An Experimental Study of **Rapidly Alternating Bottleneck** in n-Tier Applications

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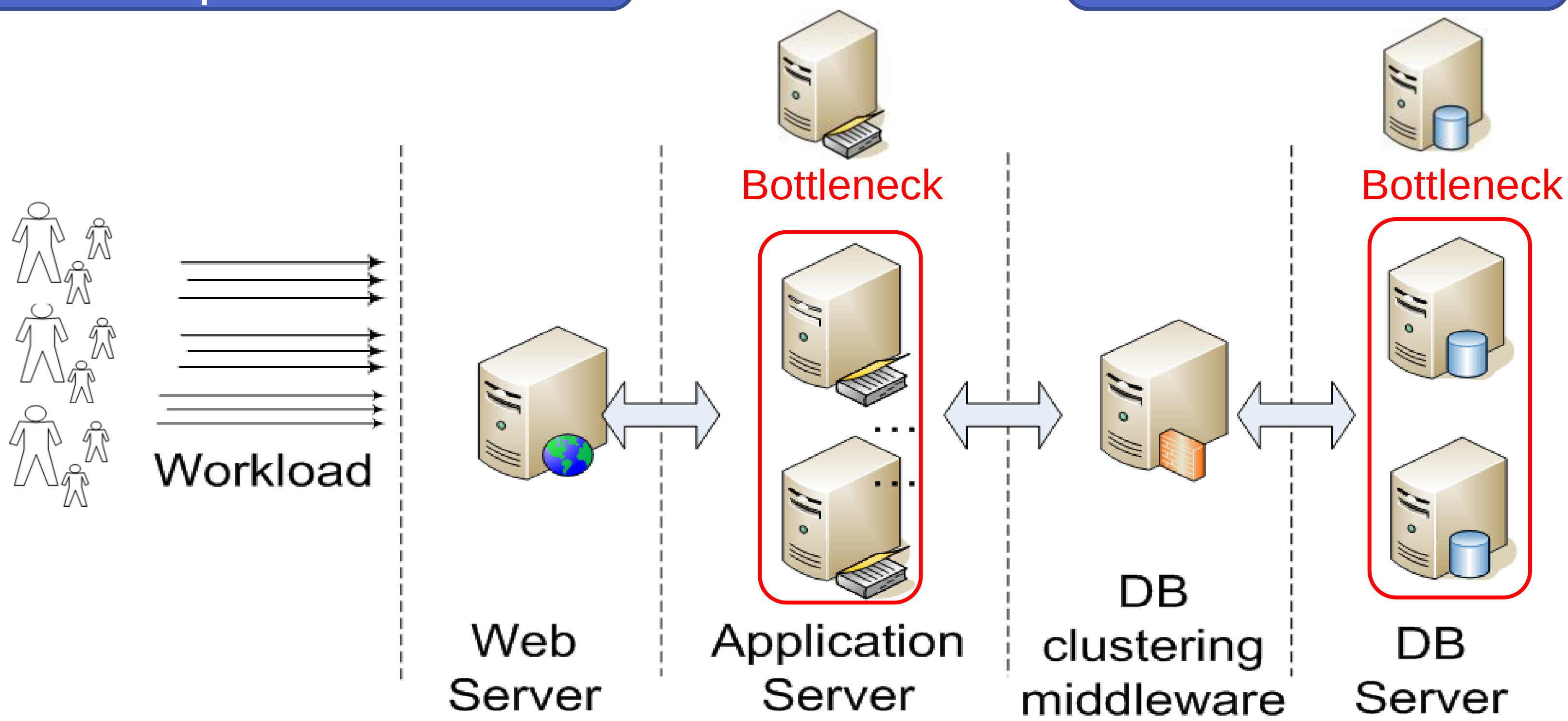
Scaling Web Applications On-Demand in Cloud

Good performance + Cost efficiency

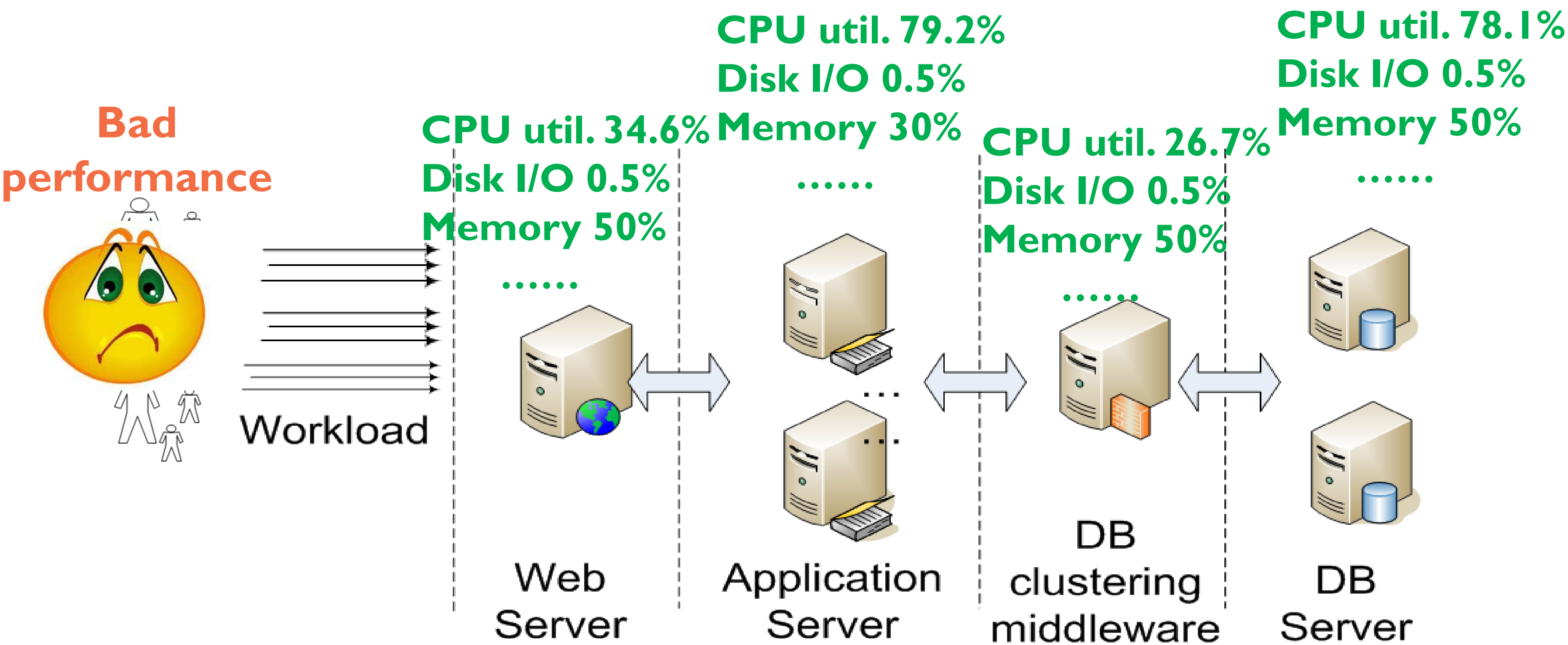
High throughput + low response time

High resource utilization

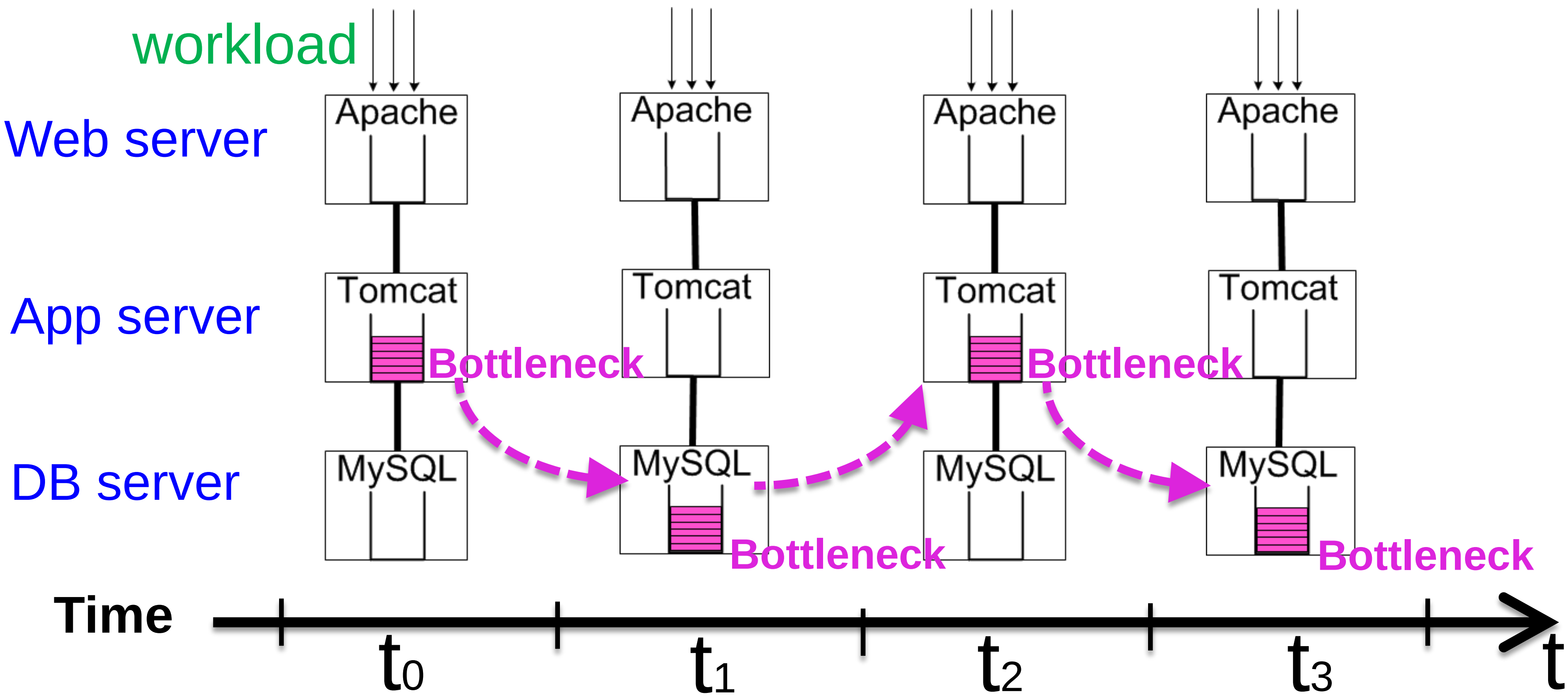


What If No Bottleneck Was Detected?

How to scale a web application while no bottleneck is identified?



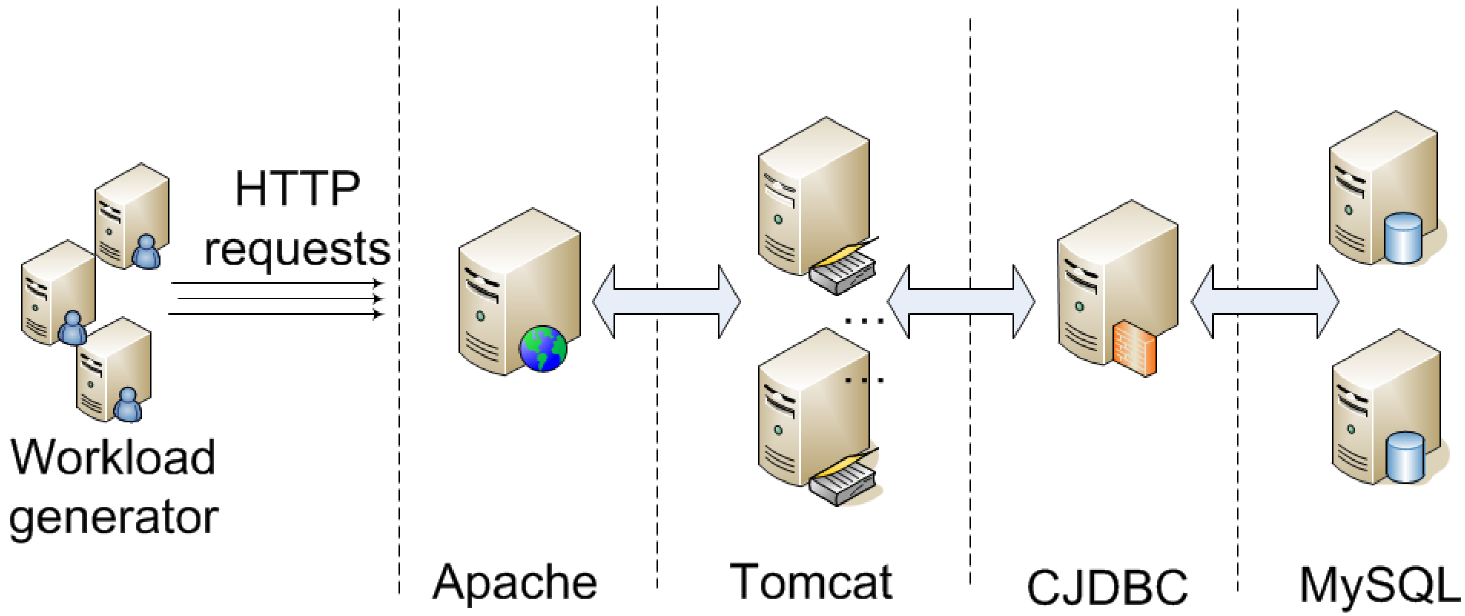
Rapidly Alternating Bottlenecks



1. Throughput is limited with no saturated resources

2. Duration of each bottleneck is short (e.g., < 100ms)

Experimental Setup

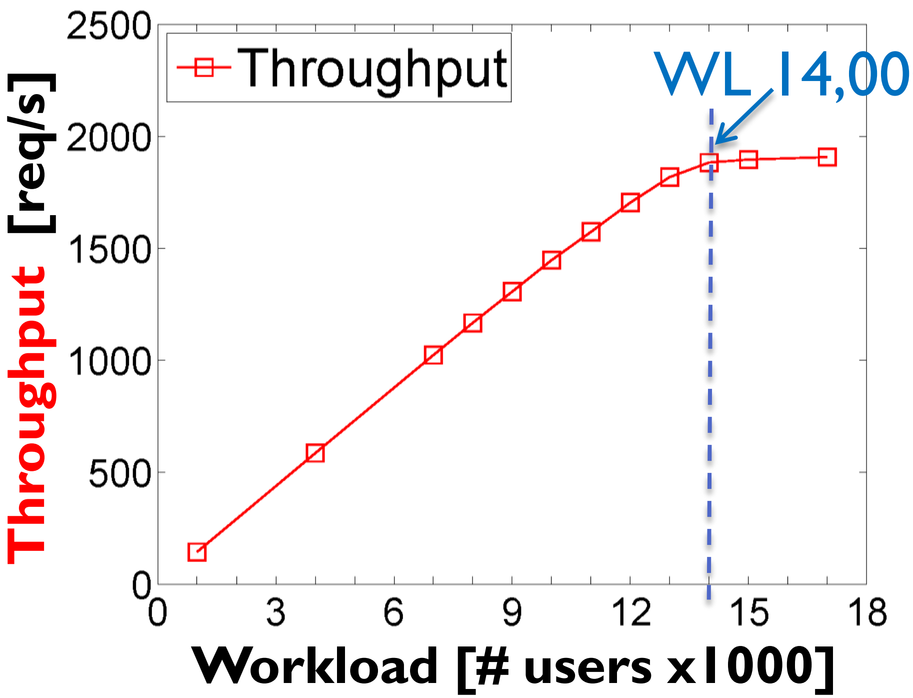


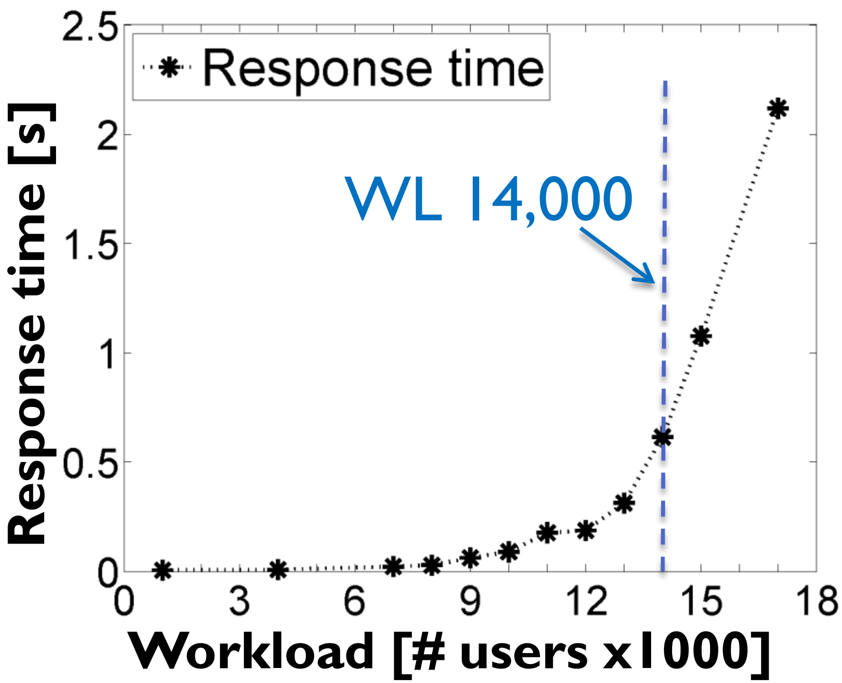
- RUBBoS benchmark: a bulletin board system like Slashdot
- 24 web interactions
  CPU intensive
- Workload consists of emulated clients

- Intel Xeon E5607
  2 quad-core 2.26 GHz
  16 GB memory

Motivational Example

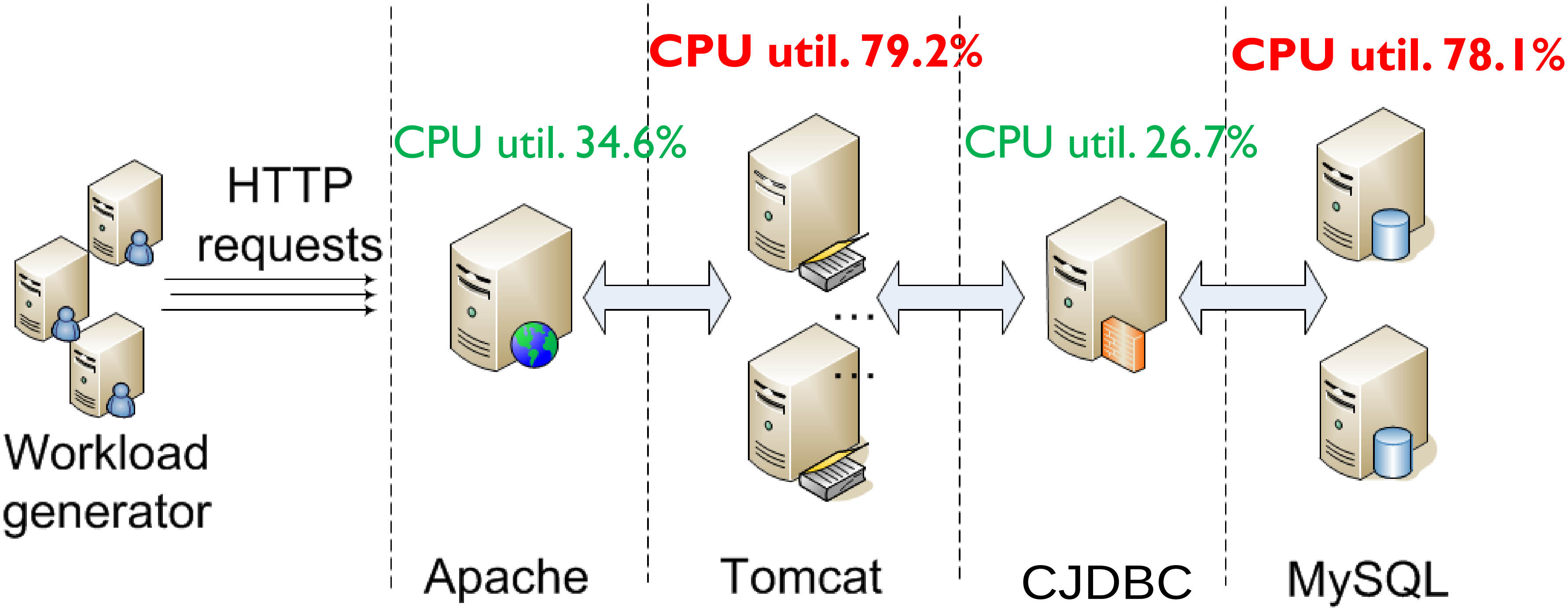
- Response time & throughput of a 3-minute benchmark on the 4-tier application with increasing workloads.





No Obvious Bottleneck is Detected at WL 14,000

- Workload is CPU intensive
  - Disk I/O utilization (<5%), network I/O utilization (< 20%), Memory usage (<40%);



Rapidly Alternating Bottleneck: Sources and Detection

- Sources: We find that other than bursty workload, system environmental conditions:
  - JVM garbage collection
  - VM collocation

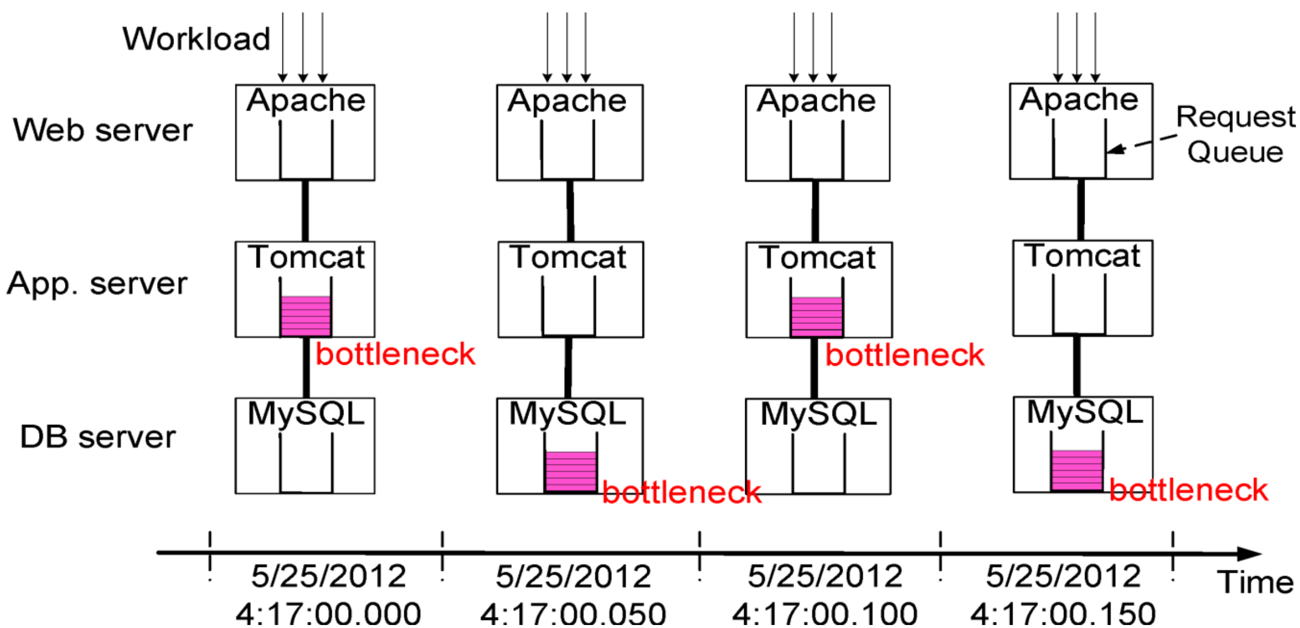
- Detection and Visualization: We implement a fine-grained monitoring method based on passive network tracing.
  - Negligible monitoring overhead for running applications

Outline

- Introduction & Motivation
- Detection and Visualization
  - Fine-grained load/throughput analysis
- Two Observations of Rapidly Alternating Bottlenecks
  - JVM garbage collection (JVM GC)
  - VM collocation
- Conclusion & Future Works

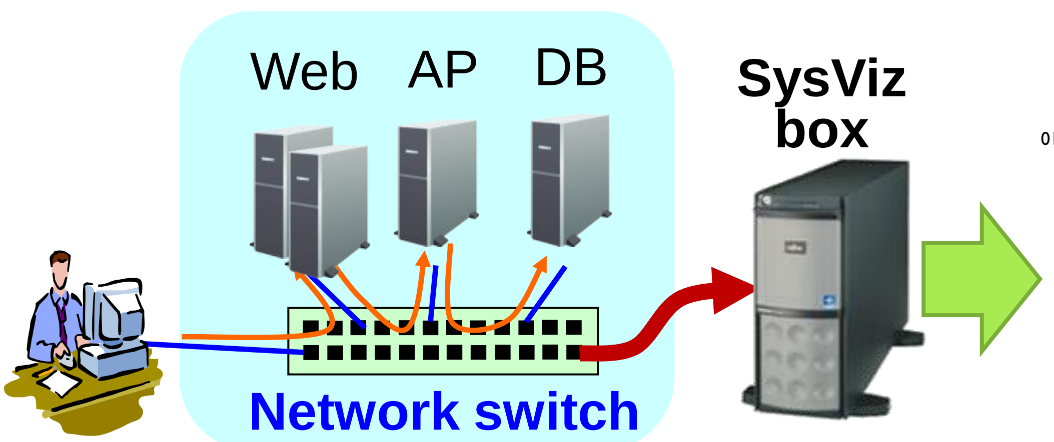
Two Steps for Detecting Rapidly Alternating bottlenecks

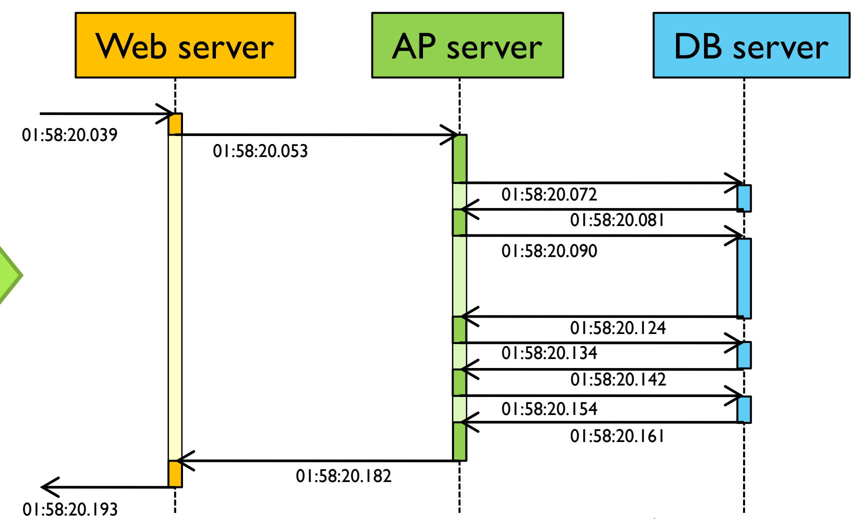
1. Find the participating servers that present transient bottlenecks(e.g., 50ms)
2. Check whether the transient bottlenecks of each participating server occur in an alternating pattern



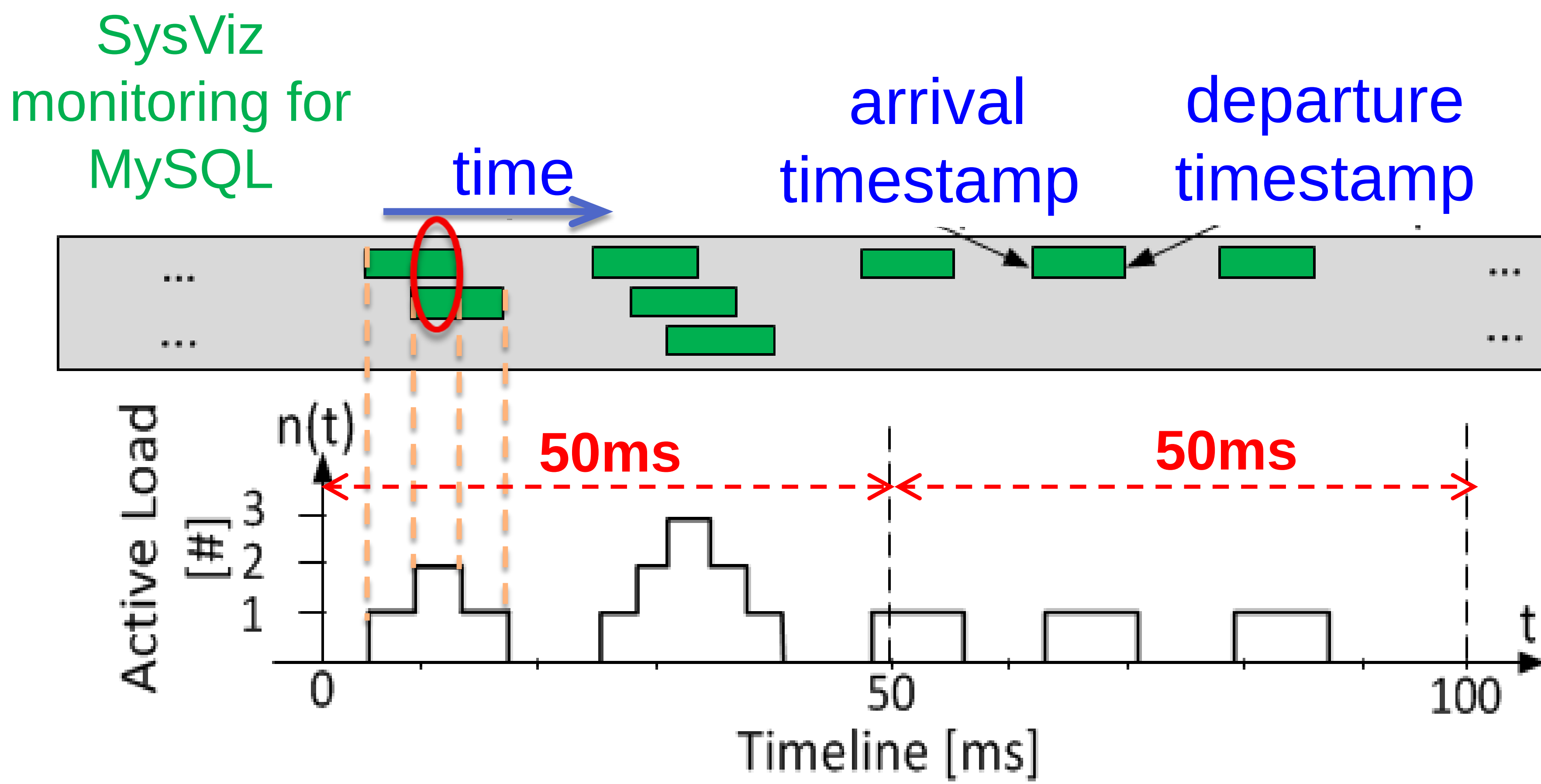
Passive Network Tracing Infrastructure

- Collect interaction messages in the system using SysViz to measure fine-grained active load and throughput on each server.
  - **Active load**: The # of concurrent requests in a server
  - **Throughput**: The # of completed requests of a server

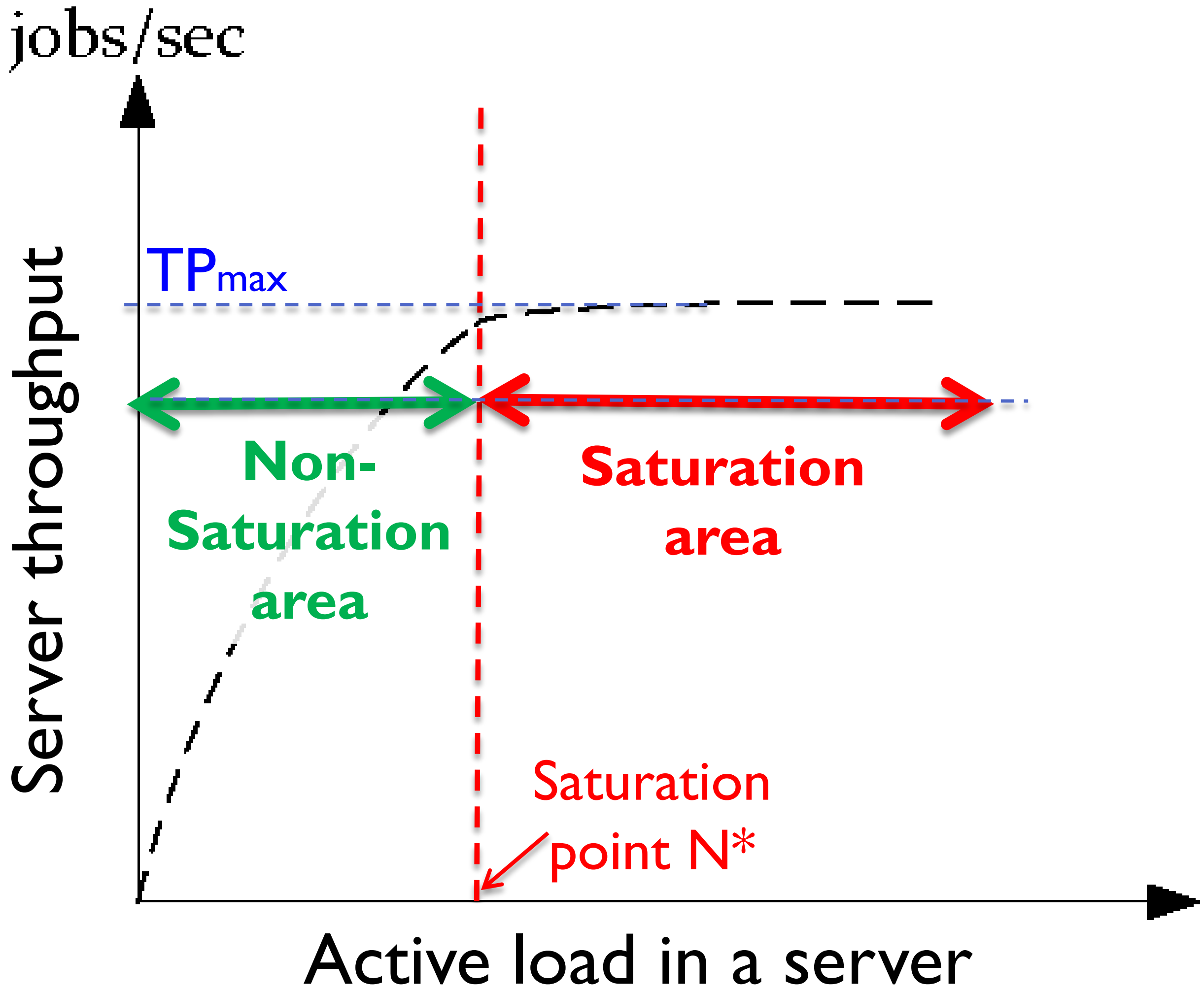




Fine-Grained Active Load Calculation in a Server



Active-Load/Throughput Correlation Analysis



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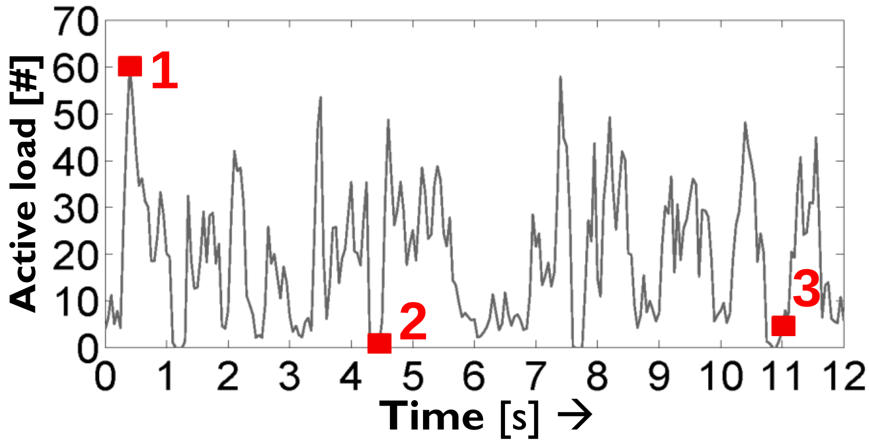
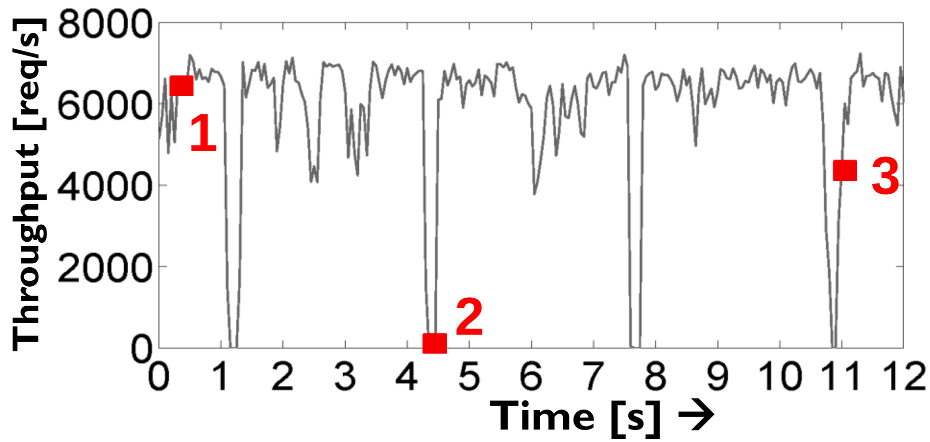
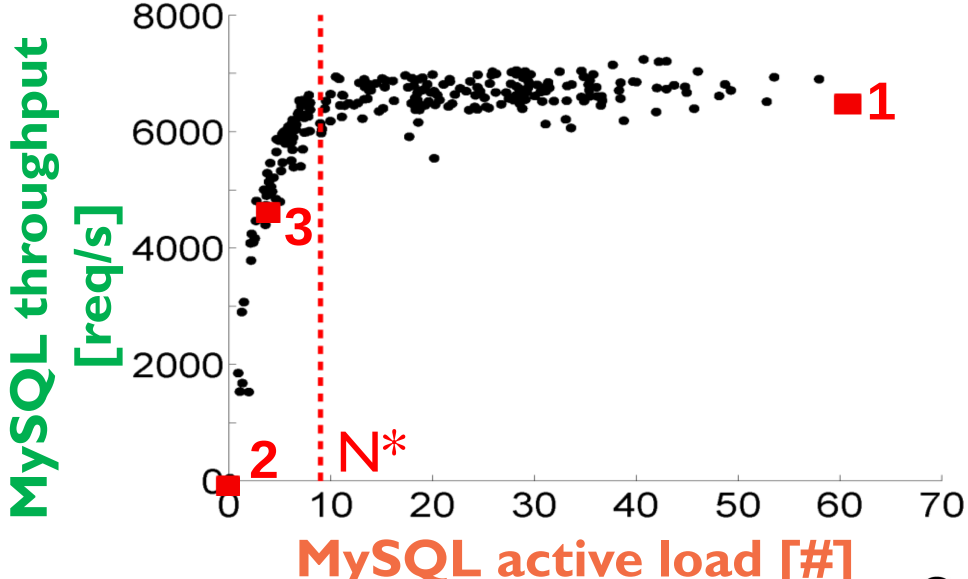
Active-Load/Throughput Analysis for MySQL at WL 14,000

MySQL active load (every 50ms)



MySQL throughput (every 50ms)





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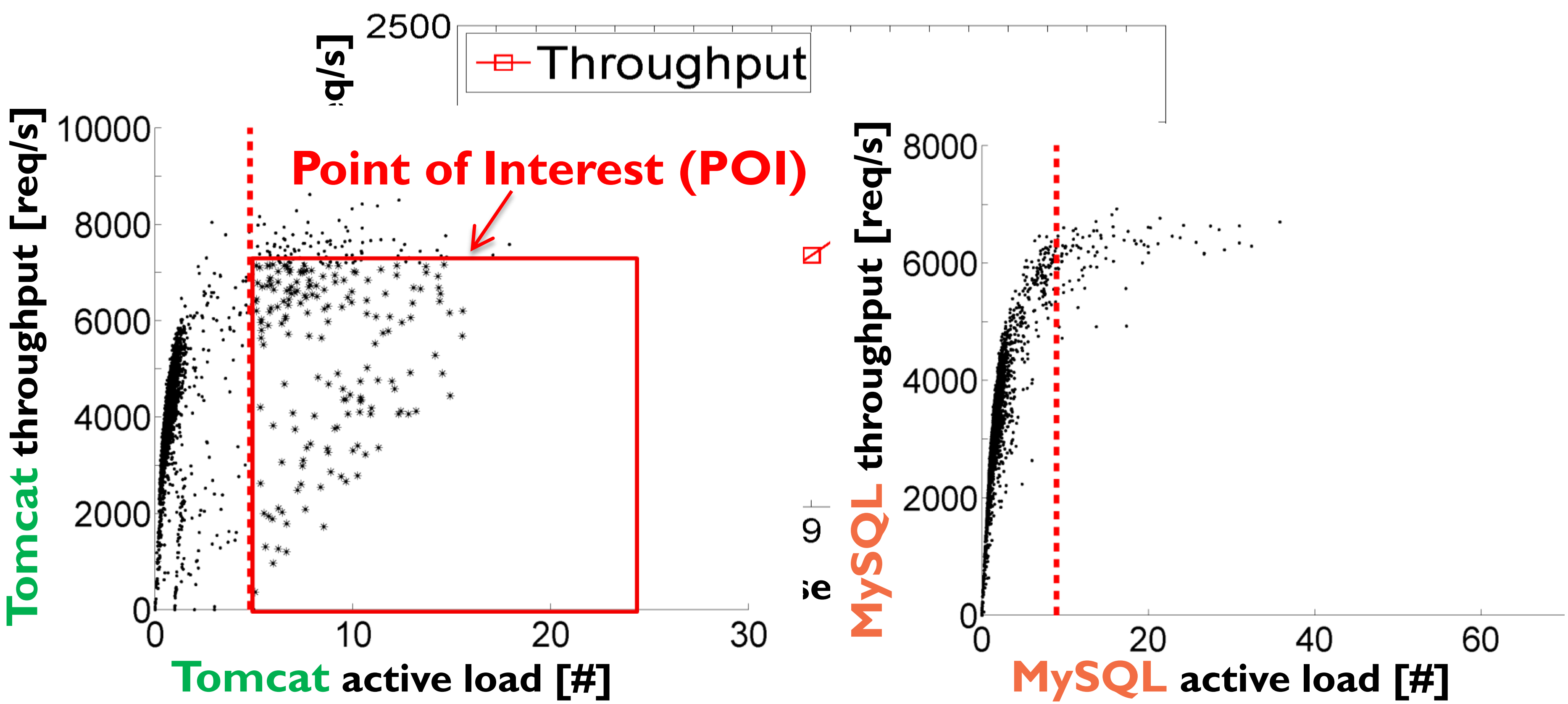
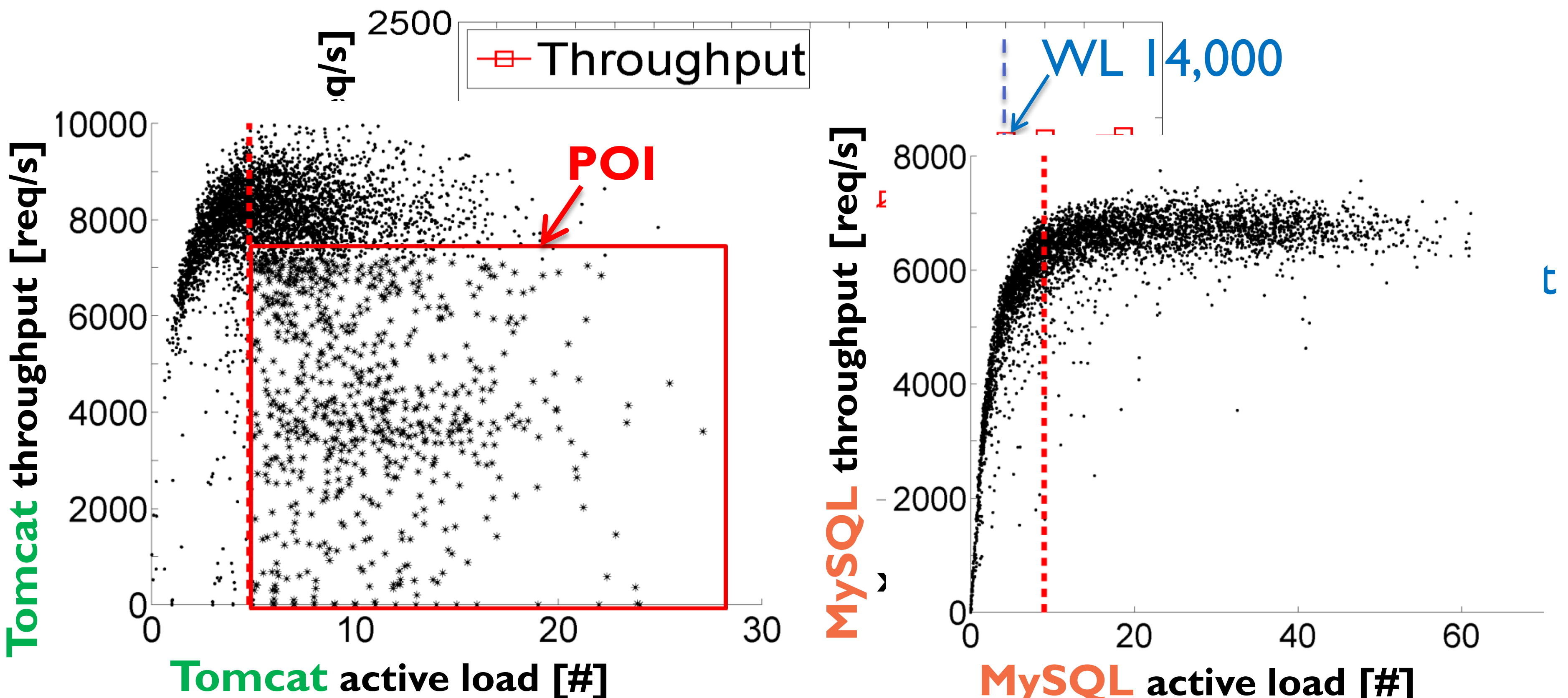
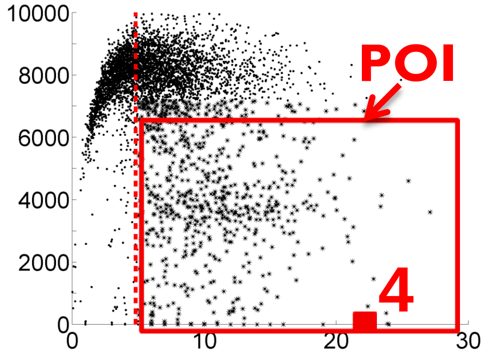
Active-Load/Throughput Analysis at Workload 7,000



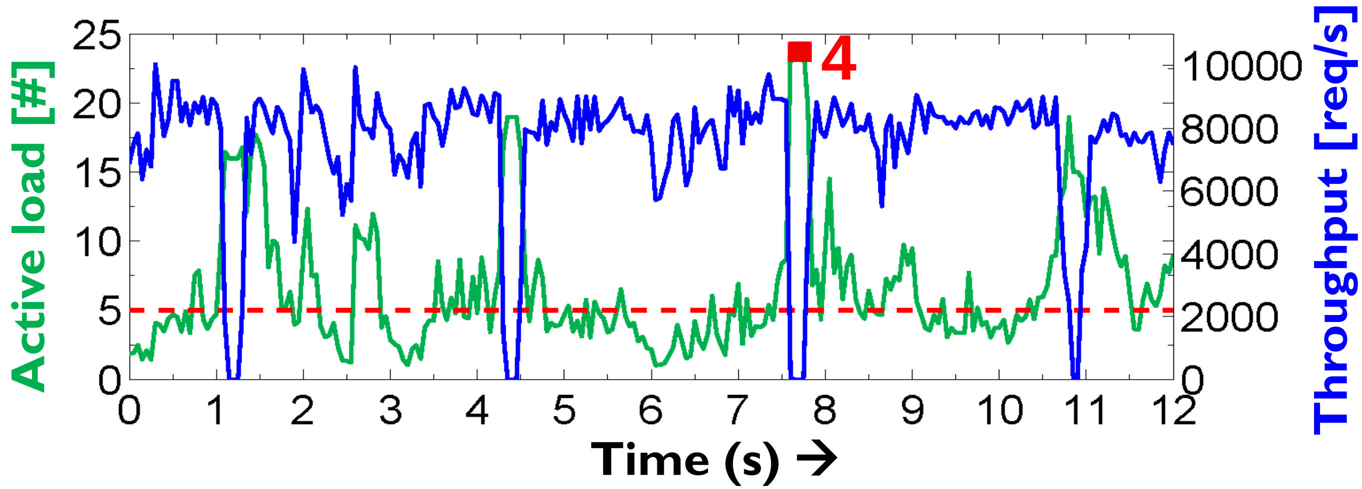
Active-Load/Throughput Analysis at Workload 14,000

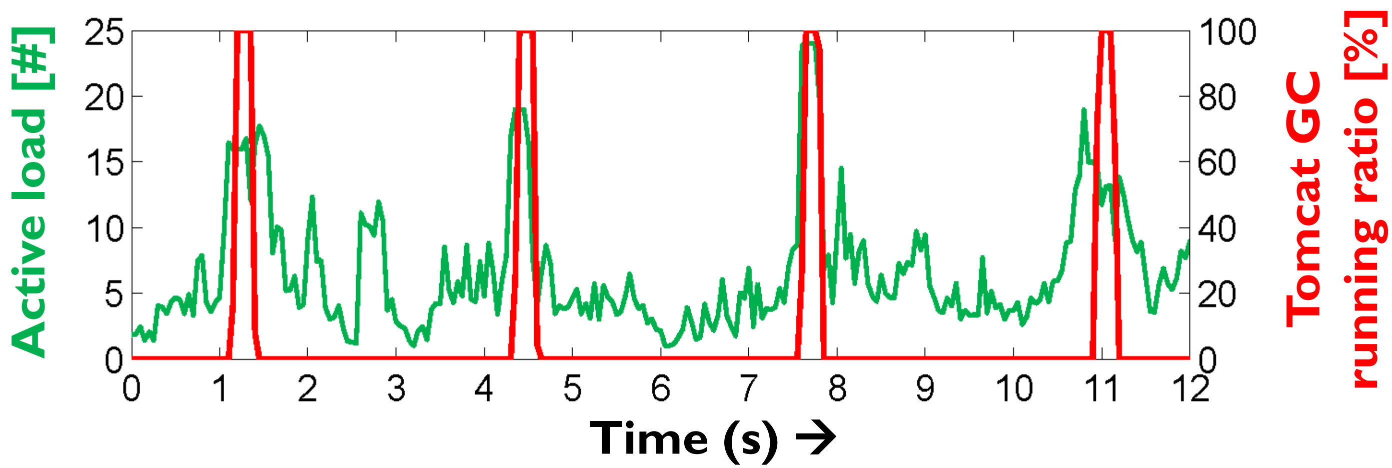


Timeline Analysis at Workload 14,000

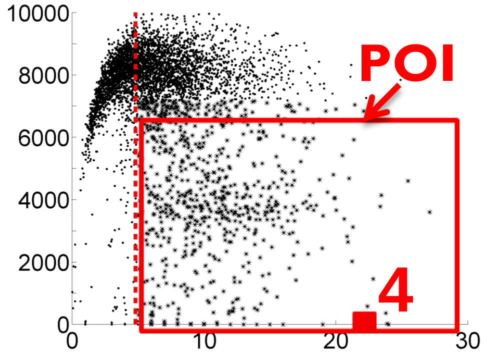


Tomcat scatter graph

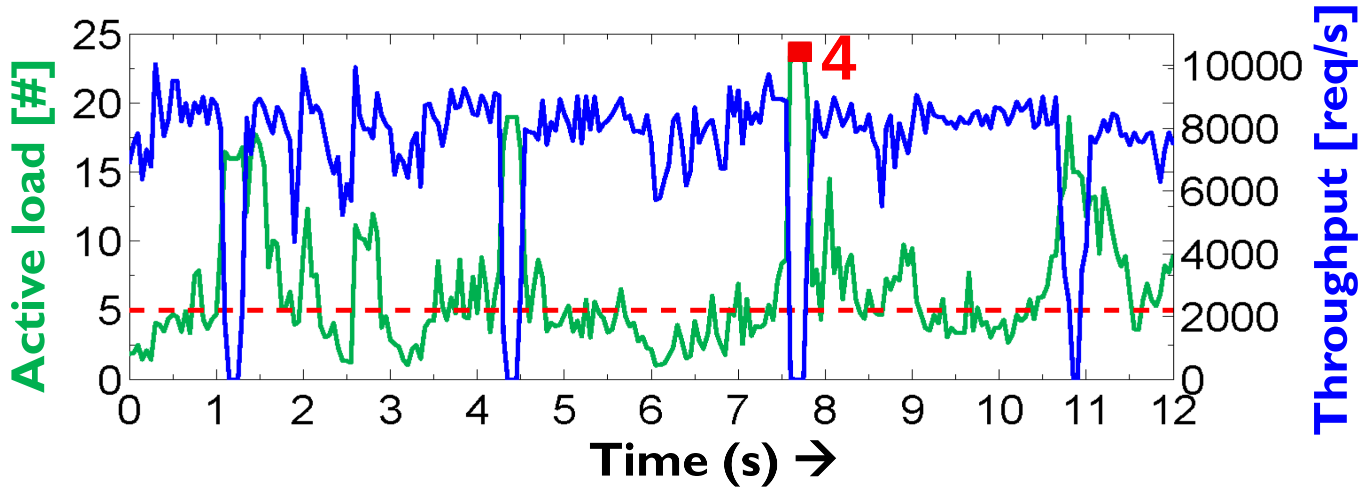


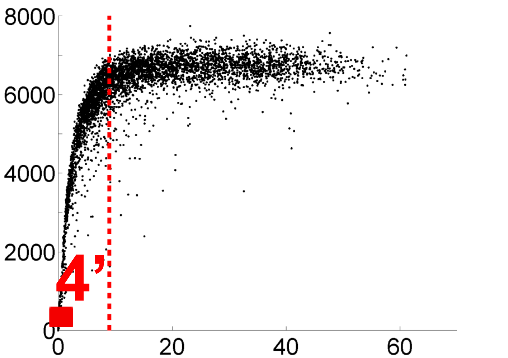


Timeline Analysis at Workload 14,000 (Cont.)

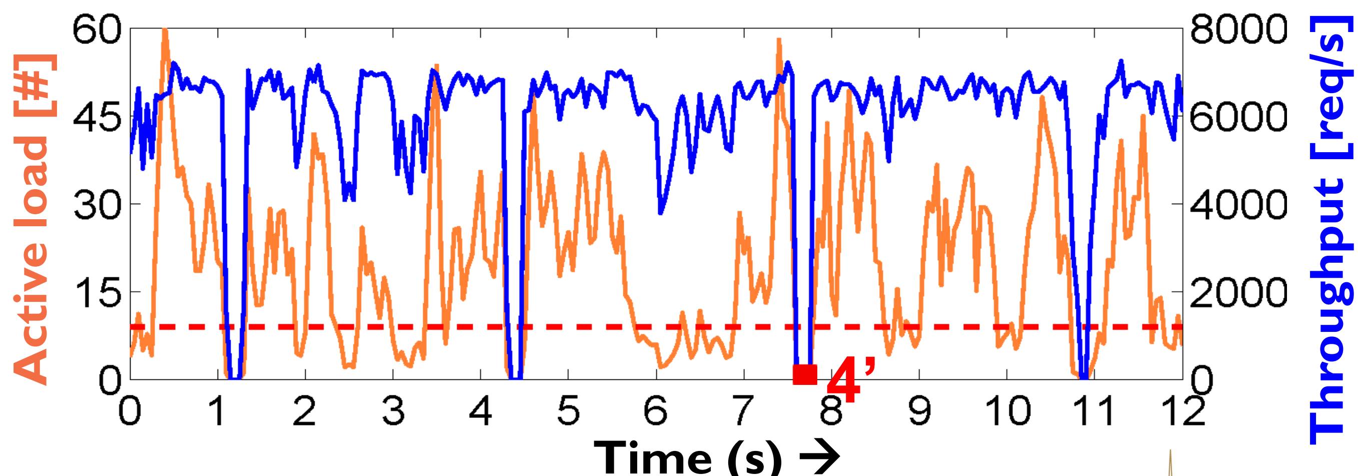


Tomcat scatter graph





MySQL scatter graph



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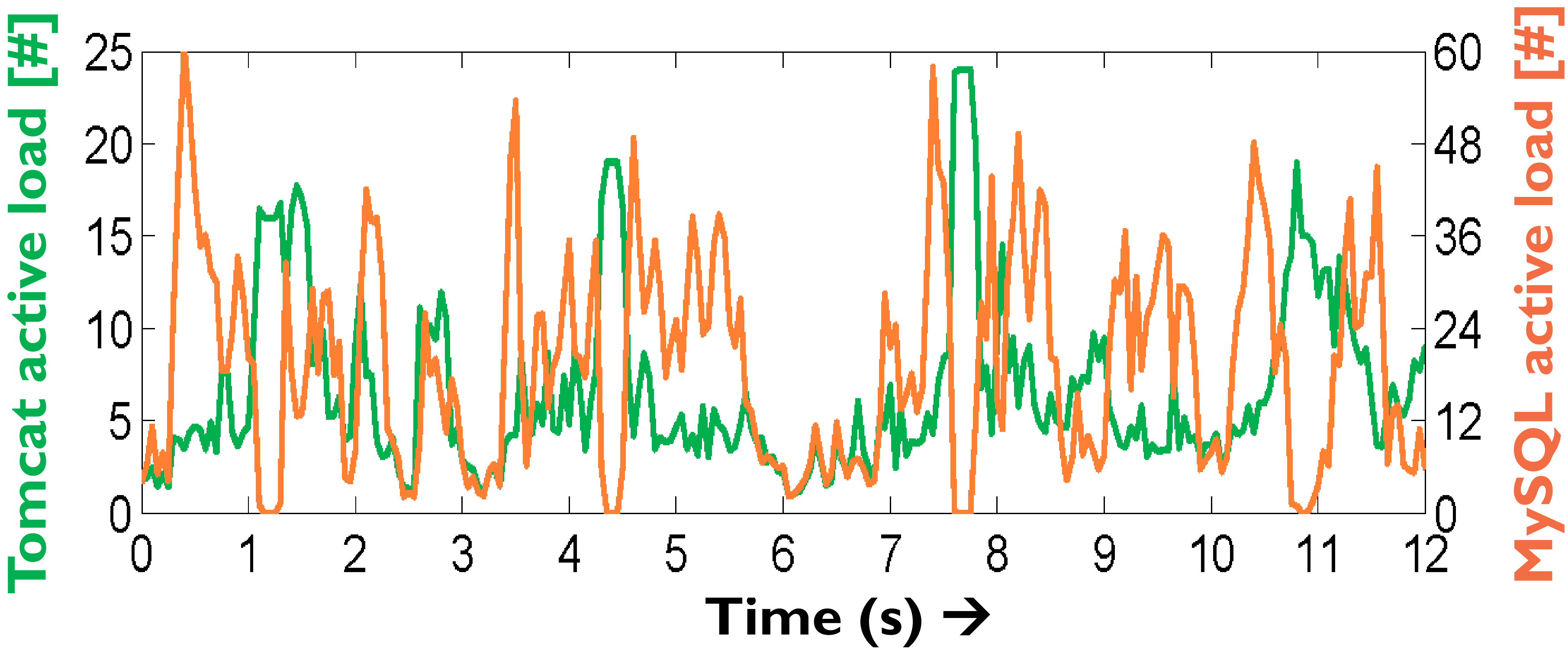
Correlation Analysis of Rapidly Alternating Bottlenecks



Correlation coefficient: -0.42, negative correlation suggests rapidly alternating bottleneck.

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Conclusion & Future Work

- Rapidly alternating bottlenecks can cause non-trivial performance loss in an n-tier system.
- We proposed a rapidly alternating bottleneck detection and visualization method through fine-grained active-load/throughput analysis
- Ongoing work: more analysis of different types of workloads and more system factors that cause rapidly alternating bottlenecks.

Thank You. Any Questions?

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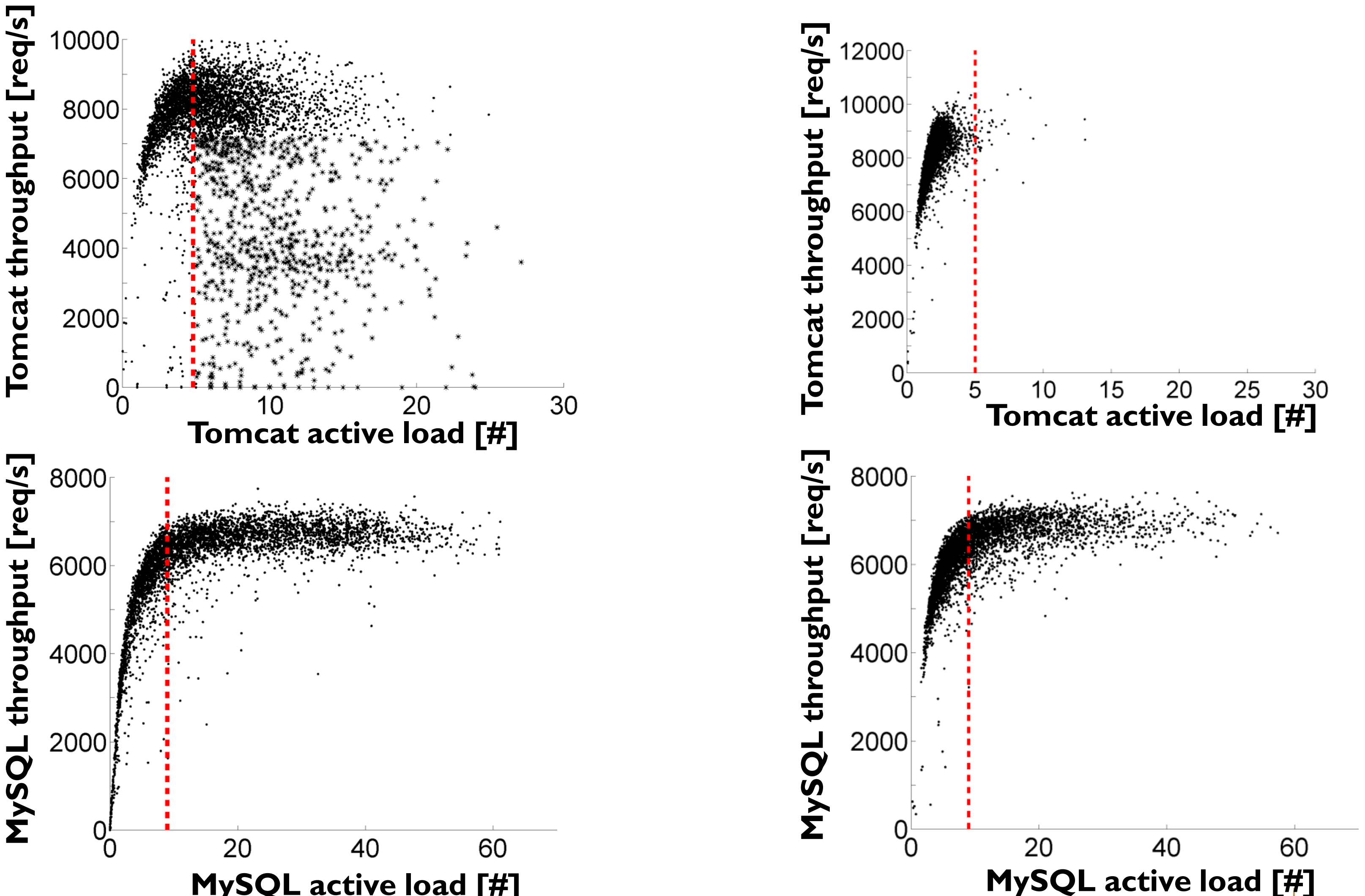
Backup slides

Resolving Rapidly Alternating Bottlenecks



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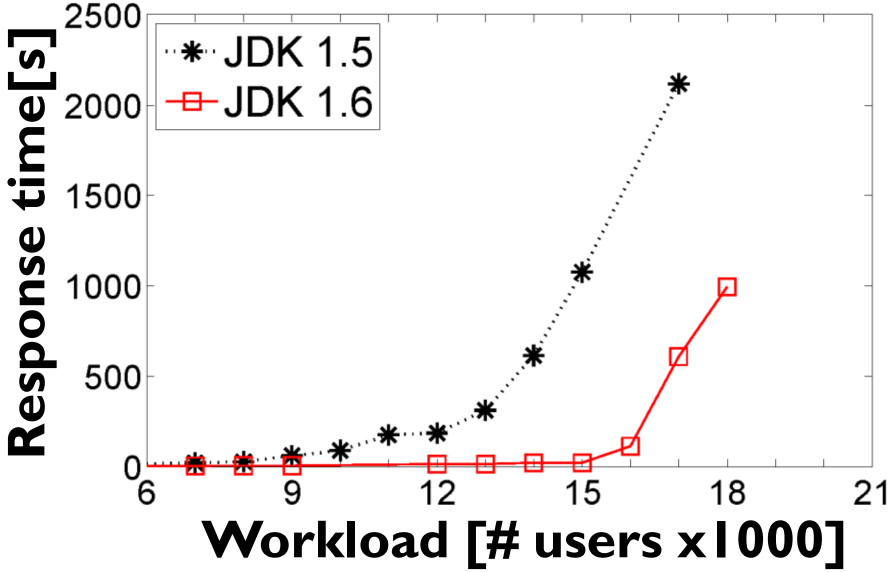
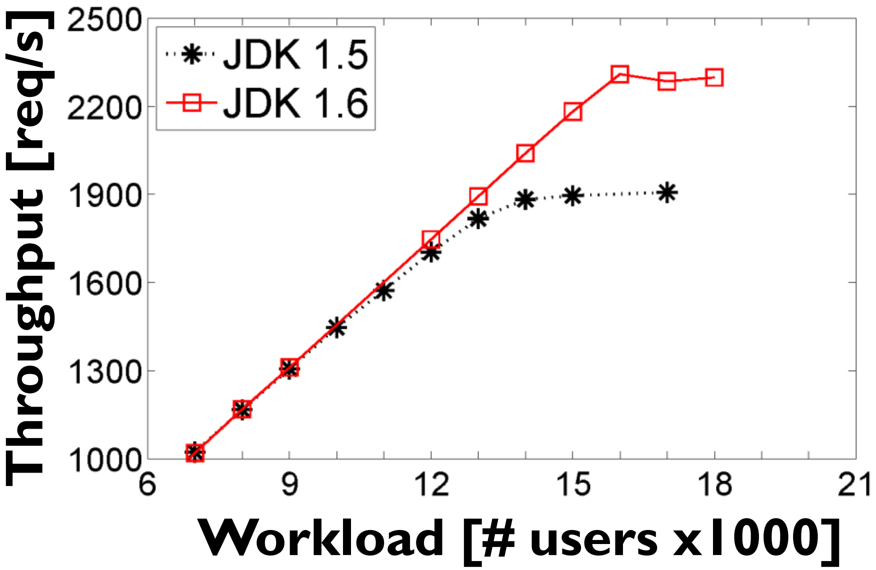
Performance Gain After Resolving Rapidly Alternating Bottlenecks





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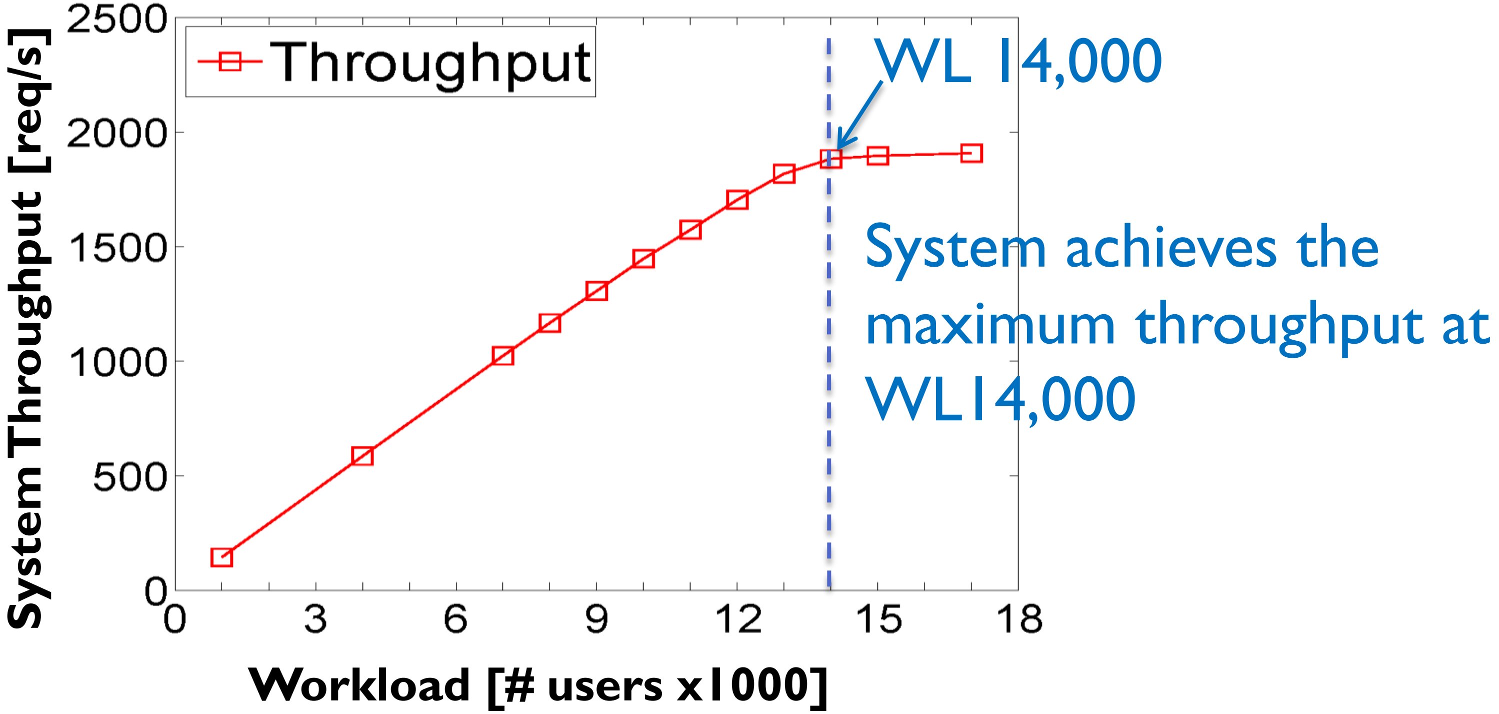
Active-Load/Throughput Analysis at Workload 14,000



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