Canopy: An End-to-End Performance Tracing And Analysis System

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Analyzing and troubleshooting performance is difficult

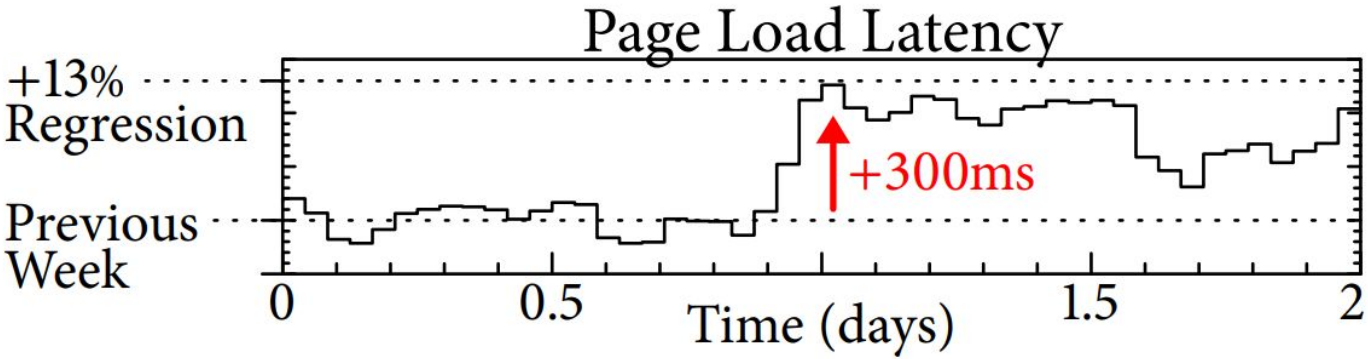
- users perform various actions and use heterogeneous clients
- performance data itself is heterogeneous
- the environment is constantly changing
- our performance tracing system should be open to modification
- we want to be able to do both the exploratory analysis and to look at low-level event data
- many engineers share the same tracing infrastructure

Motivation for creating Canopy

What is Canopy?

- Facebook’s end-to-end performance tracing infrastructure
- records causally related performance data across the end-to-end execution path of requests, including from browsers, mobile applications and backend services
- processes traces in near real-time,derives user-specified features, and outputs to performance datasets
- deployed in 2015
- currently records and processes over 1 billion performance traces per day
- supports interactive ad-hoc analysis of performance data
- enables deep customization by users, from sampling traces to extracting and visualizing features

Canopy analysis example



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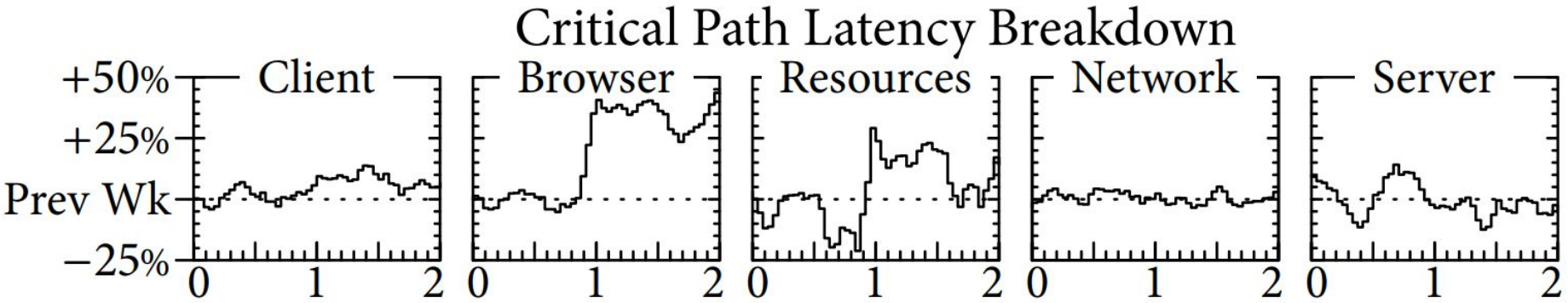

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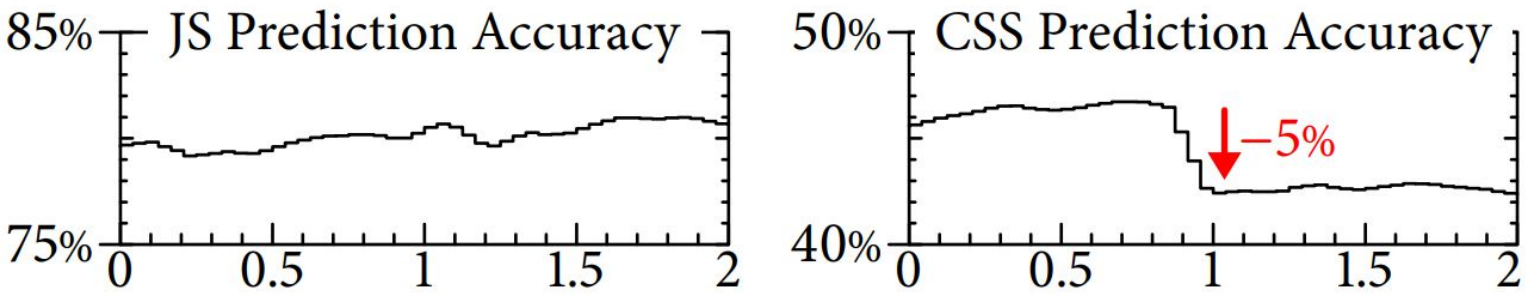
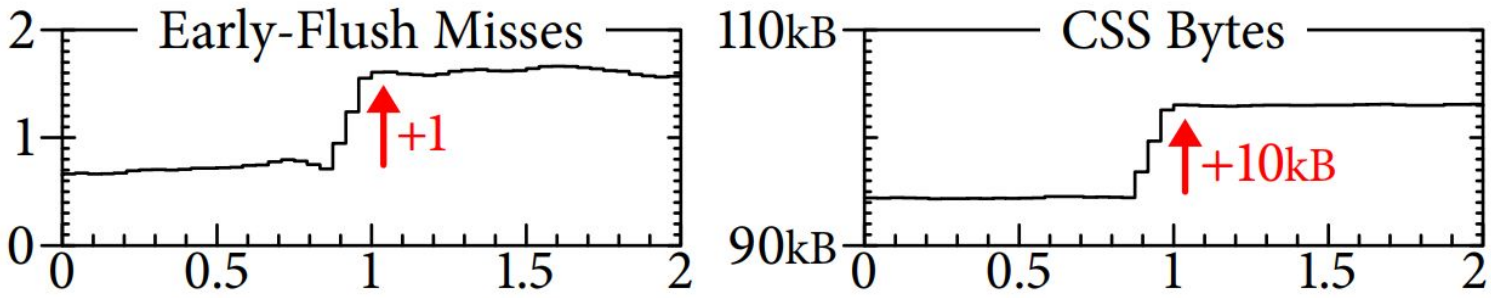


Canopy analysis example



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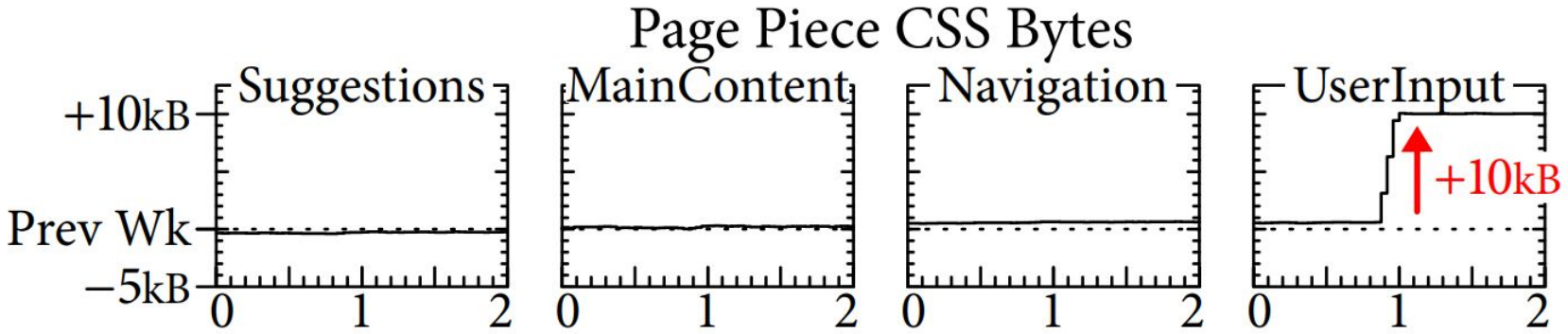

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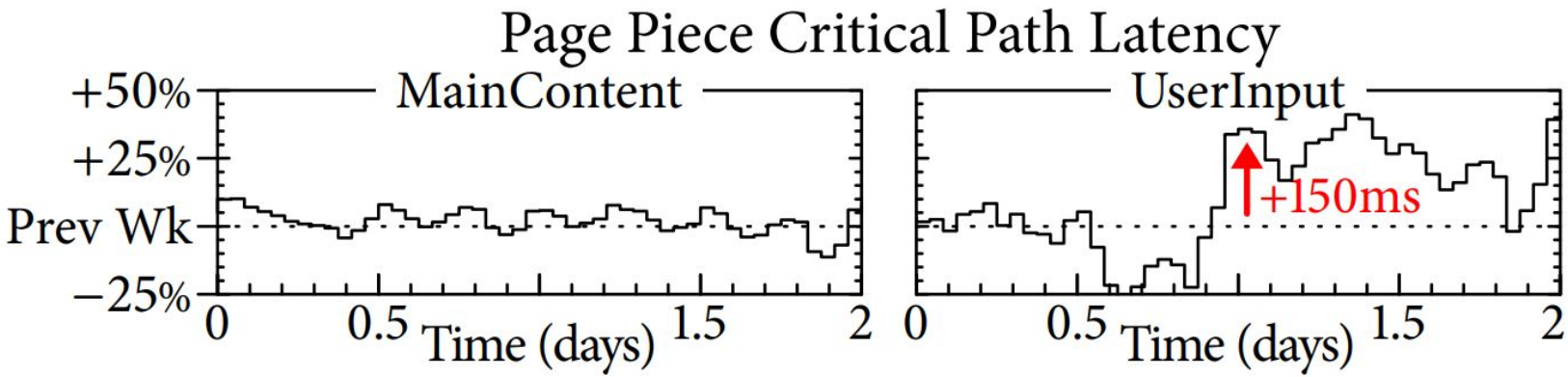
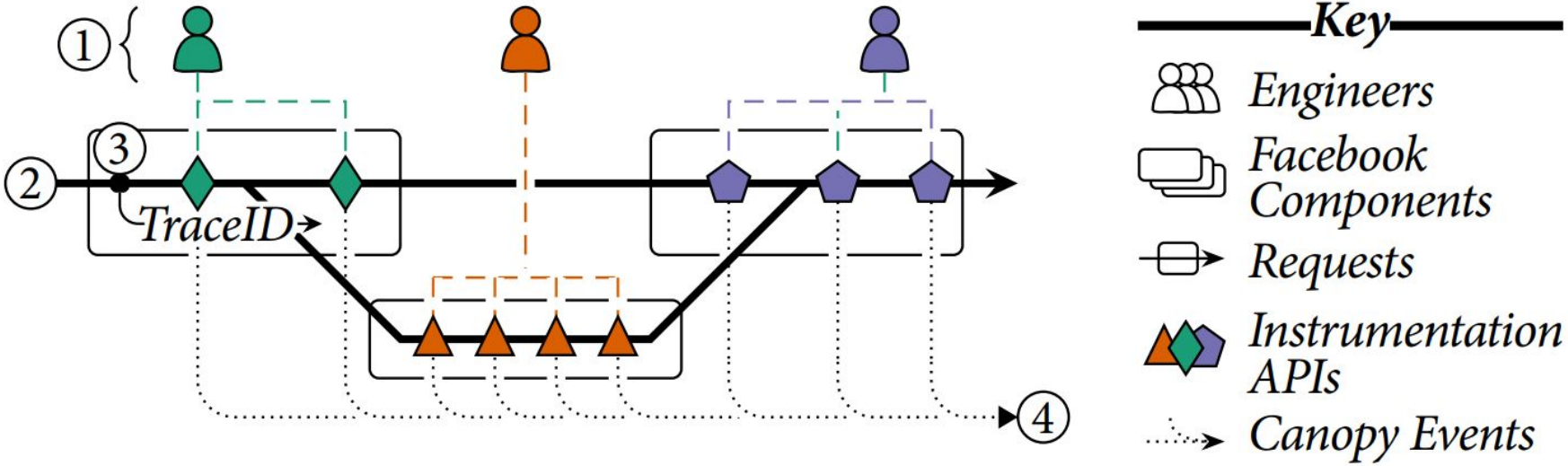
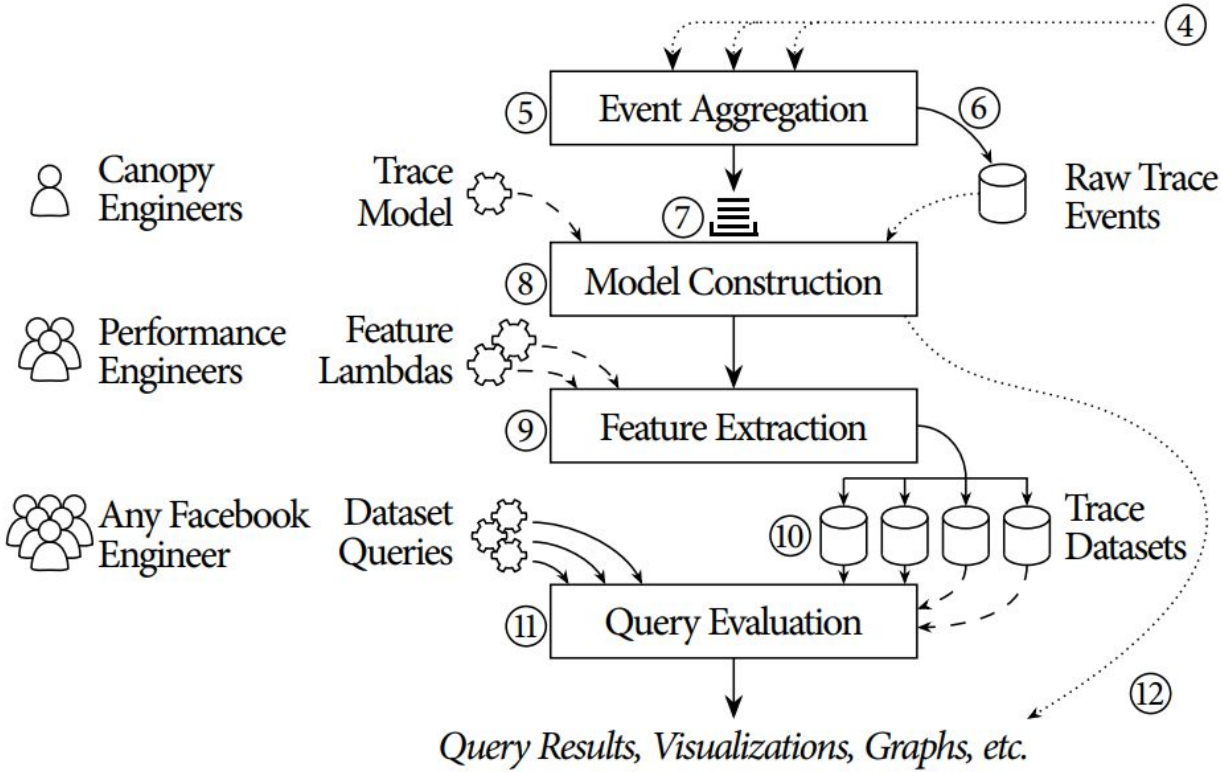


Canopy's high level design



Canopy's high level design



Instrumentation API tasks

- propagate the TraceID alongside requests as they execute, to associate performance data generated by different components
- record the request structure, e.g.where and when it executes, causality between threads and components, and network communication
- capture useful performance data, e.g. logging statements, performance counters, and stack trace

Instrumentation API - Java example

```
try (Block b = Canopy.block("Doing some work")) { ... }
```

Instrumentation API - PHP example

```
Canopy()->inform('Evicting Cache Entry');
Canopy()->measure('Evicting', $evictFunction);
```

Event structure

```
struct Event {
  1: required string traceID;
  2: required string type;
  3: required string id1;
  4: optional string id2;
  5: optional i64 sequenceNumber;
  6: required i64 timestamp;
  7: optional map<string,string> annotations;
}
```

Trace datasets

$$f: \text{Trace} \rightarrow \text{Collection}\langle\text{Row}\langle\text{Feature}\rangle\rangle$$

Trace datasets

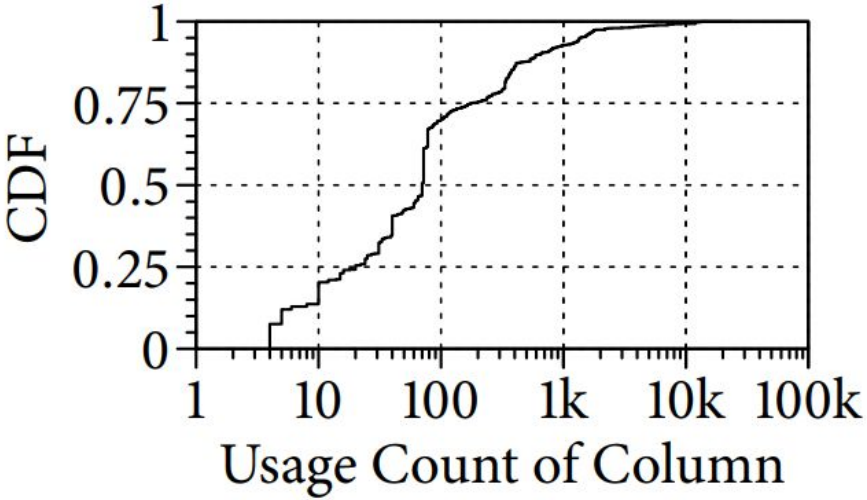
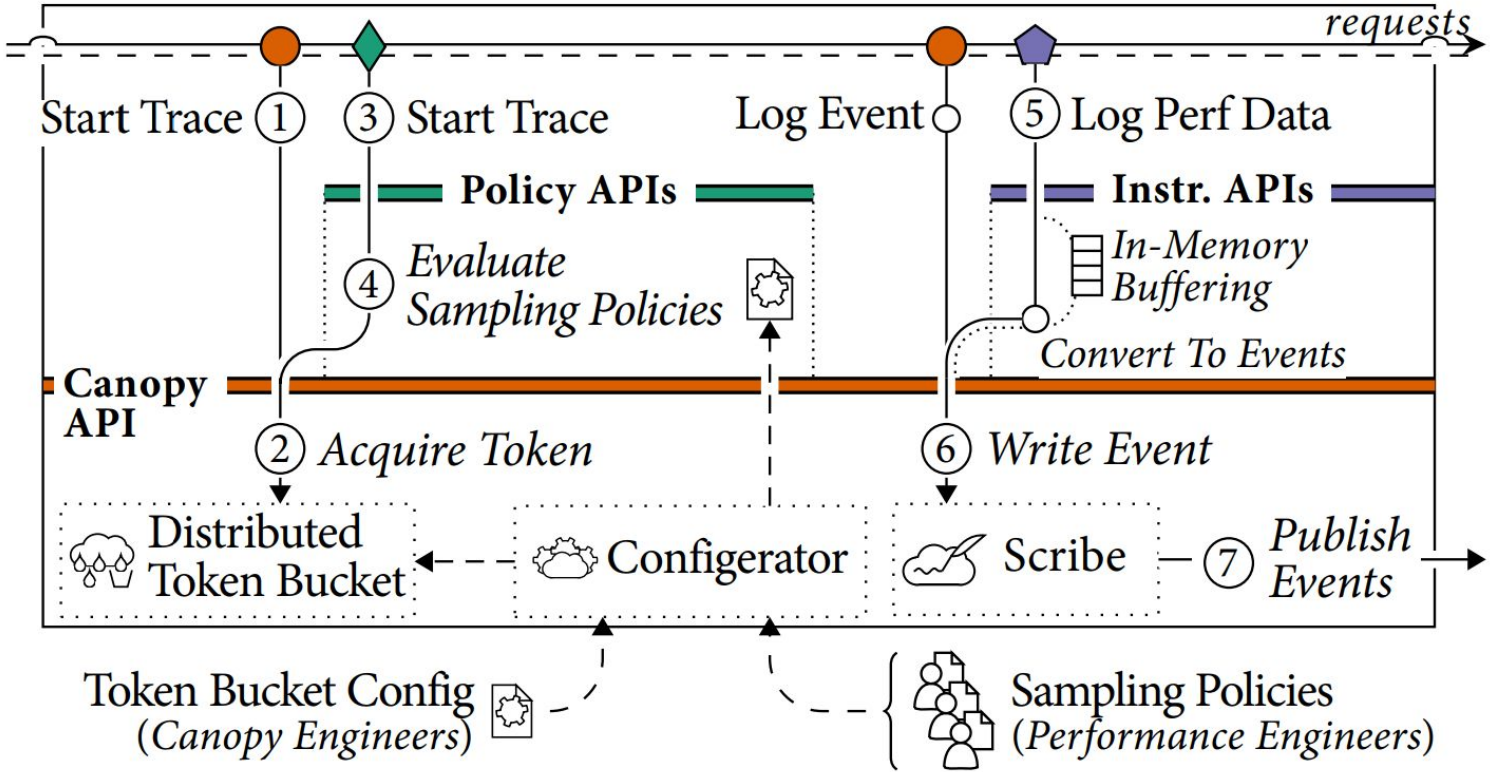
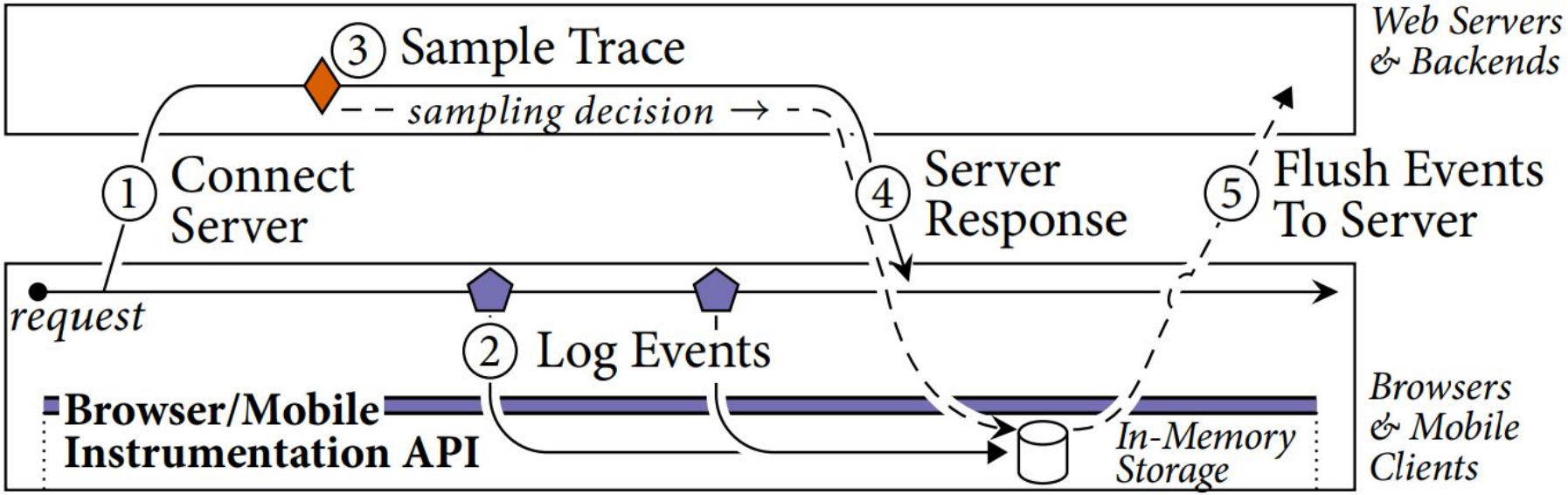


Figure 4: Frequency of columns occurring in dataset queries, for 2,852 columns in 45 datasets, from 6 months of queries to Canopy's main querying UI.

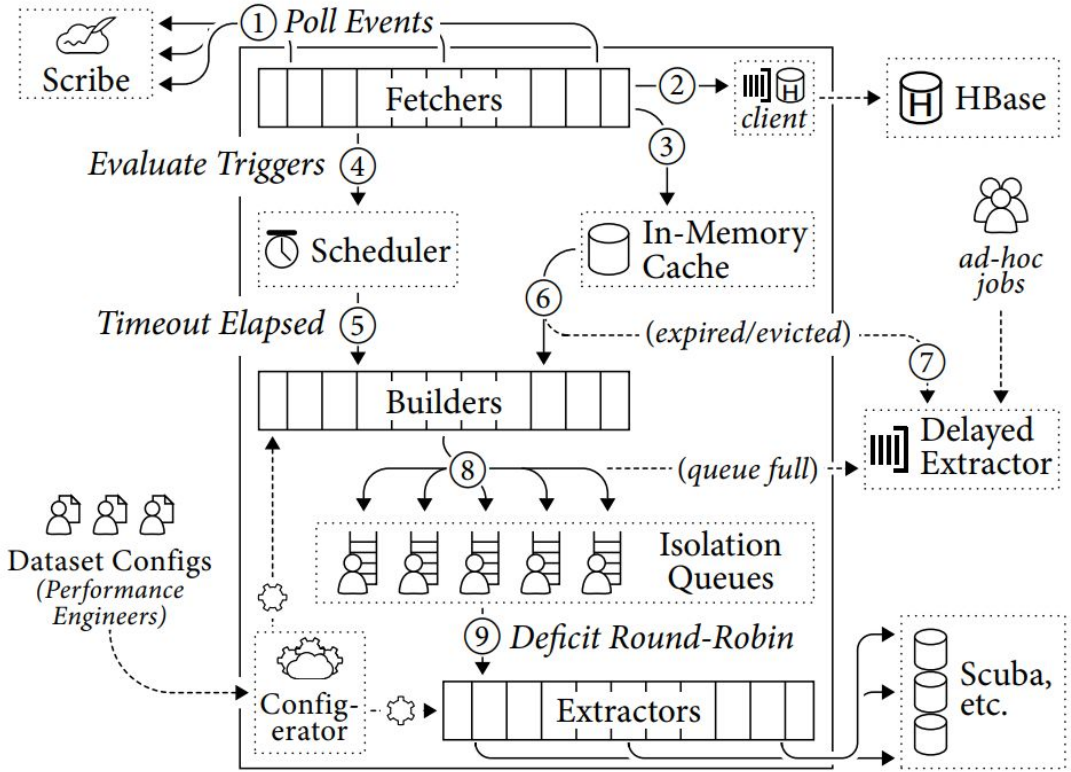
Initiating traces and generating events



Client-side event caching



Tailer architecture



Feature extraction

Find the earliest client-side point

```
Begin = ExecUnits | Filter(name="Client") | Points | First
```

Find the client-side "display done" marker.

```
DisplayDone = ExecUnits | Filter(name="Client") | Points |
              Filter(marker="display_done") | First
```

Calculate display done latency.

```
DisplayDone | Timestamp | Subtract(Begin | Timestamp) |
 RecordAs("display_done")
```

Find all network resource loading on the critical path.

```
ResourceEdges = CriticalPath(Begin->DisplayDone) | Edges |
                Filter(type="resource")
```

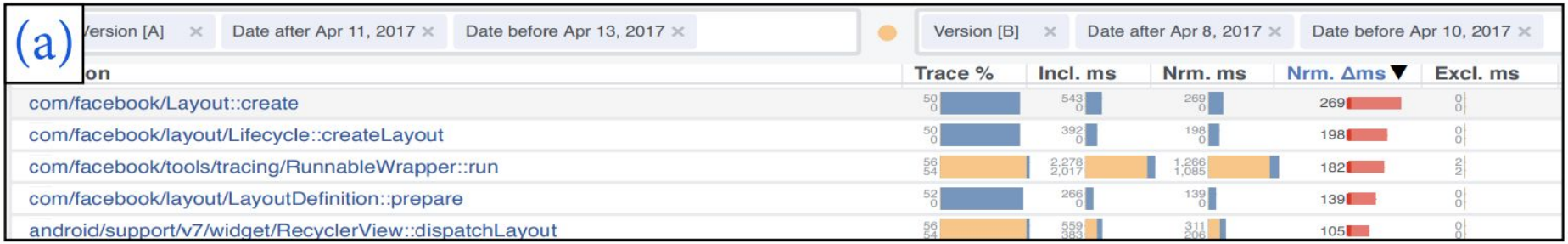
Calculate the total resource loading time on the critical path.

```
ResourceEdges | Duration | Sum | RecordAs("res_load")
```

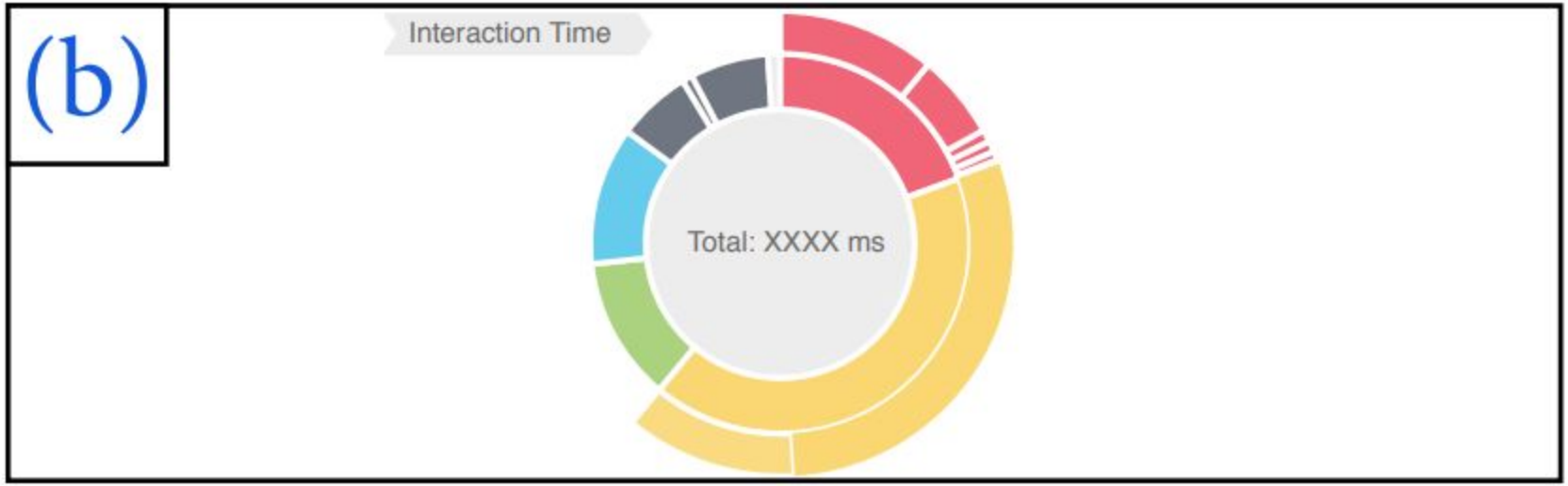
Calculate the total CSS bytes on the critical path.

```
ResourceEdges | Filter(resource="css") | Counter(bytes) |
 Sum | RecordAs("css_bytes")
```

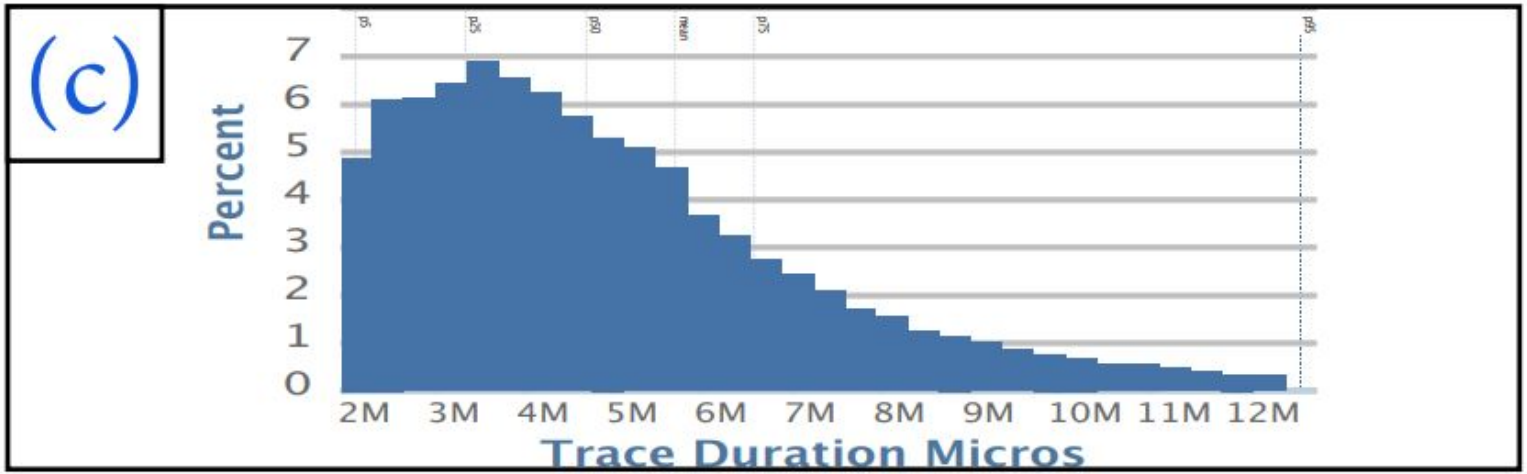
Querying and visualization



Querying and visualization



Querying and visualization



Querying and visualization

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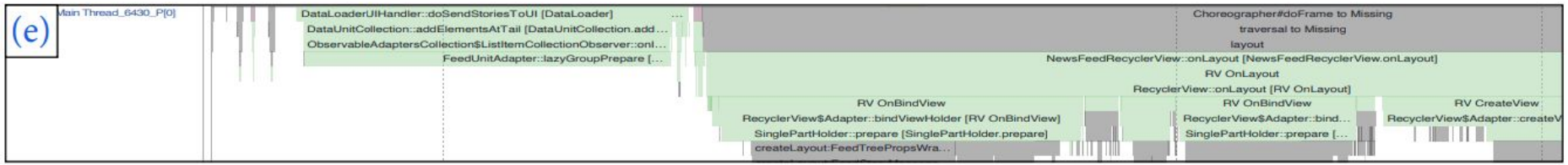
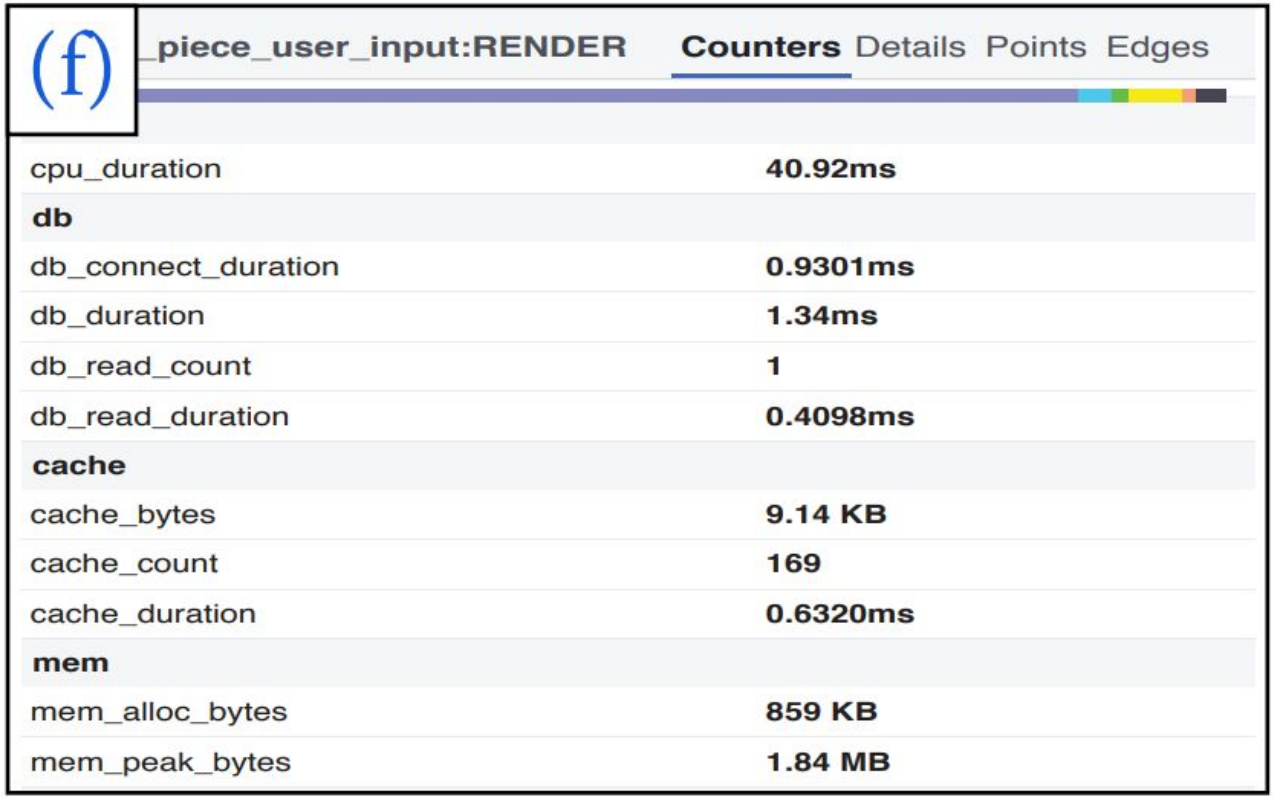


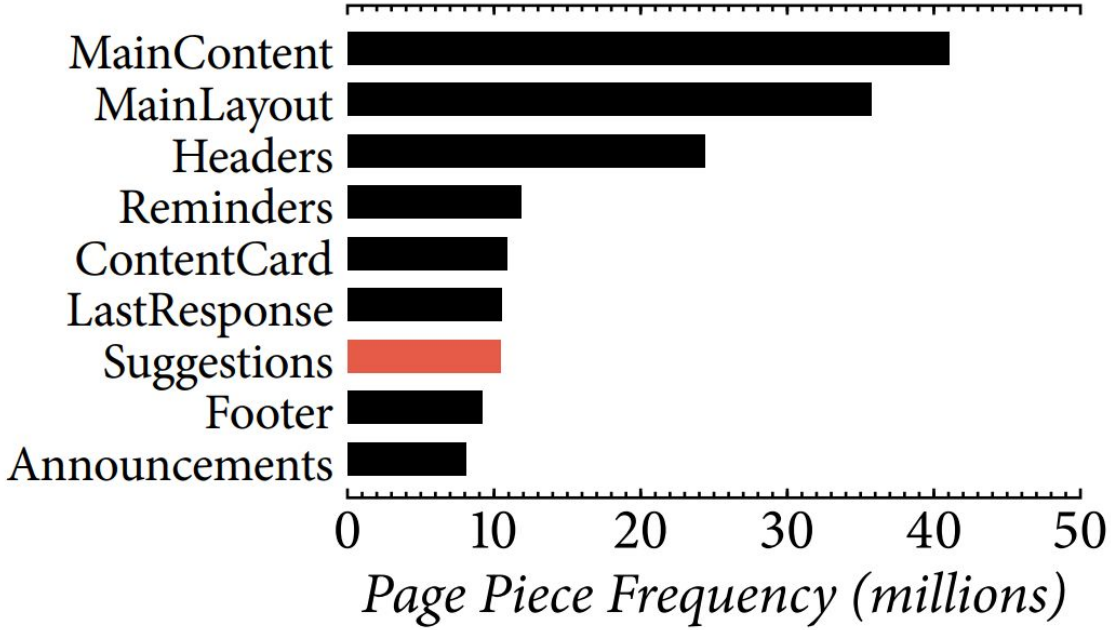
Querying and visualization



Canopy performance overhead

		Mean	1st	25th	50th	75th	99th
WWW	CPU	6.76%	11.11%	7.31%	6.86%	6.44%	4.44%
	Wallclock	2.28%	7.11%	2.18%	2.14%	2.38%	2.70%
Android	Cold Start	8.57%	5.29%	4.88%	10.78%	13.37%	0.00%
Service	ServiceA Wallclock	8.15%	6.83%	7.03%	7.15%	7.53%	10.44%
	ServiceB Wallclock	0.76%	0.72%	0.79%	0.80%	0.79%	0.38%

Case studies - causal ordering



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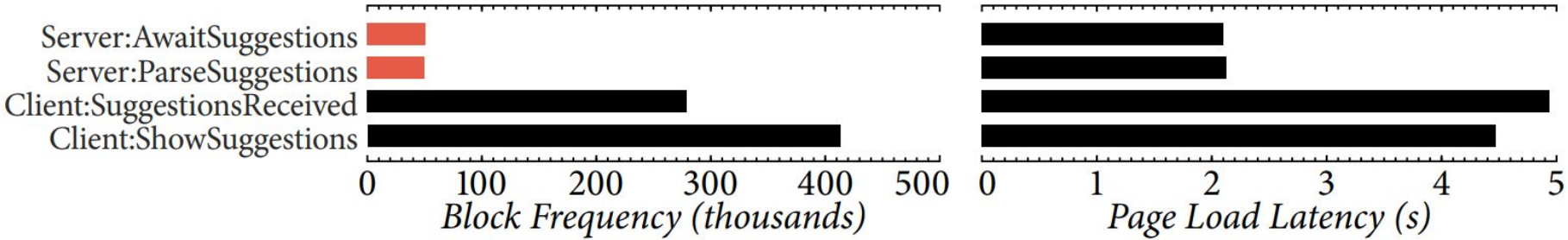

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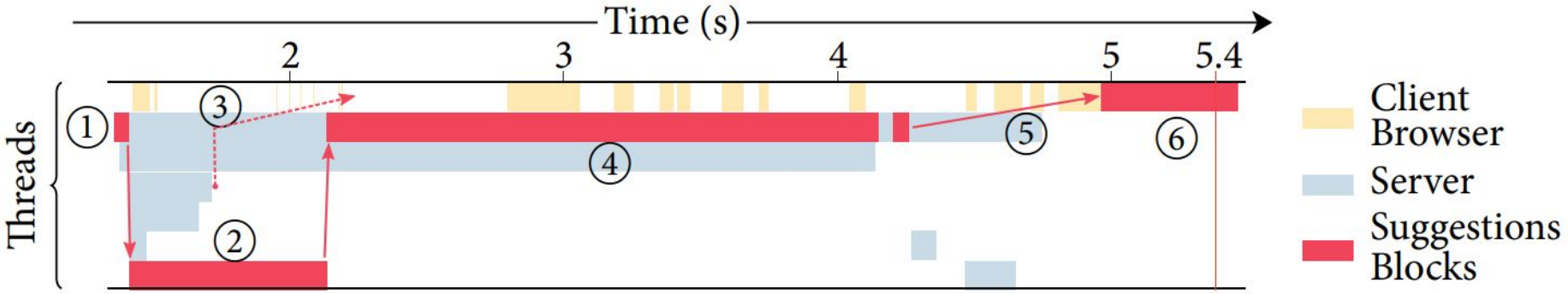

Other case studies

Thank you for listening!

Questions?