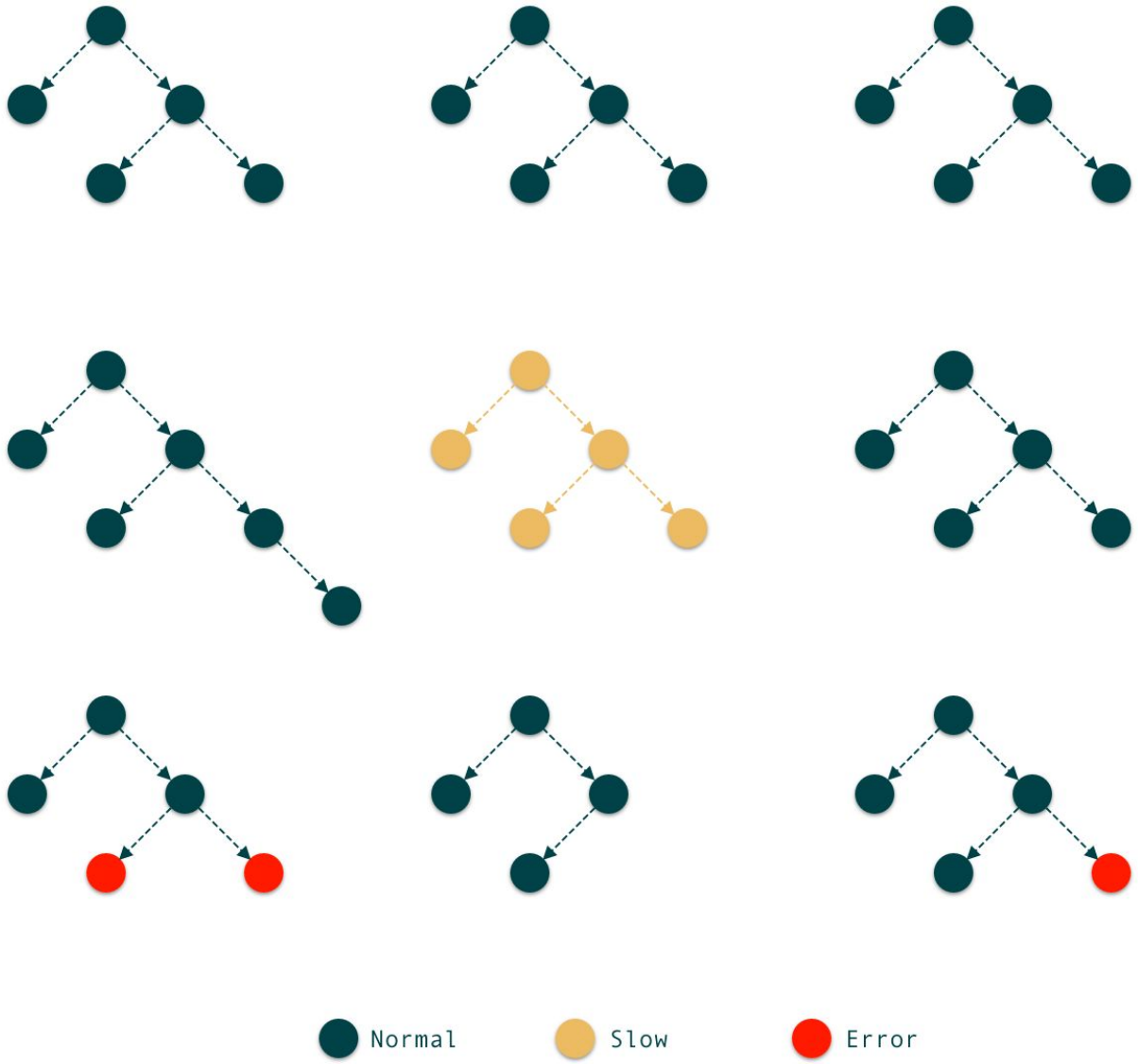


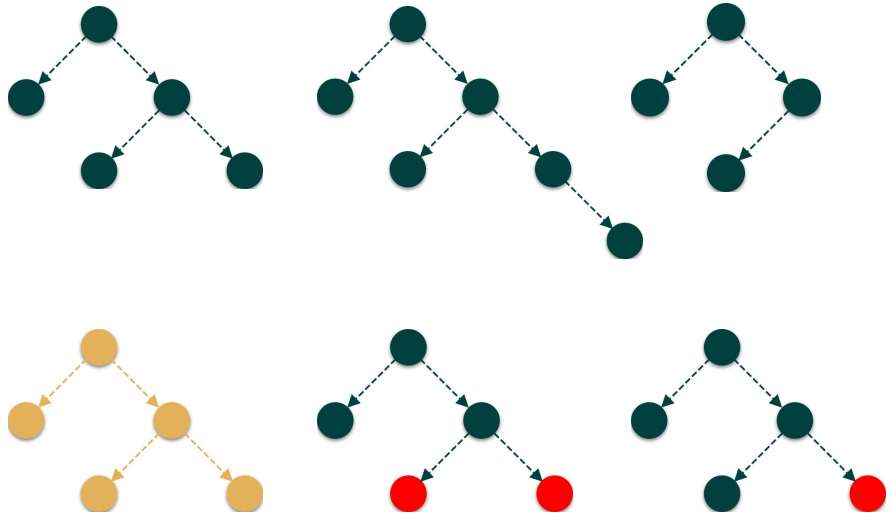
Tail-based Sampling Result

(Based on Error / Latency)

尾部采样结果（基于错误 / 耗时）

The Chaos of Trace Data

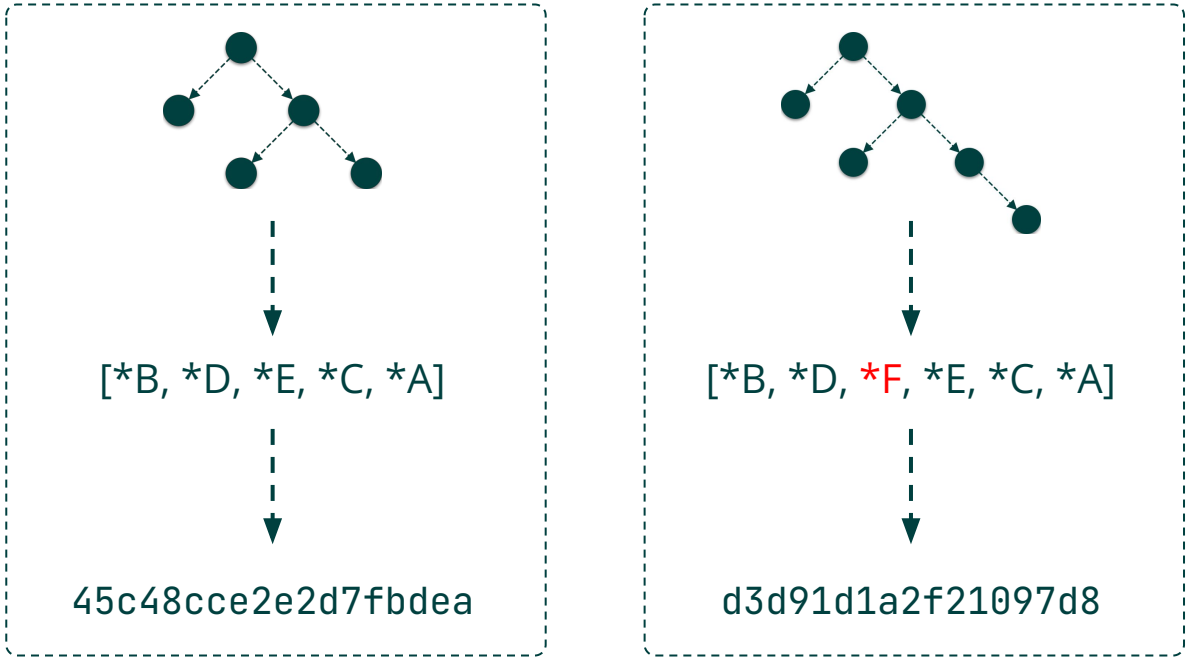




How to Collect **Unique** Traces?

如何捕获一些与众不同的Trace 呢？

Identifying Unique Traces



Metadata Serialization & Digestion

元数据序列化 & 摘要计算

Trace ID	Type ID	Frequency (/min)	Sample Decision
c4ca42	45c4	9238212	No
c81e72			No
eccbc8			No
a87ff6	d3d9	8	Yes

Sample Decision

采样决策

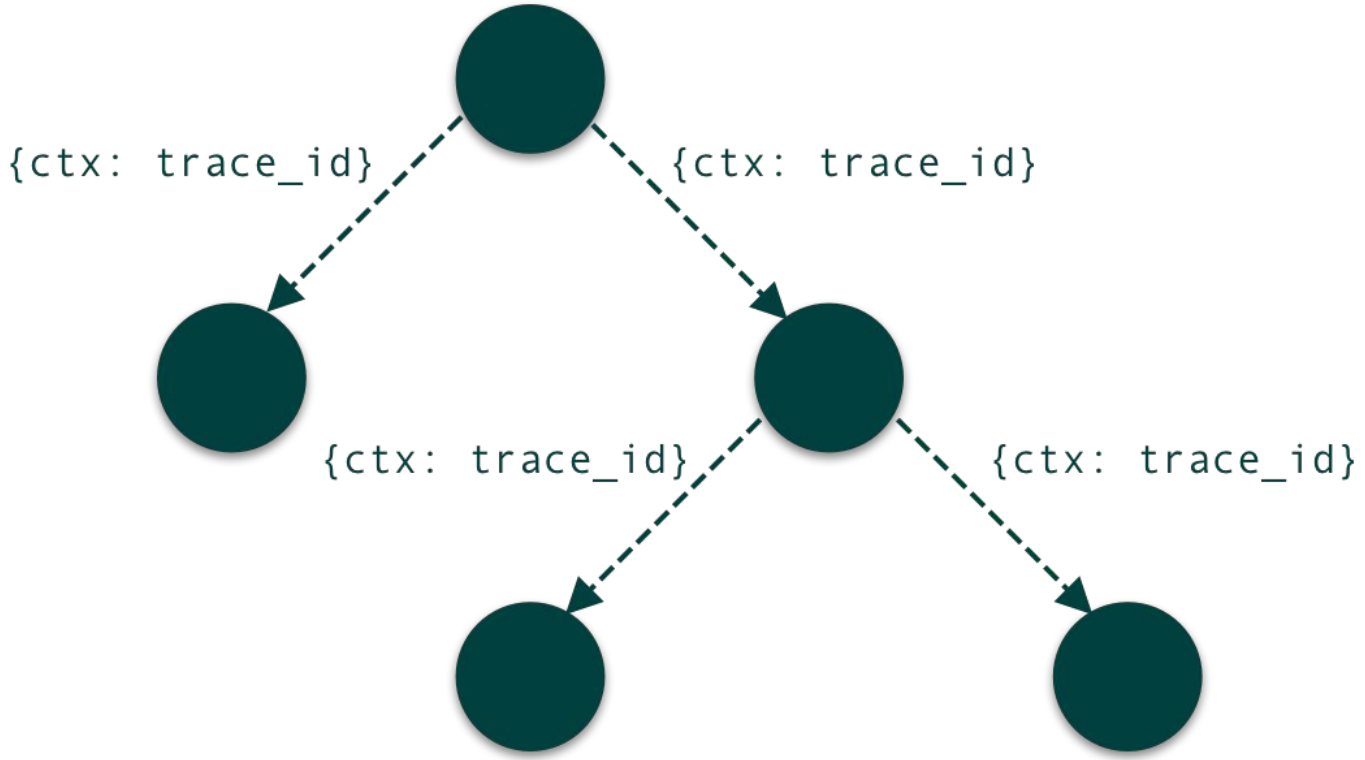
Minimizing Data Transfer

Current Status:

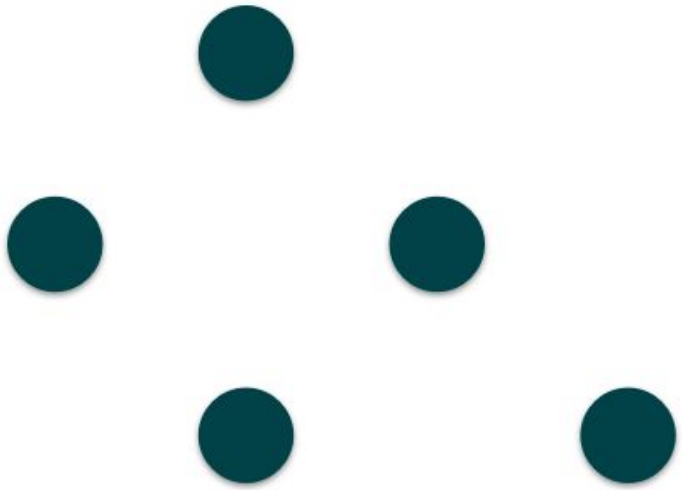
- Trace context propagate from top to bottom.
  当前，Trace 信息从上往下传播。

What If:

- Trace context propagate from bottom to top.
  Trace 信息从下往上传播会怎么样？



Retroactive Sampling



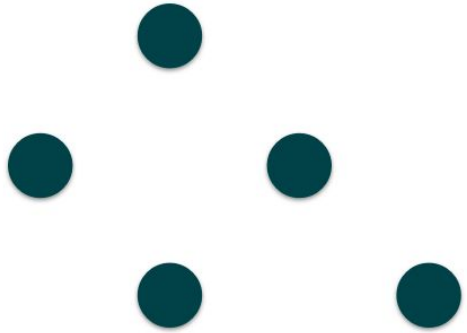
Retroactive Sampling

Pros

- Grant all applications control over sampling.
  让所有应用服务都拥有采样的决定权
- Less data being reported by client SDK.
  Client 侧采样，更少数据上报至后续处理流程。

Cons

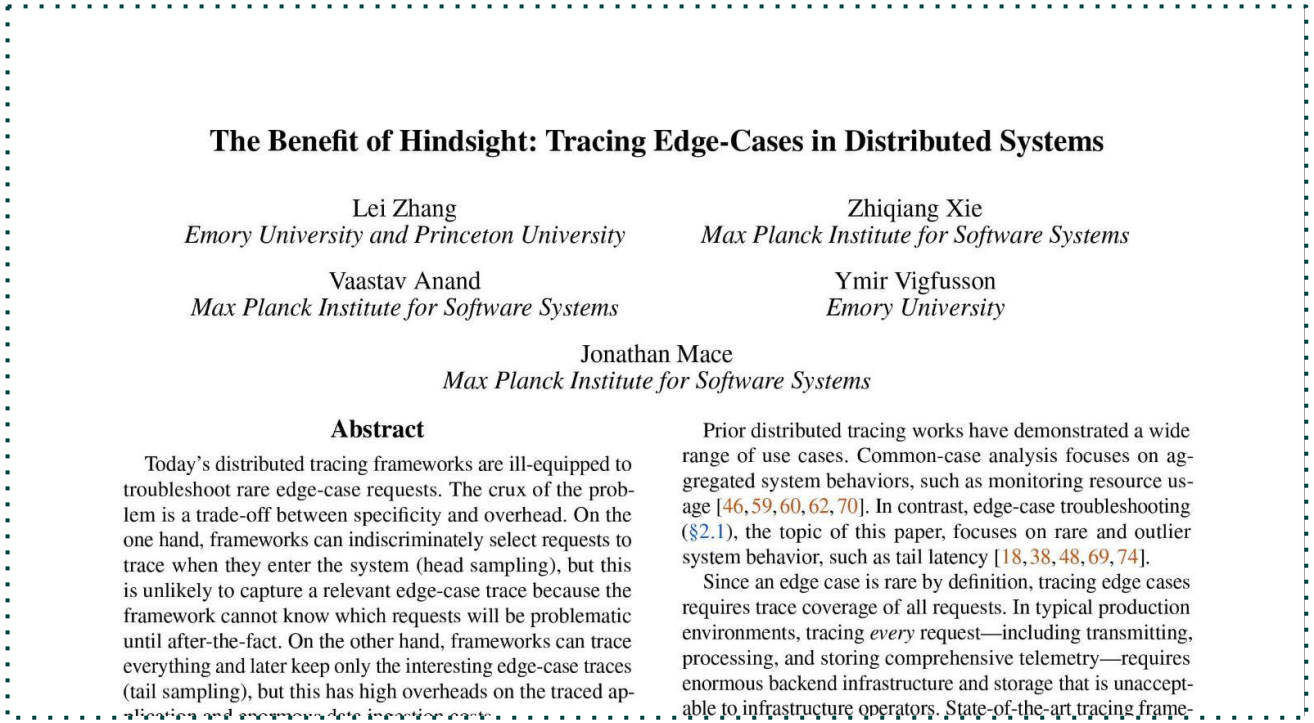
- Completed spans cannot be sampled.
  已结束的 Span 无法被采样到。
- Require a highly unified RPC framework / protocol.
  依赖高度统一的通信框架或协议。



Retroactive Sampling: Further Reading

Goals

- Applications control.
  应用服务决策。
- Low traffic.
  低数据传输量。
- No dependency on frameworks or SDKs.
  不依赖于特定框架或SDK。
- Coherent sampling.
  采样数据保持连贯，不缺失 Span。



The Benefit of Hindsight: Tracing Edge-Cases in Distributed Systems

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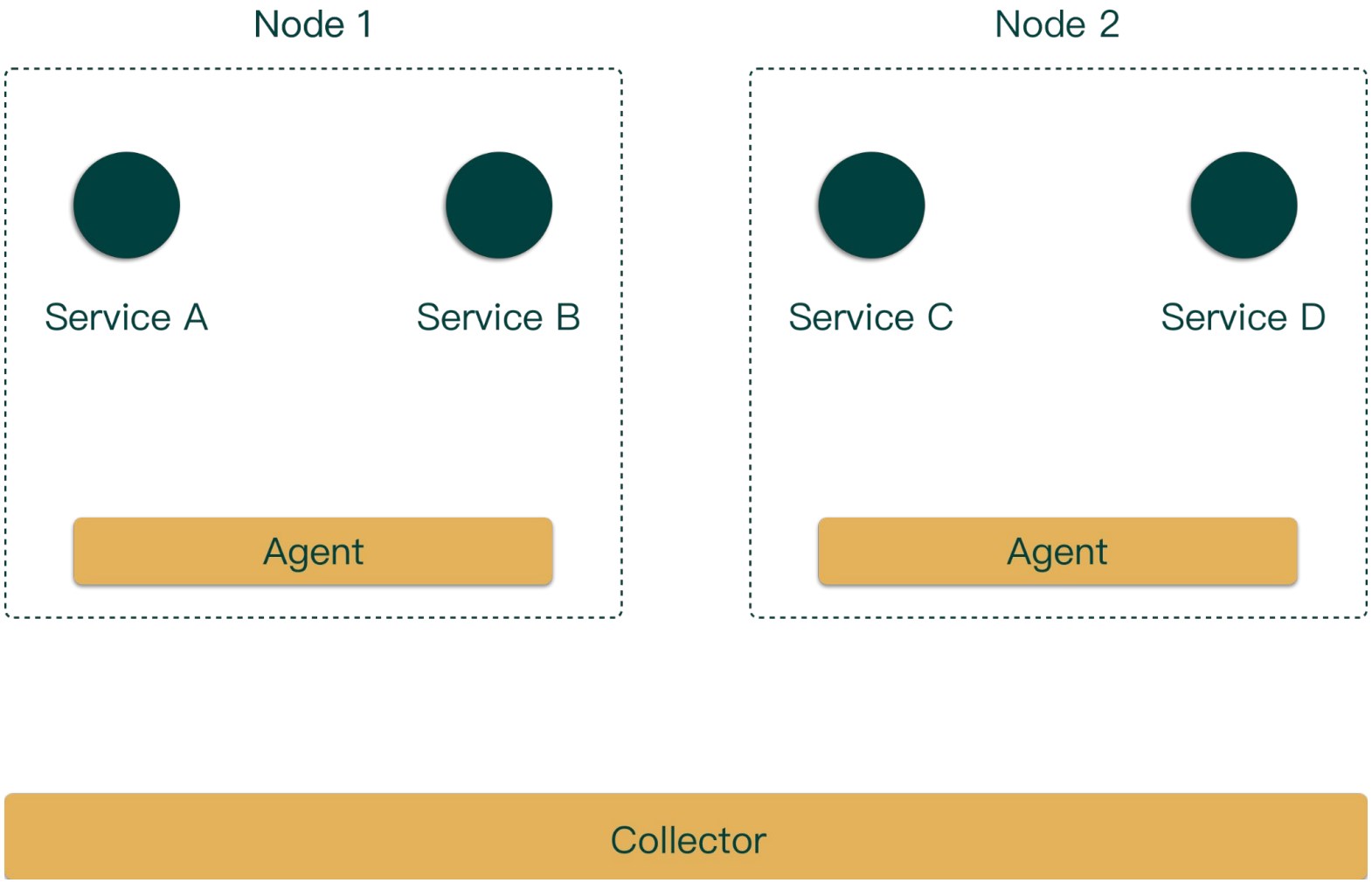
Abstract

Today's distributed tracing frameworks are ill-equipped to troubleshoot rare edge-case requests. The crux of the problem is a trade-off between specificity and overhead. On the one hand, frameworks can indiscriminately select requests to trace when they enter the system (head sampling), but this is unlikely to capture a relevant edge-case trace because the framework cannot know which requests will be problematic until after-the-fact. On the other hand, frameworks can trace everything and later keep only the interesting edge-case traces (tail sampling), but this has high overheads on the traced applications and enormous data ingestion costs.

Prior distributed tracing works have demonstrated a wide range of use cases. Common-case analysis focuses on aggregated system behaviors, such as monitoring resource usage [46, 59, 60, 62, 70]. In contrast, edge-case troubleshooting (§2.1), the topic of this paper, focuses on rare and outlier system behavior, such as tail latency [18, 38, 48, 69, 74].

Since an edge case is rare by definition, tracing edge cases requires trace coverage of all requests. In typical production environments, tracing *every* request—including transmitting, processing, and storing comprehensive telemetry—requires enormous backend infrastructure and storage that is unacceptable to infrastructure operators. State-of-the-art tracing frame-

Retroactive Sampling: Further Reading



Retroactive Sampling: Further Reading

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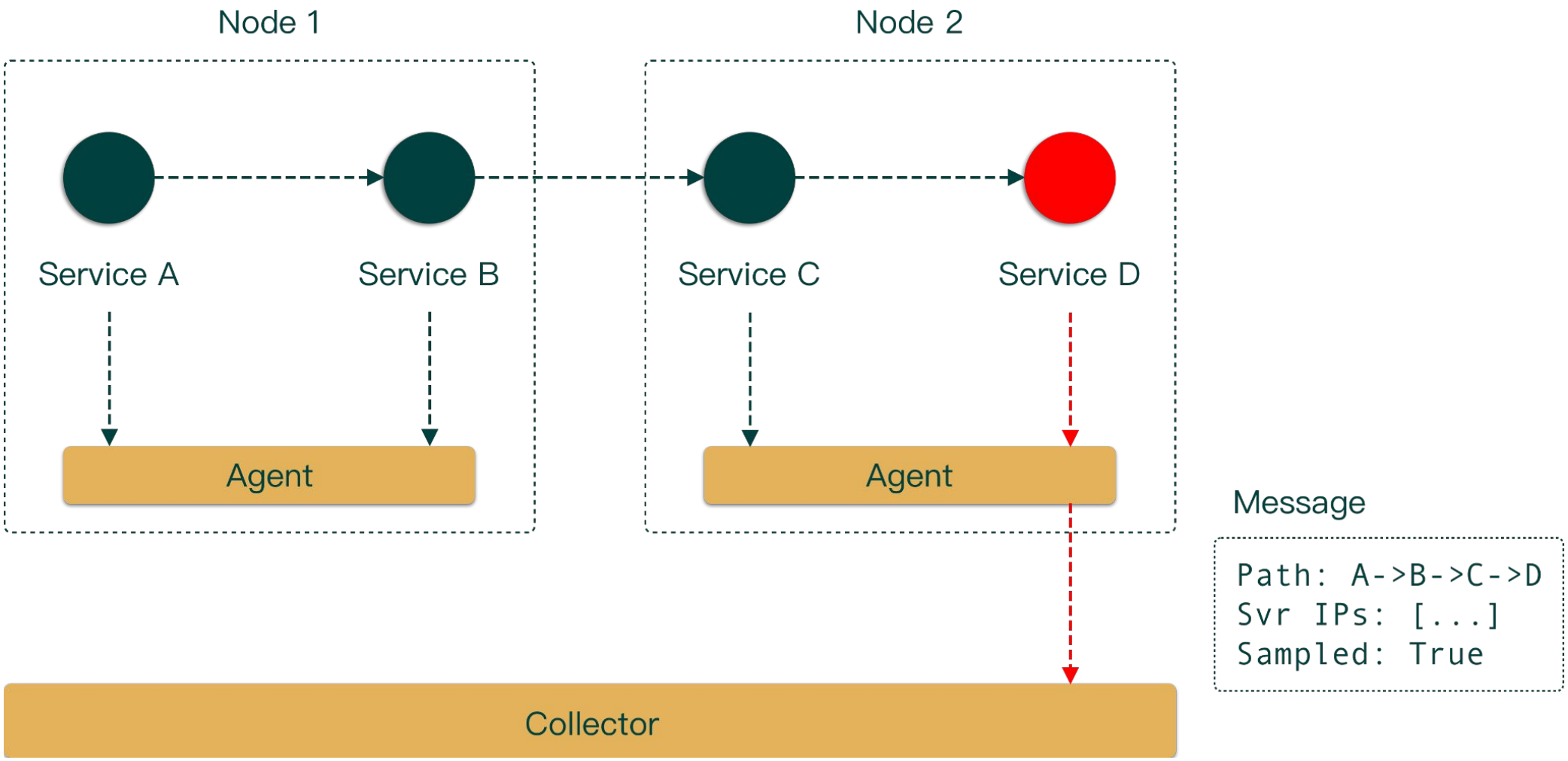
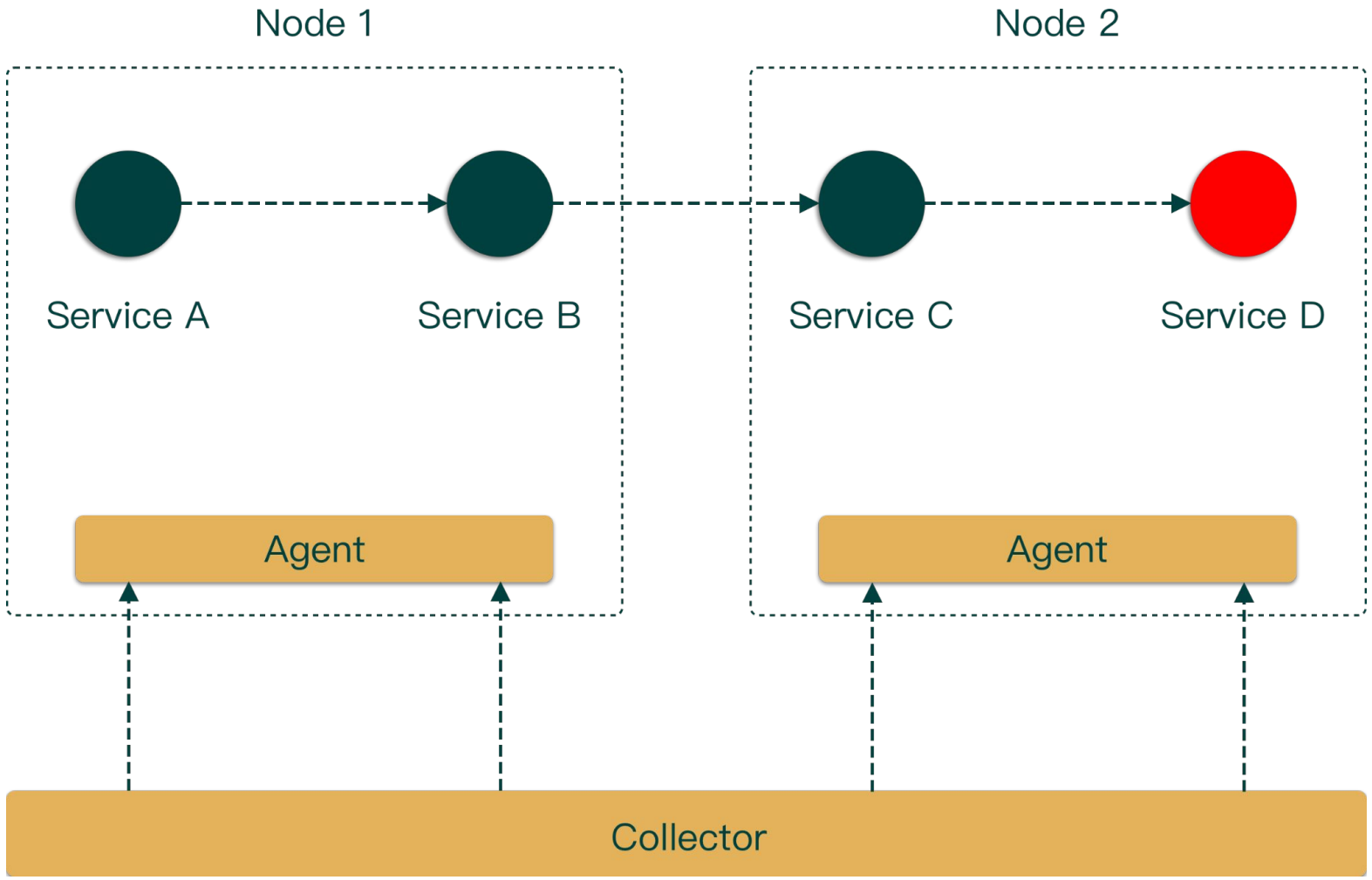


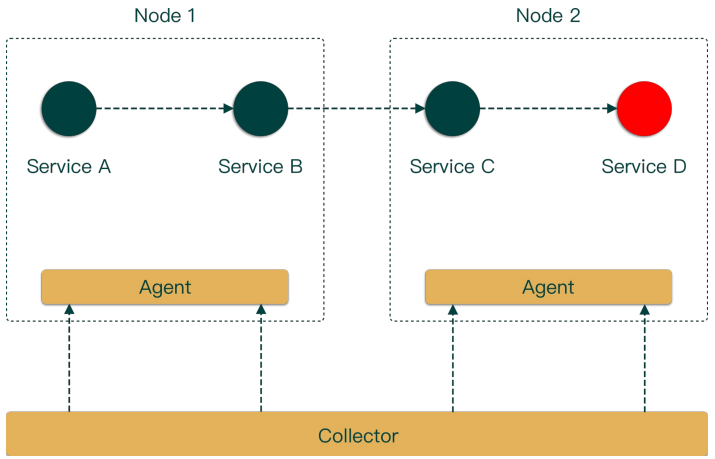
Retroactive Sampling: Further Reading



Retroactive Sampling: Further Reading

Keypoint

- Only metadata is transmitted over the network for the majority of the time.
  大多数时间只有 metadata 在网络中传输，降低数据量。
- Address info is included in the metadata as breadcrumbs and sent to the collector.
  调用链路信息以面包屑形式随metadata 发送给 Collector。
- The collector requests full trace data only when an issue occurs.
  仅当有问题发生时，Collector 才向 Agent 索要完整数据。

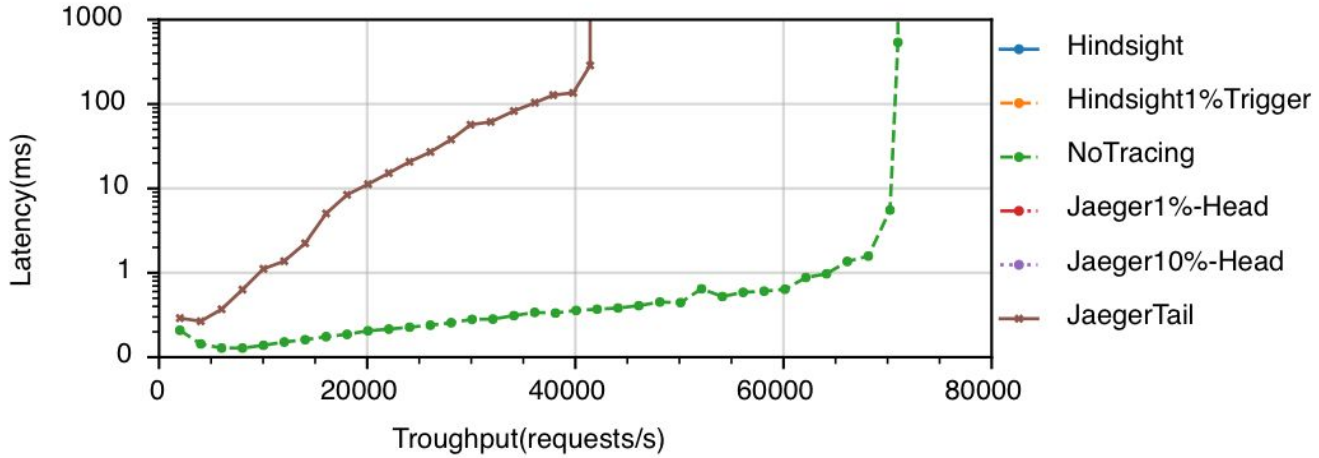


Retroactive Sampling: Further Reading

TL;DR:

- Impact <3.5% when 200 MB/s trace data generated.

  在每秒产生 200 MB Trace 数据的情况下，对延迟和吞吐量影响不足 3.5%。

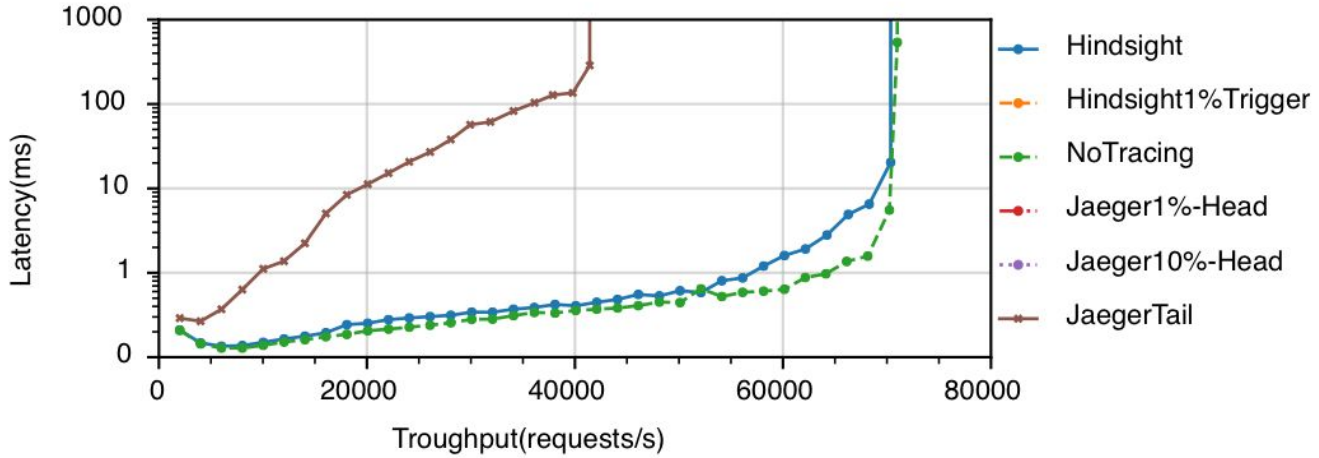


Retroactive Sampling: Further Reading

TL;DR:

- Impact <3.5% when 200 MB/s trace data generated.

  在每秒产生 200 MB Trace 数据的情况下，对延迟和吞吐量影响不足 3.5%。



Retroactive Sampling: Further Reading

TL;DR:

- Impact <3.5% when 200 MB/s trace data generated.

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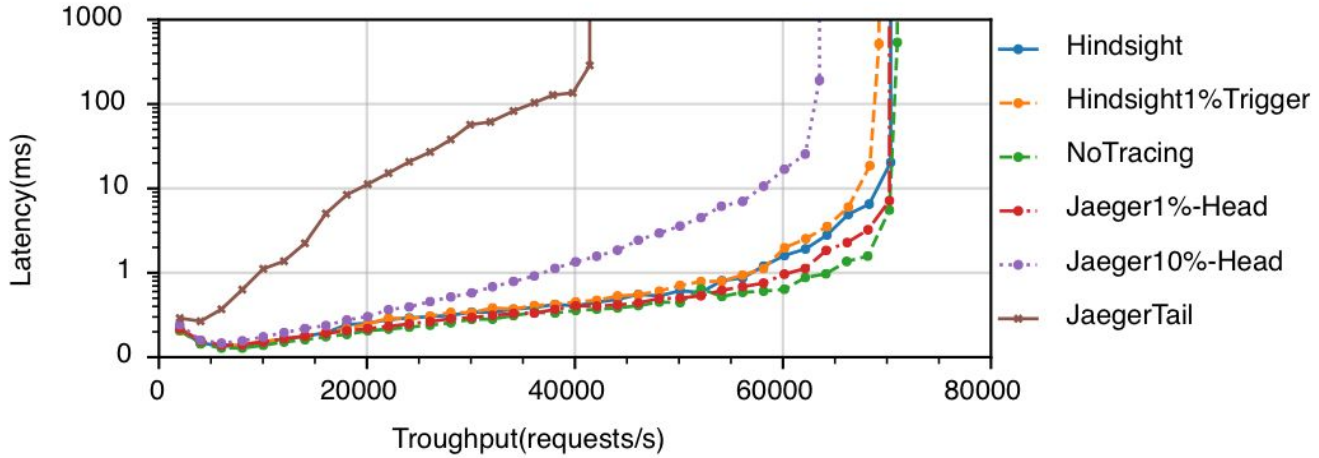

Retroactive Sampling: Further Reading

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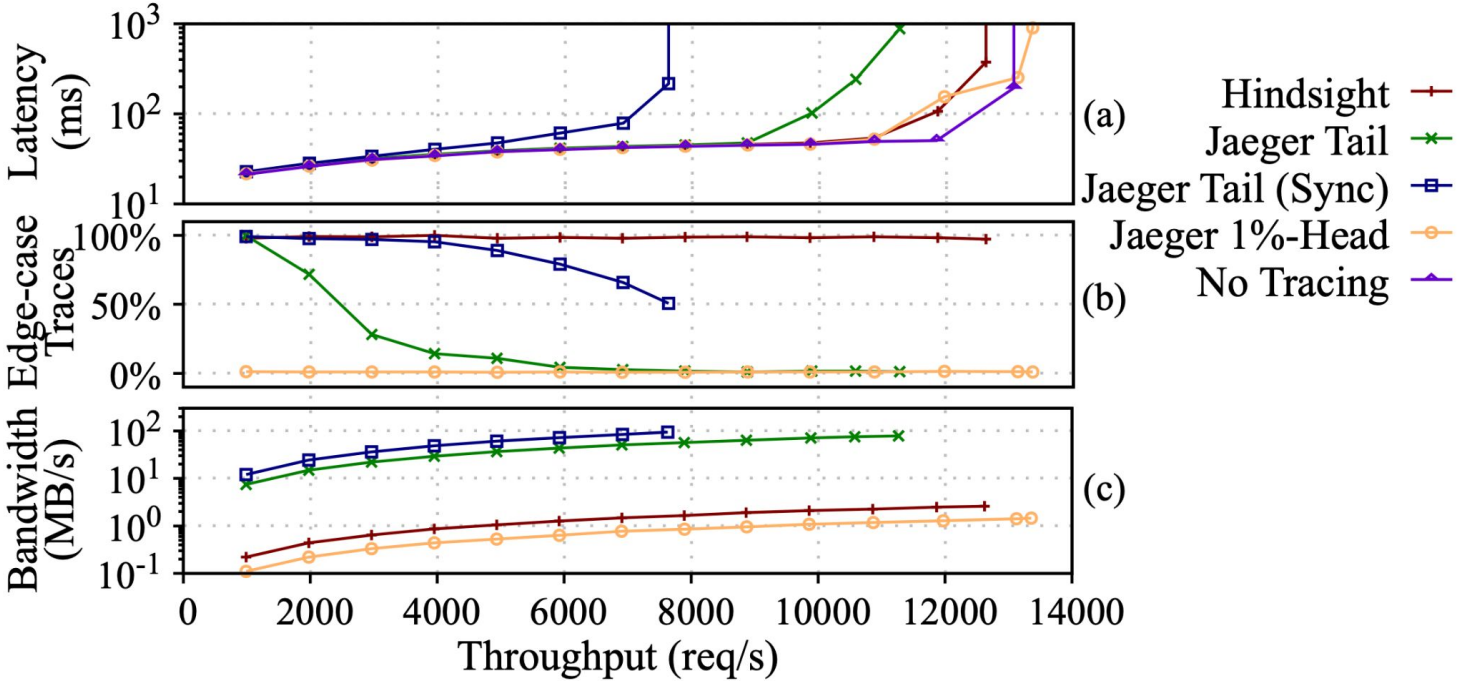
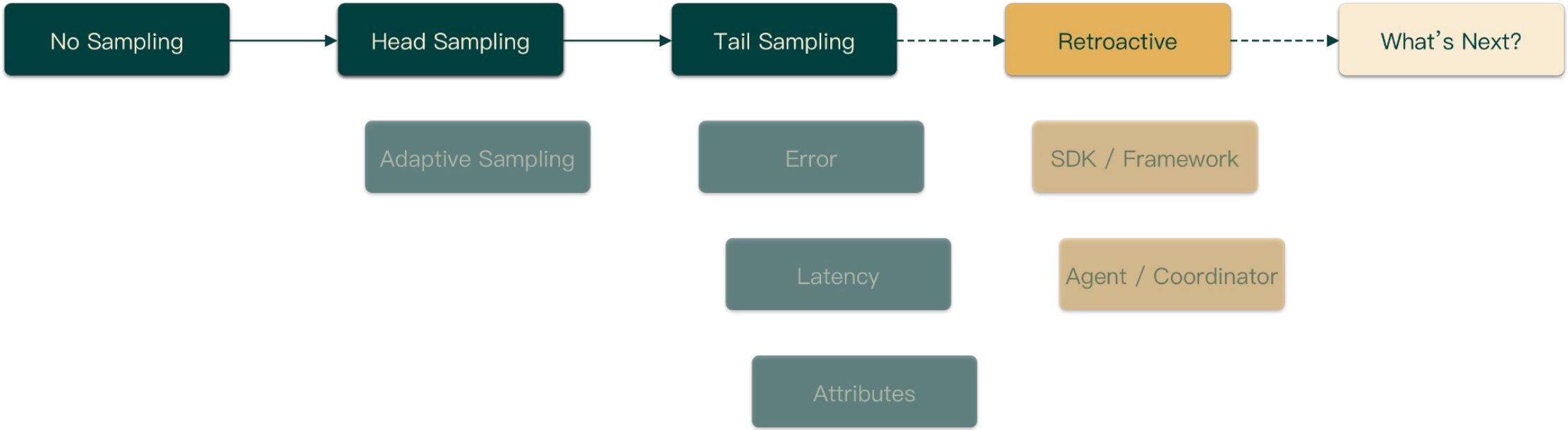


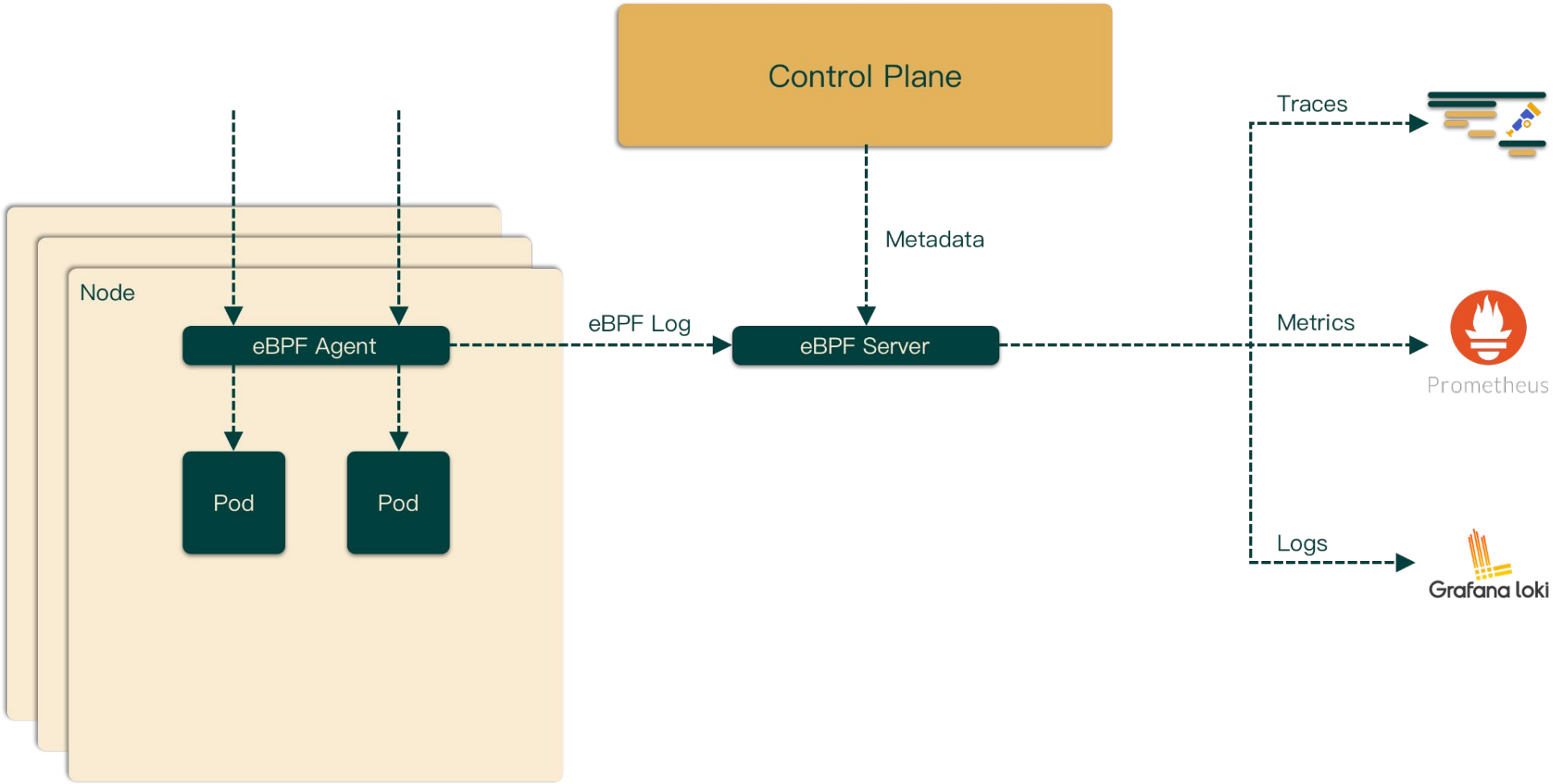
05. Build the Future with OpenTelemetry

杂谈 & 分享你的想法

Sampling Strategy Evolution

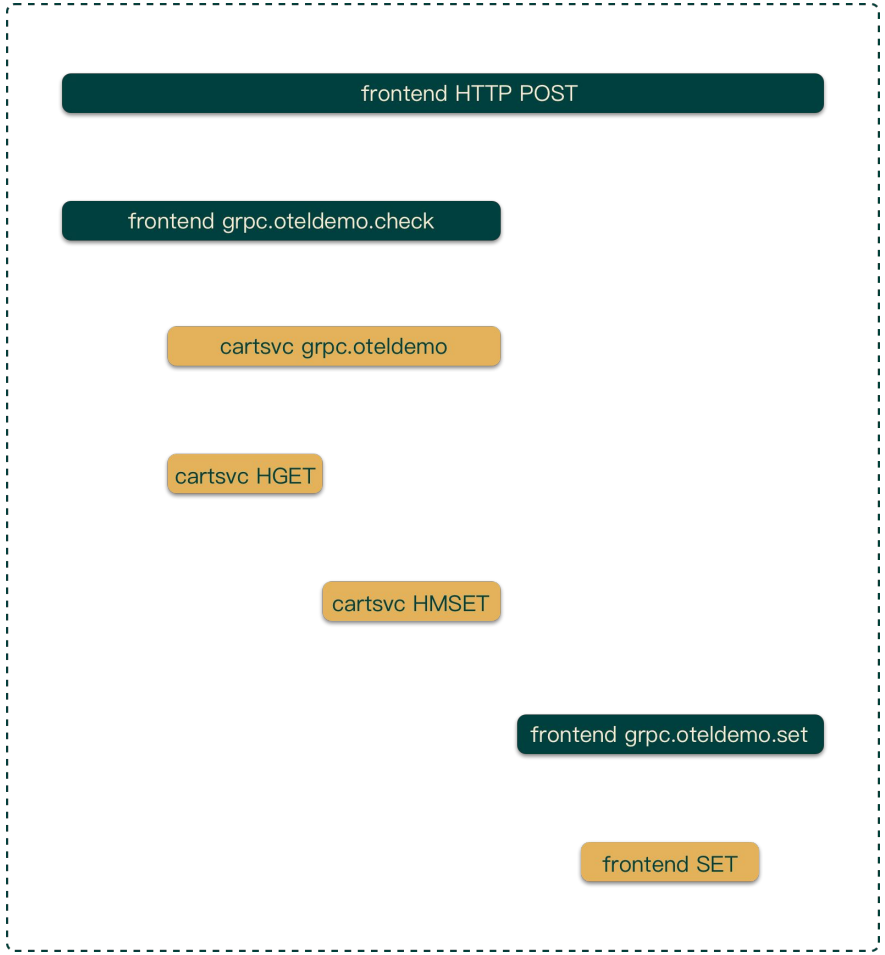


About Auto-Instrumentation

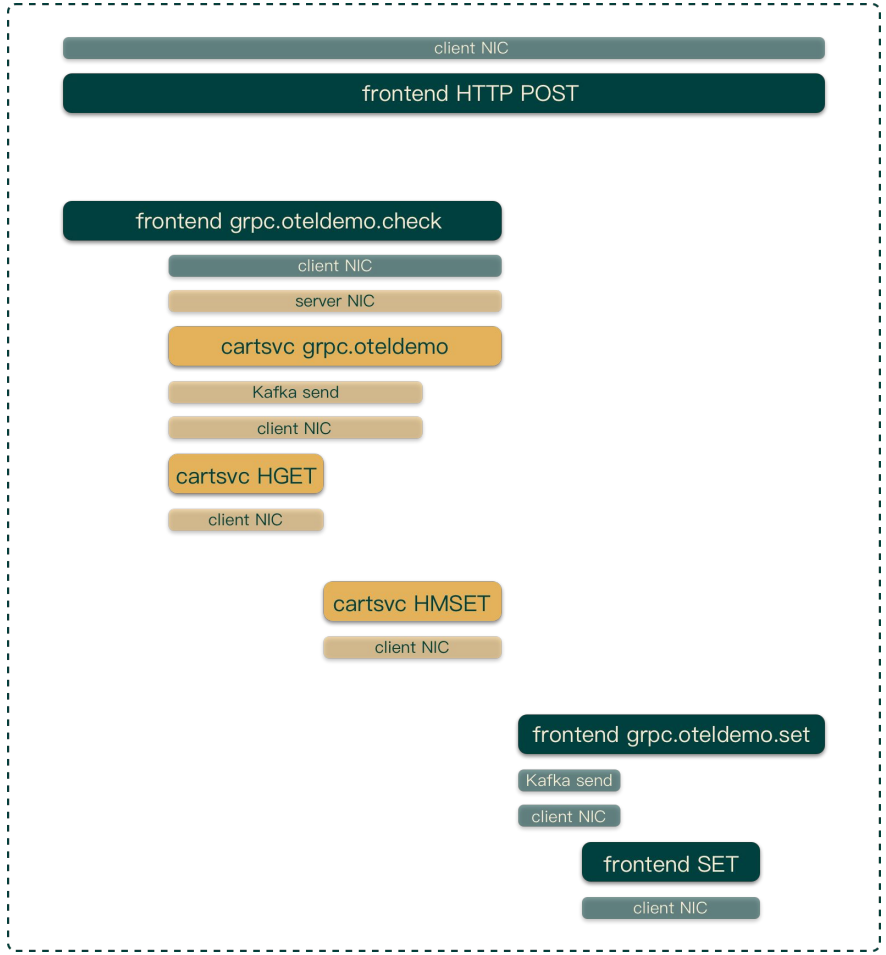


About Auto-Instrumentation

Manual Instrumentation



eBPF



About Auto-Instrumentation


```
func Exec(ctx Context, sql string) (result interface{}) {


  return db.WithContext(ctx).Exec(sql)
}
```

OpenTelemetry Community

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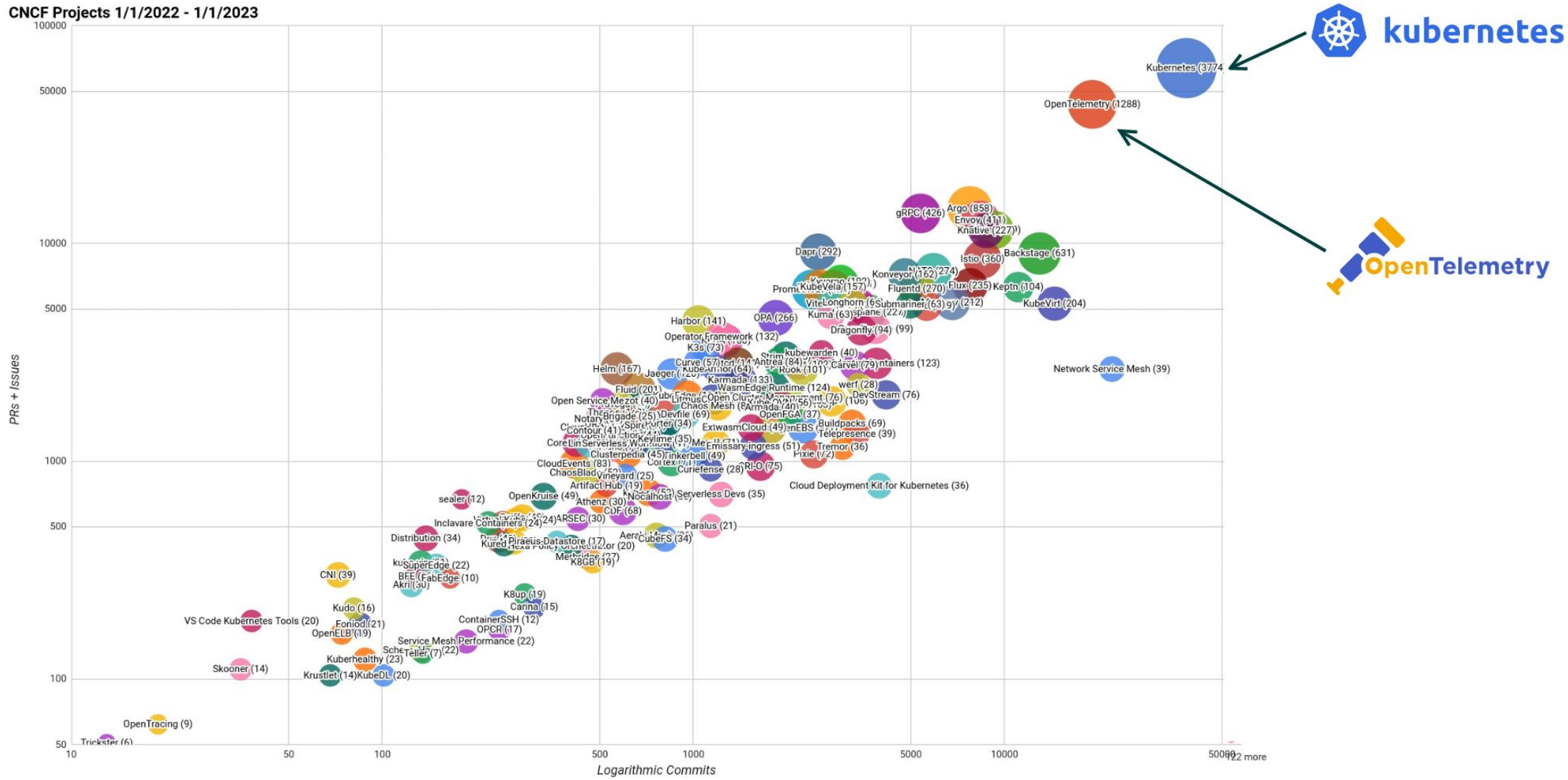


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Thank You for Listening


TailSampling


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