Tune Your Way To Savings!

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About the Speakers

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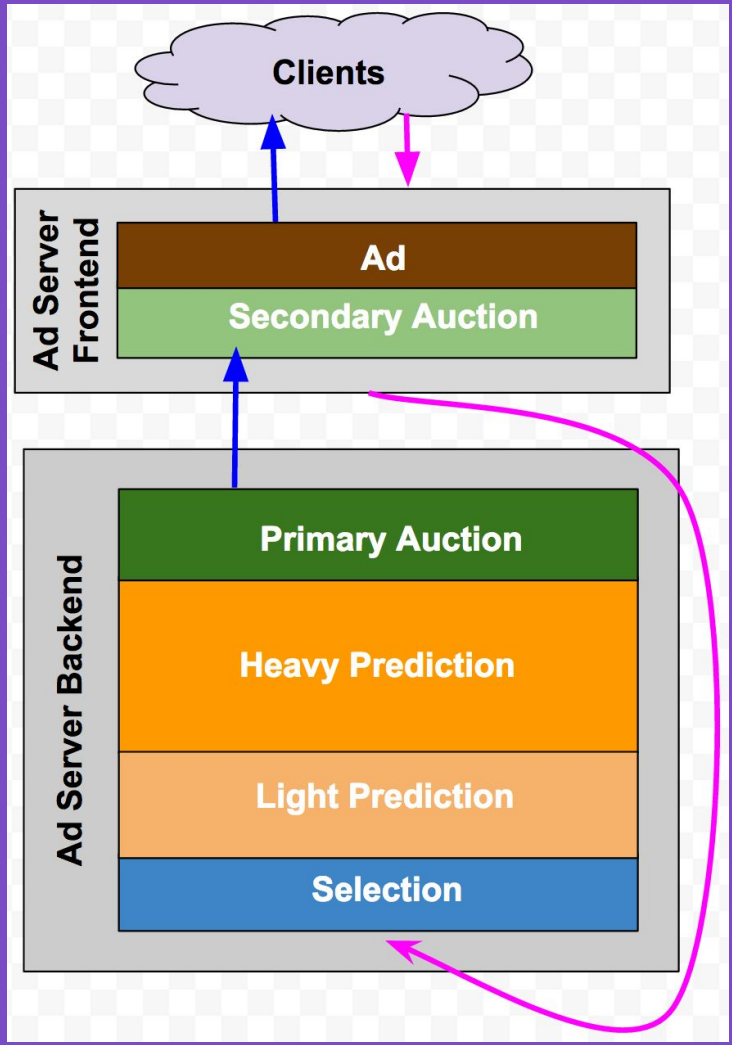
Agenda

- Overview of Ad Server & Our Goals
- Getting Started
- Experimentation & Analysis
- Post-Launch Care & Feeding
- Insights & Takeaways
- Conclusions

Overview of Ad Server & Our Goals

About the Ad Server

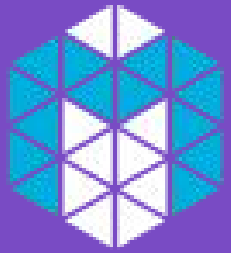
- Runs on the JVM
- *Frontend*: routes Ads requests from clients to backend
- *Backend:* calculates Ads to display



What is our environment?

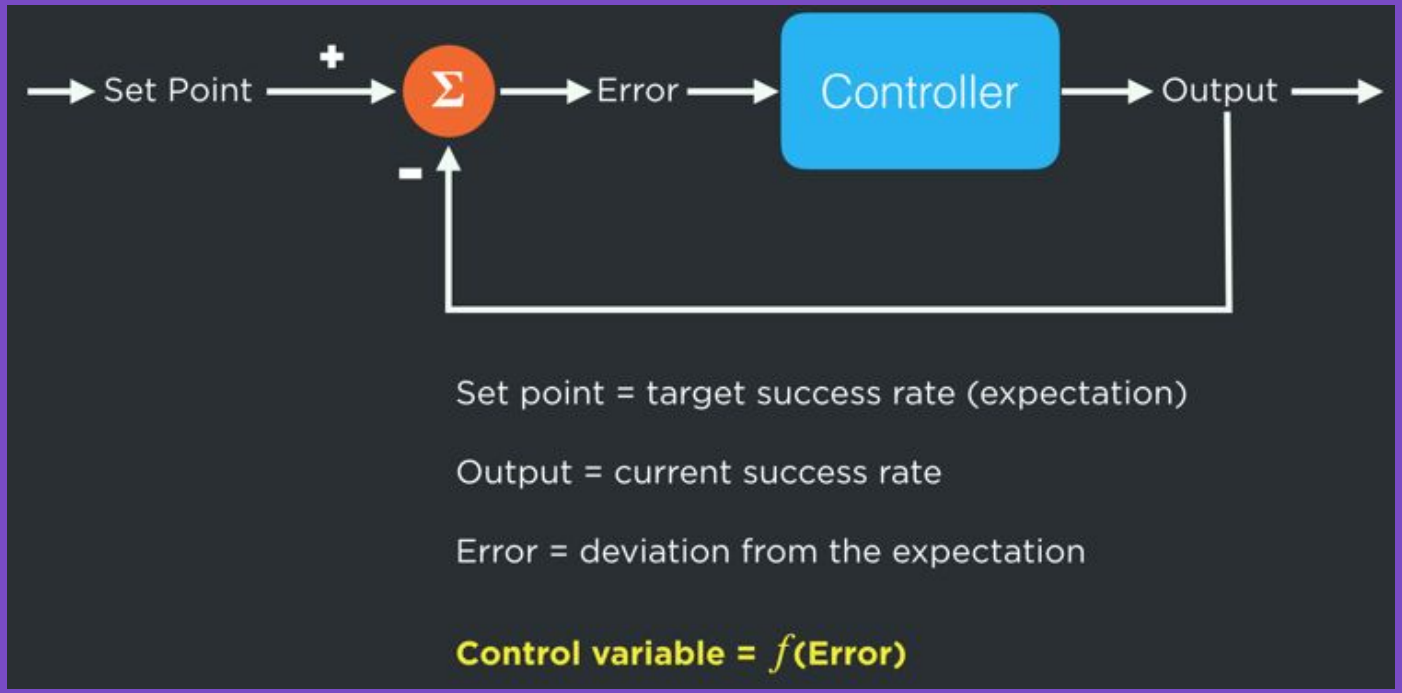
Environment: Aurora / Mesos

- Large deployment
- Abstraction over the DC resources
- Schedules jobs across machines
  - May be mixed platform types
- Shared vs Hybrid Mesos



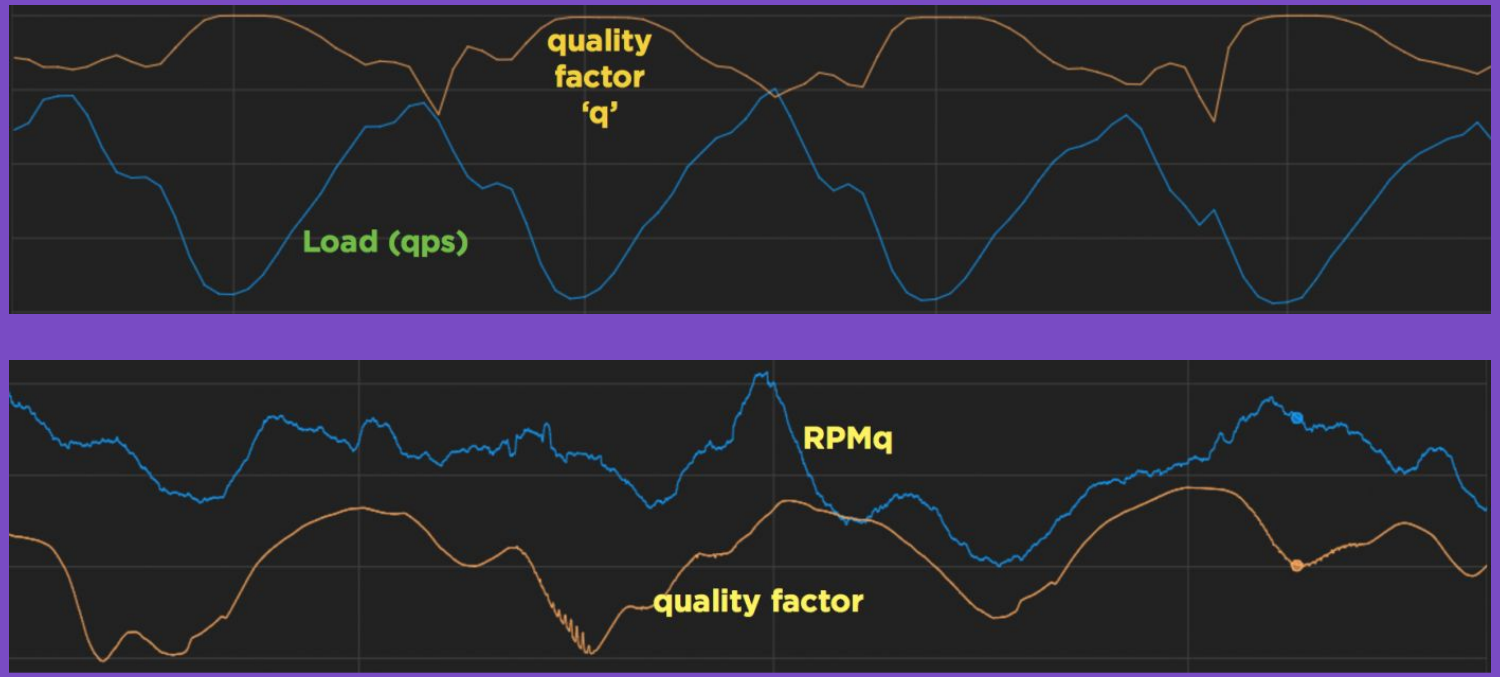
Apache MESOS™

Basic Controller for CPU Utilization & Latency



Key Metrics:

- QF: adaptive Quality Factor
- Latency (affected by CPU, Network)
- RPMq: Revenue Per Thousand queries



Hypothesis & Goals

Hypothesis:

- **Greater control over how resources (CPU, network) are used will enable us to use them more efficiently.**

Goal:

- **Reduce the cost (resource footprint) of running Ad Server without adversely impacting revenue**

Why?

- **Small efficiency gains in a large service can result in large savings**

Getting Started

Assemble a Team

- Mix of different skillsets
  - Site Reliability
  - Software Engineering
  - Hardware Engineering

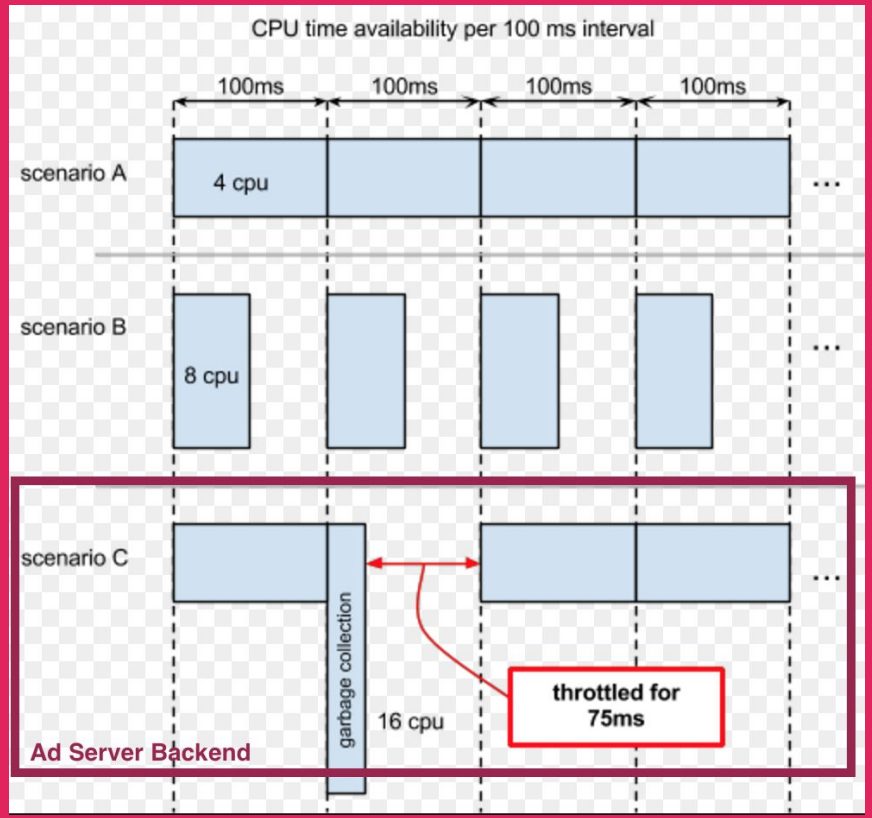
Testing Environment

- Get hardware for a hybrid Mesos environment
  - Homogenous hardware platform
  - High-speed networking
  - Isolated from other workloads
  - Ability to tune for the hardware

High-Level Things We Can Change

- Container Shape
  - Shrink & shard wider
  - Use taller instances
  - How does this affect QF?

- Mesos Resource Isolation
  - Remove CPU throttling
  - Raise or eliminate network egress limits



Low-Level Things We Can Change

- System
  - Take control over scheduling
  - Enable hugepages
- Hardware
  - Enable/Disable Intel Turbo Boost
- Non-exhaustive list, many more experiments possible

Experimentation & Analysis

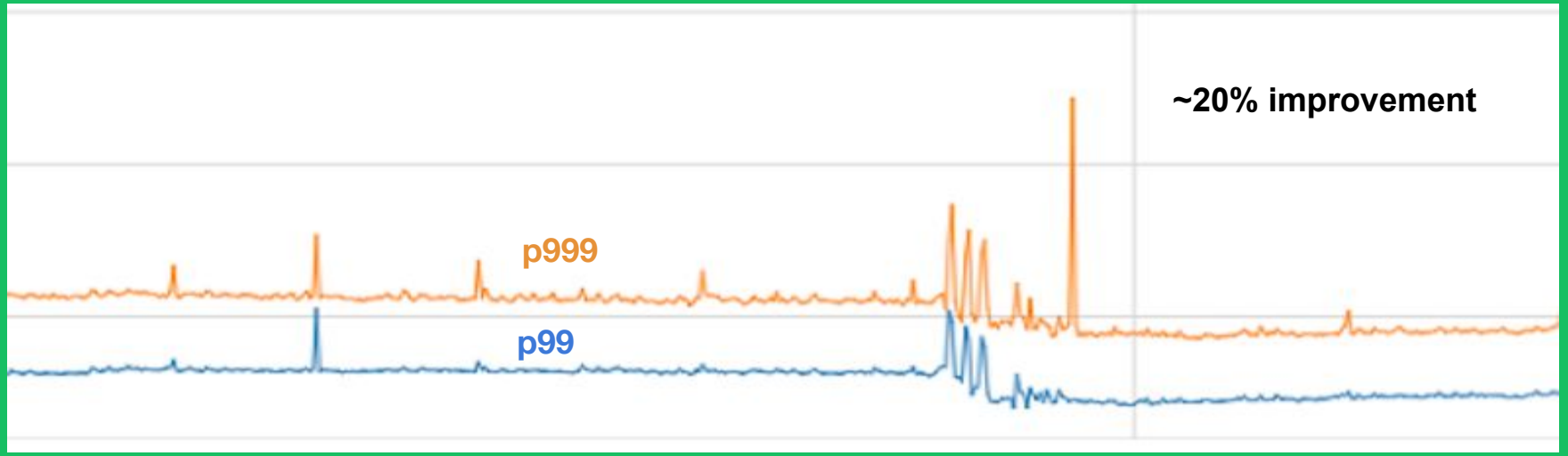
Areas to Explore

Things we thought of first:

- **High-speed networking for all instances**
- **Disable Mesos network egress limits**
- **Disable Mesos CPU throttling (CFS)**

Disable Egress Limit: Bandwidth (Frontend)

Disable Egress Limit: Latency (Frontend)

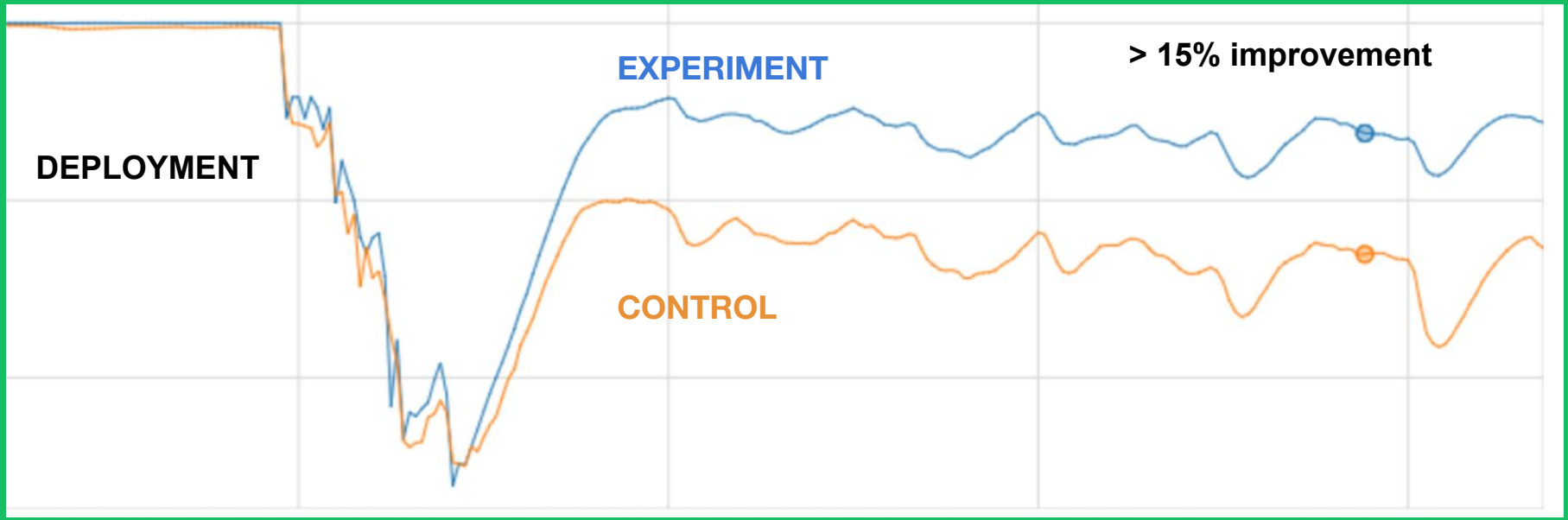


Hugepages

What are hugepages?

- 2MB or 1GB pagesize vs 4KB default
  - architecture dependent
- 1GB pages must allocate at boot time
- Hypothesis: by using hugepages for the java process, we will see improvements to memory access patterns

Hugepages (1GB): Impact on QF



NUMA

What is NUMA?

- Non-Uniform Memory Access
- Some memory is close, some is far
- Hypothesis: if we can control where our process allocates memory and schedules, we can gain efficiency by reducing foreign memory access

NUMA

- 2-socket systems
  - Half of the RAM is in each zone
  - Memory access across zones is more costly
- Non-pinned:

```
Per-node process memory usage (in MBs) for PID 19494 (java)
                           Node 0          Node 1           Total
Total                   10666.06         8476.95        19143.01
```

- Pinned:

```
Per-node process memory usage (in MBs) for PID 26969 (java)
                           Node 0          Node 1           Total
Total                      16.84        32708.68        32725.52
```

NUMA Results

- Foreign memory access eliminated
  - 10% to 0%
- L1 Cache
  - 60% clockticks to 15% clockticks
- Cycles Per Instruction (CPI)
  - 1.54 to 1.23 (20% improvement)

Ad Server Backend: Instance Packing

- How will changing the process layout impact efficiency?
  - NUMA / CPU Pinning

- How many instances fit on a machine?
  - If we allocate all cores, this determines possible shapes of the Ad Server job

Ad Server Backend: Instance Reshaping

- How is the application affected by differently shaped containers?
  - 4 14-CPU instances/box != 2 28-CPU instances/box
  - Hyperthreads: Backend exploits CFS

- What does it look like if we give the instance an entire NUMA zone?
  - More cores/threads and memory per instance
  - Fewer instances means more QPS per instance
  - More memory means larger heap to GC

Iterate and Refine

- Experiment, keeping notes about configurations and results
- Repeat until we have same or better performance
- Analyzing data can be challenging because...
  - Compute workloads vary by time, day, and world events
  - Adaptive nature of system in response to changing SR and latency
- Use load tests and redline tests to validate proposed configurations

Exp. #	Summary	Outcome	Start	End	Cluster	Dashboards	Experiment Setup	Notes
1a	Run frontend and backend on hybrid mesos with network egress limit disabled and tc disabled	With 1.5x QPS, RPMq is x% lower than the control clusters	2/10 1:30 PM	2/12 1:30 PM	5	RPMq	- 2 frontends per host - 1 backend per host - tc disabled - Network egress limit disabled - QF target SR set to 99.9 - High-speed network enabled - 1.5x QPS	Attribute Changes: Disable CFS DIsable network egress DIsable tc Expand port range Enable turbo
						Frontend		
						Backend		

Post-Launch Care & Feeding

Ongoing Operational Work

- Hardware delivery & config automation
  - Agree on support model with stakeholder teams

- Fine-tune performance
  - Adapting as production workloads change
  - Weathering application regressions

- Iterative process

Insights & Takeaways

Experiments will never match reality

- Production != Lab
- Be realistic and practical
- Don’t be afraid to get it wrong
  - But have a plan for when you do

Stay focused on the metrics you're trying to move

- Don't get sidetracked by micro-optimizations
- Underweight outlier datapoints (avoid rabbit holes)
- Resist confirmation bias

Data-driven decision making

- Make sure you have the right audience for your data
- Think about how you are presenting your data
- Aim for consensus
- Share what you learn

Think about cost

- Cost of tuning efforts (+ ongoing efforts)

- Payout of tuning efforts
  - Reduce capex%
  - Reduce burden on downstreams and storage

Set realistic deadlines

- Account for the unexpected
- Stick to your deadlines
- Show delivery

Conclusions

- Unique challenges
  - Opportunity to learn, hands-on
- Coordinating cross-team
  - Think about all layers of the stack
- Resources saved
  - 6% reduction in CPU
  - >50% reduction in R/W to certain downstreams
- Desired metrics improved
  - QF substantially improved

What’s Next?

Upcoming/Ongoing experiments

- More experiments around CPU and NUMA pinning
  - Would 4-pack work better this way?

- Evaluate newer platform, with even more cores

Resources & Further Reading

Resilient Ad Serving at Twitter-Scale (https://t.co/qdmipEyRJy)

Clarifications on Linux's NUMA stats

Systems Performance - Brendan Gregg

Want to learn more?

Twitter is hosting an SRE Open House at HQ on Wednesday, March 15.

RSVP here:

https://t.co/2yLeAFrGcY

Q&A