Control issues in warehouse-scale datacenters

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Cloud Control Workshop, Lund, Sweden

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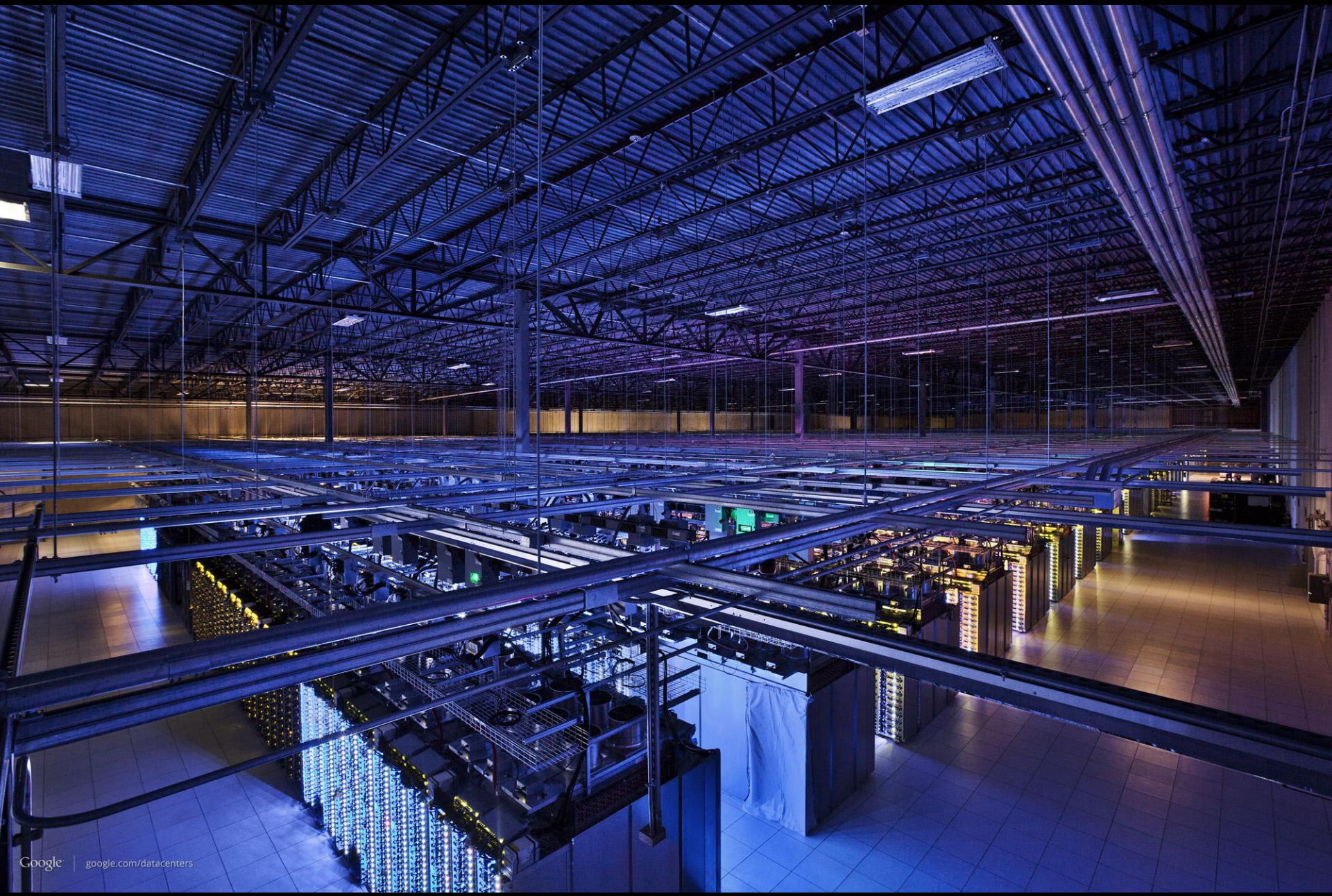
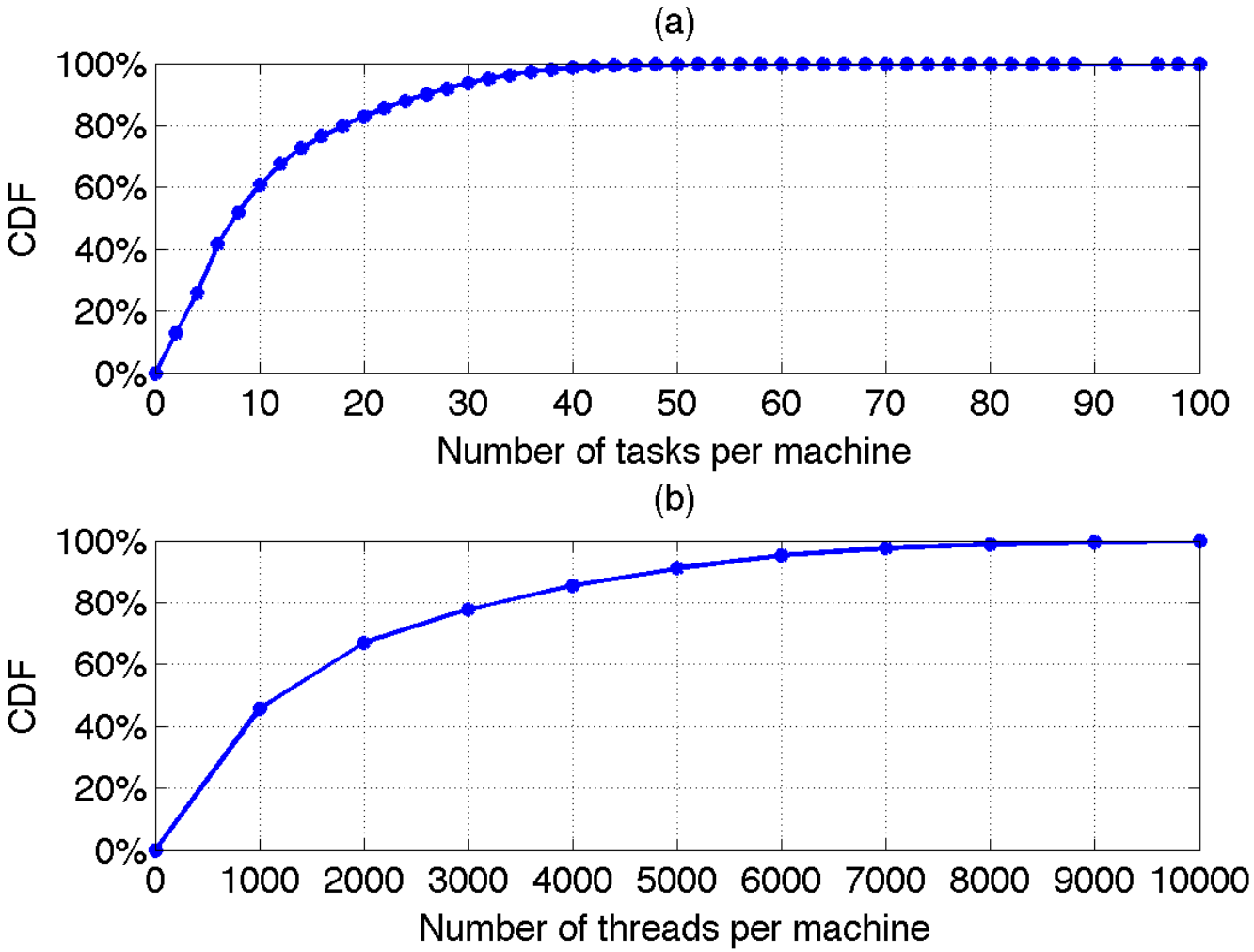

Google | google.com/datacenters

The problem

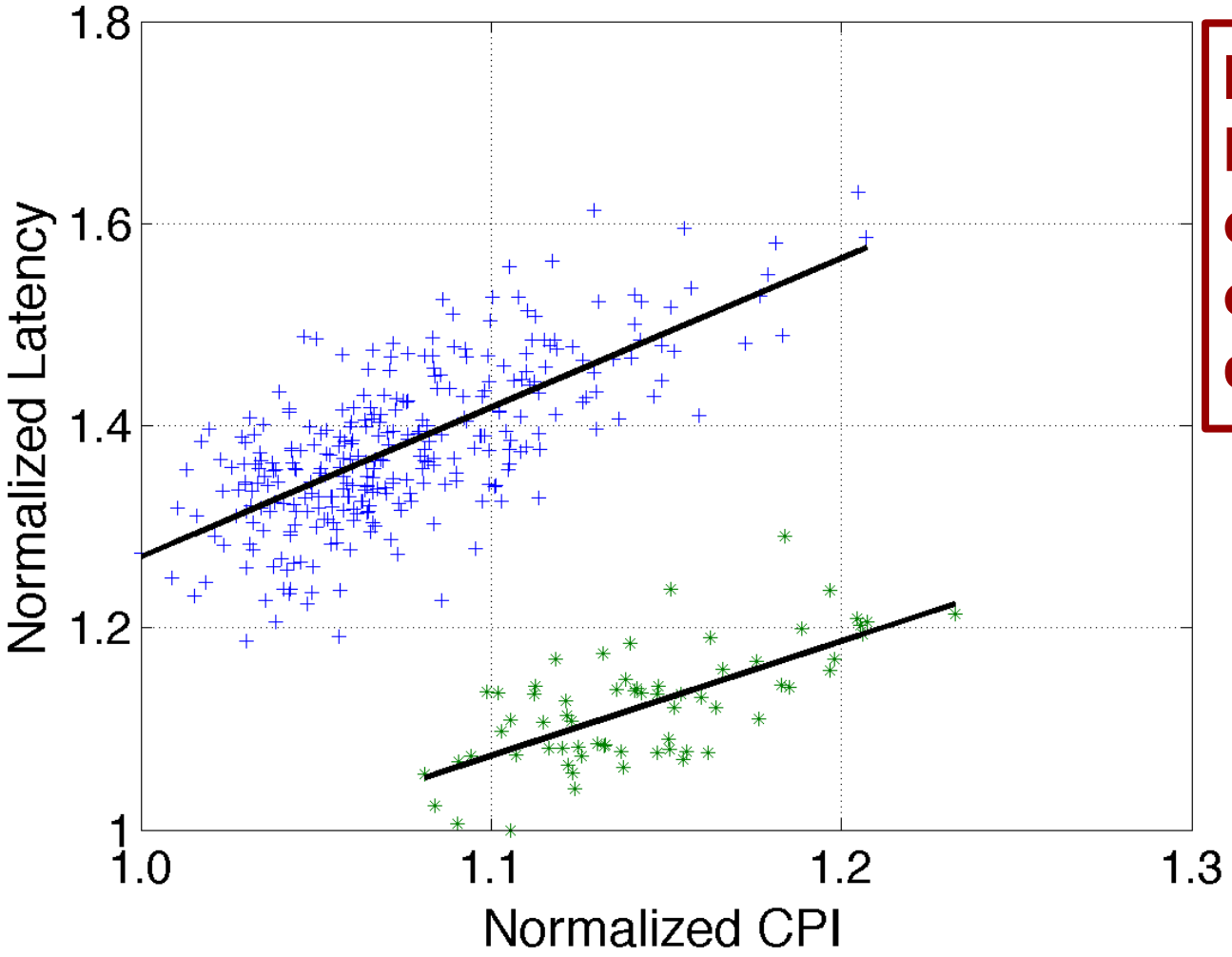
From: **CPI^2: CPU performance isolation for shared compute clusters**. EuroSys'13.

high utilization => resource sharing



The problem

resource sharing => interference



Interference happens tens of thousands of times per day

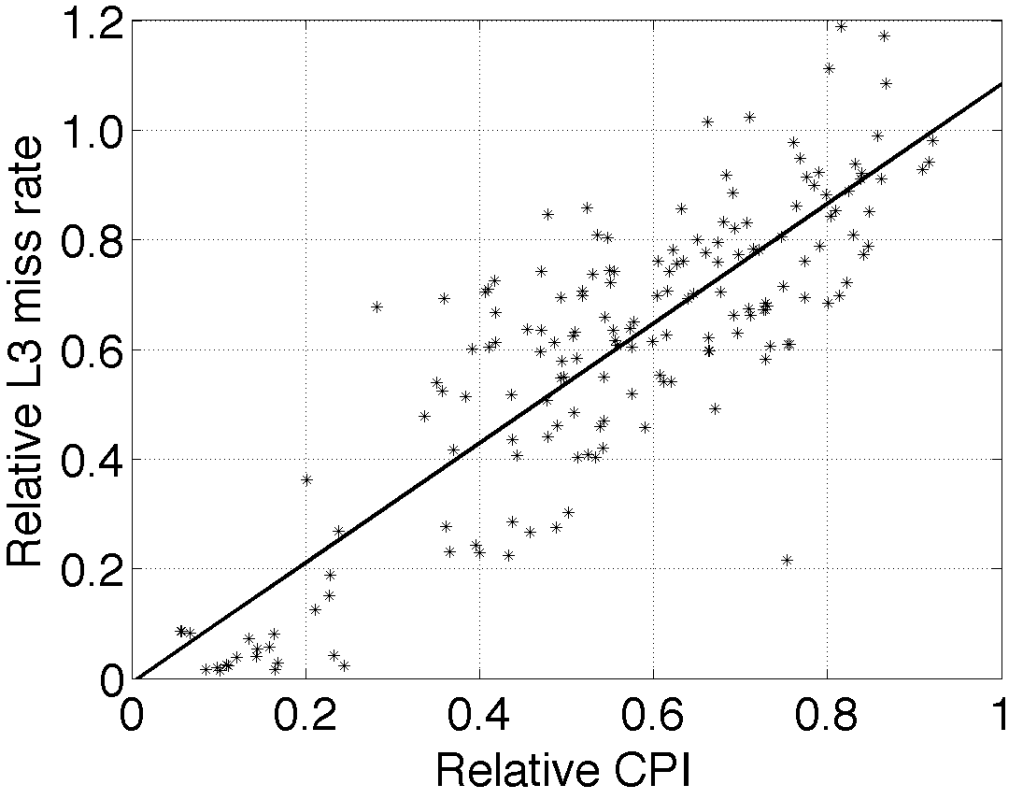
Our solution: CPI^2

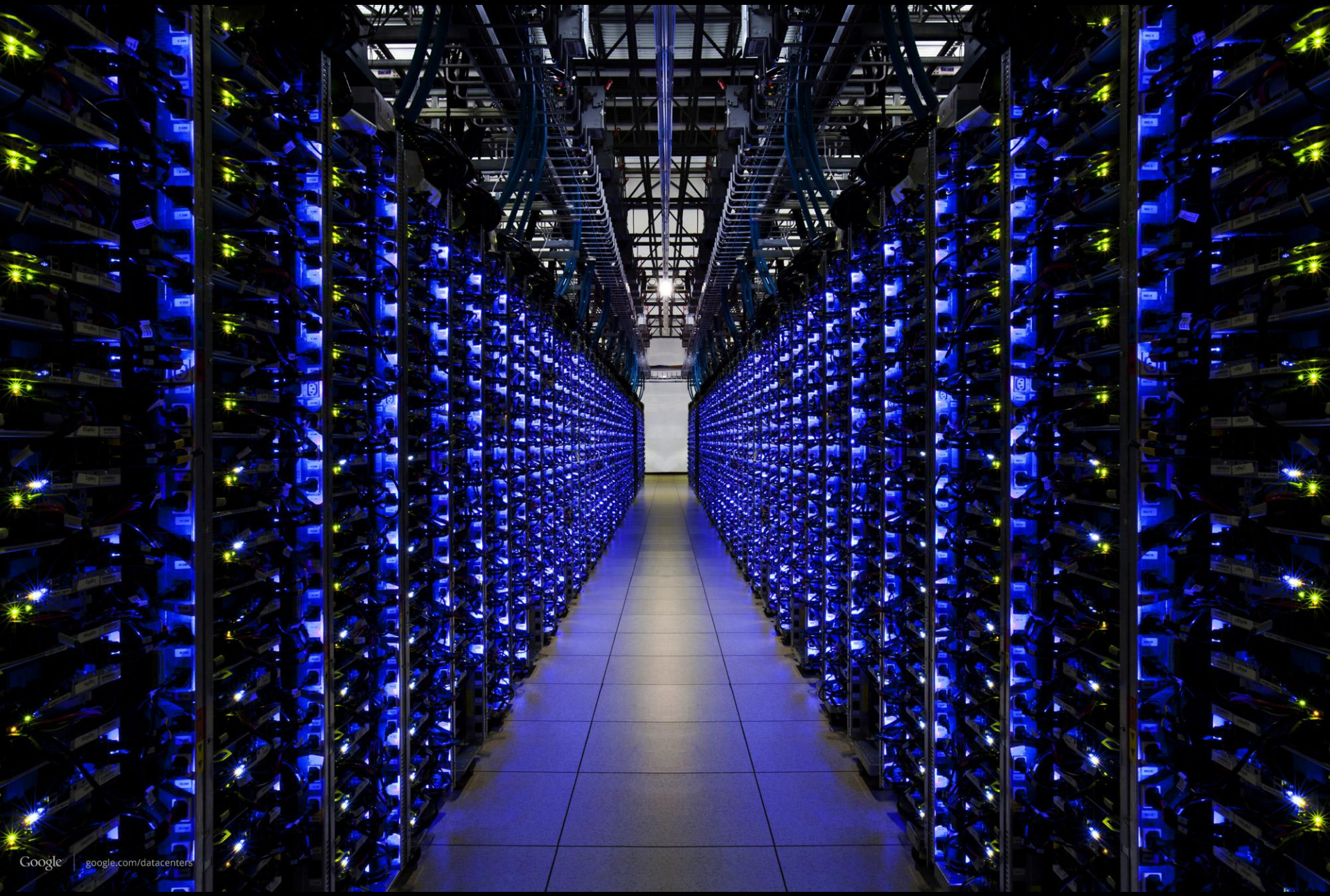
a simple control system

1. Monitor *Cycles Per Instruction* (**CPI**)
2. Learn anomalous behaviors
3. Identify a likely antagonist
4. Throttle it to shield victims

Why use CPI?

- It's cheap: < 0.1% CPU overhead, invisible to users
- It's stable (across time and space)
- It correlates well with L3 cache miss rate

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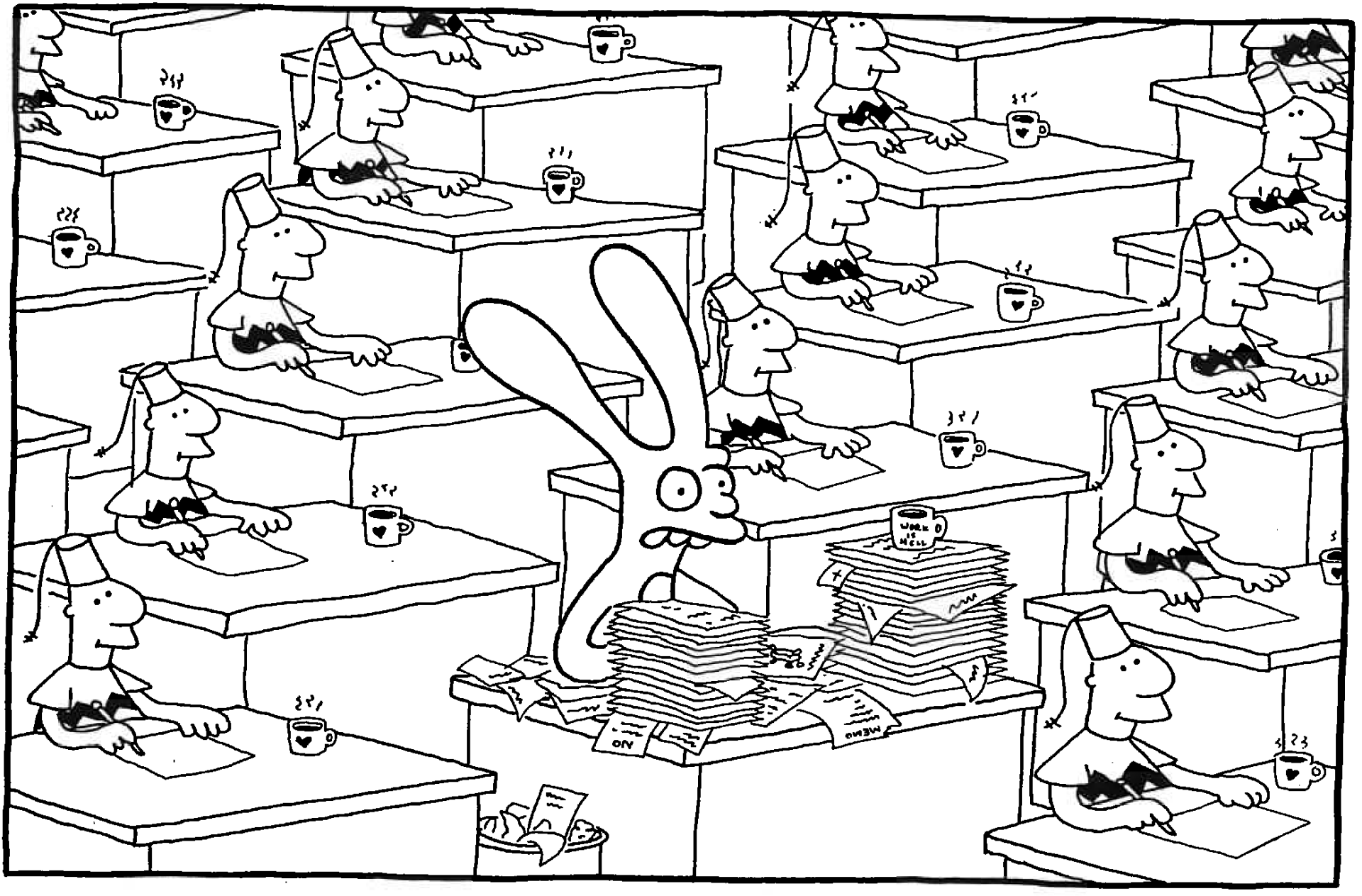
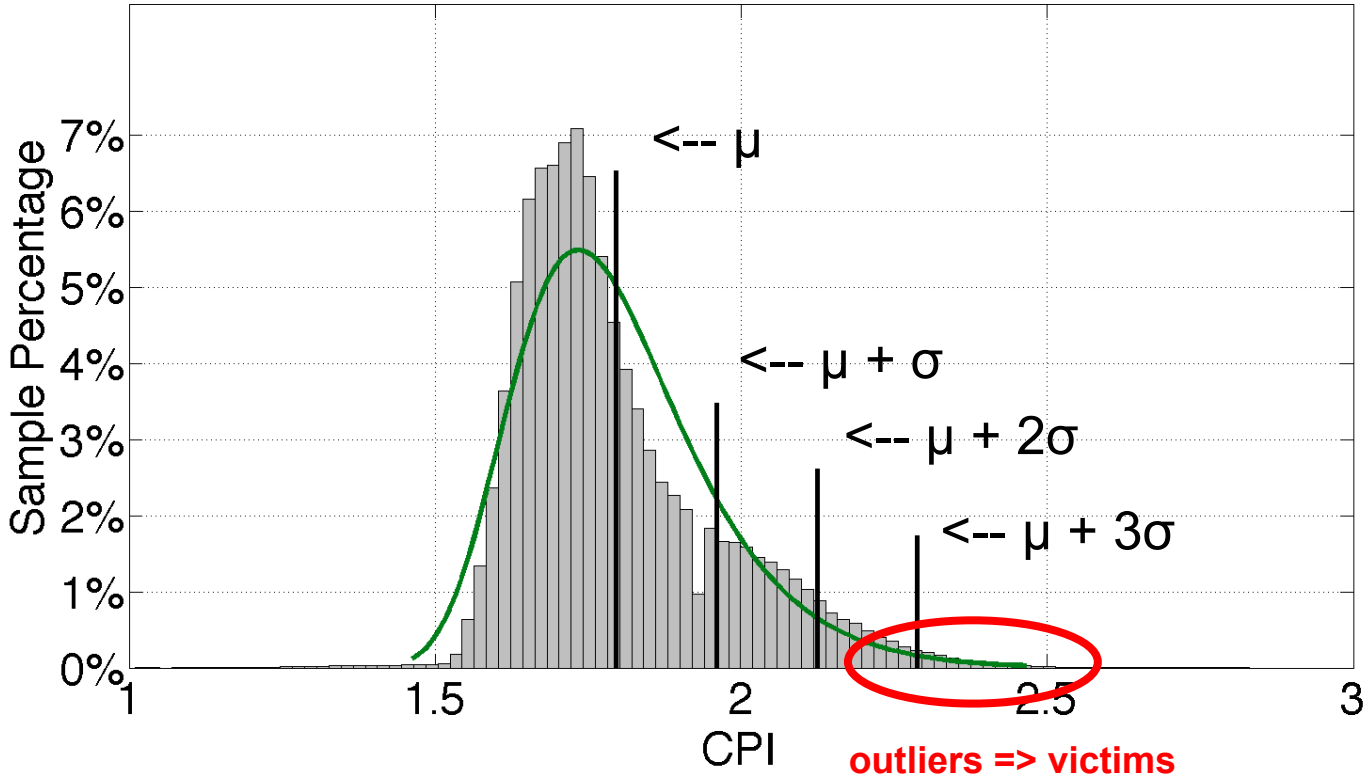


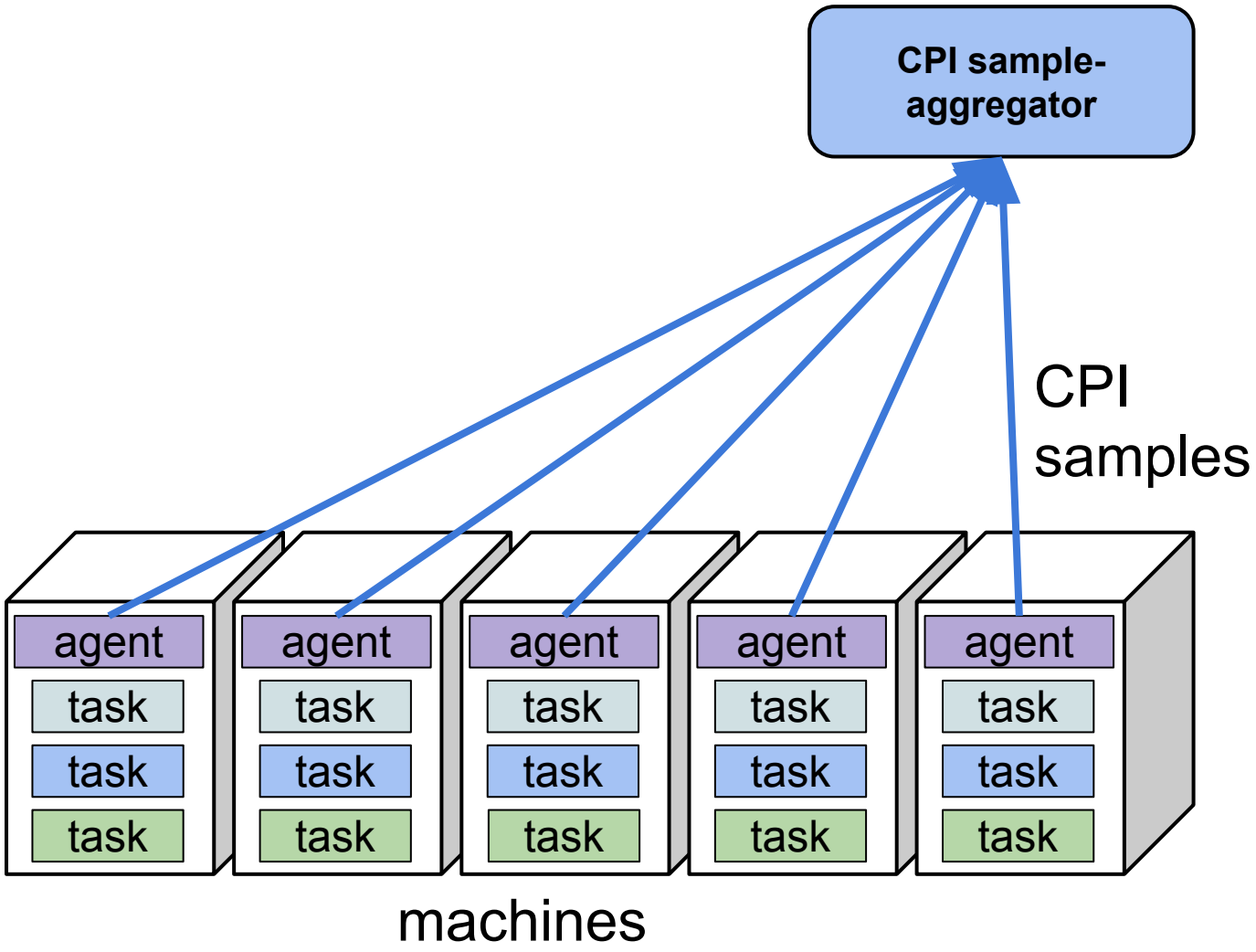
Gathering CPI

Build a CPI profile for a job

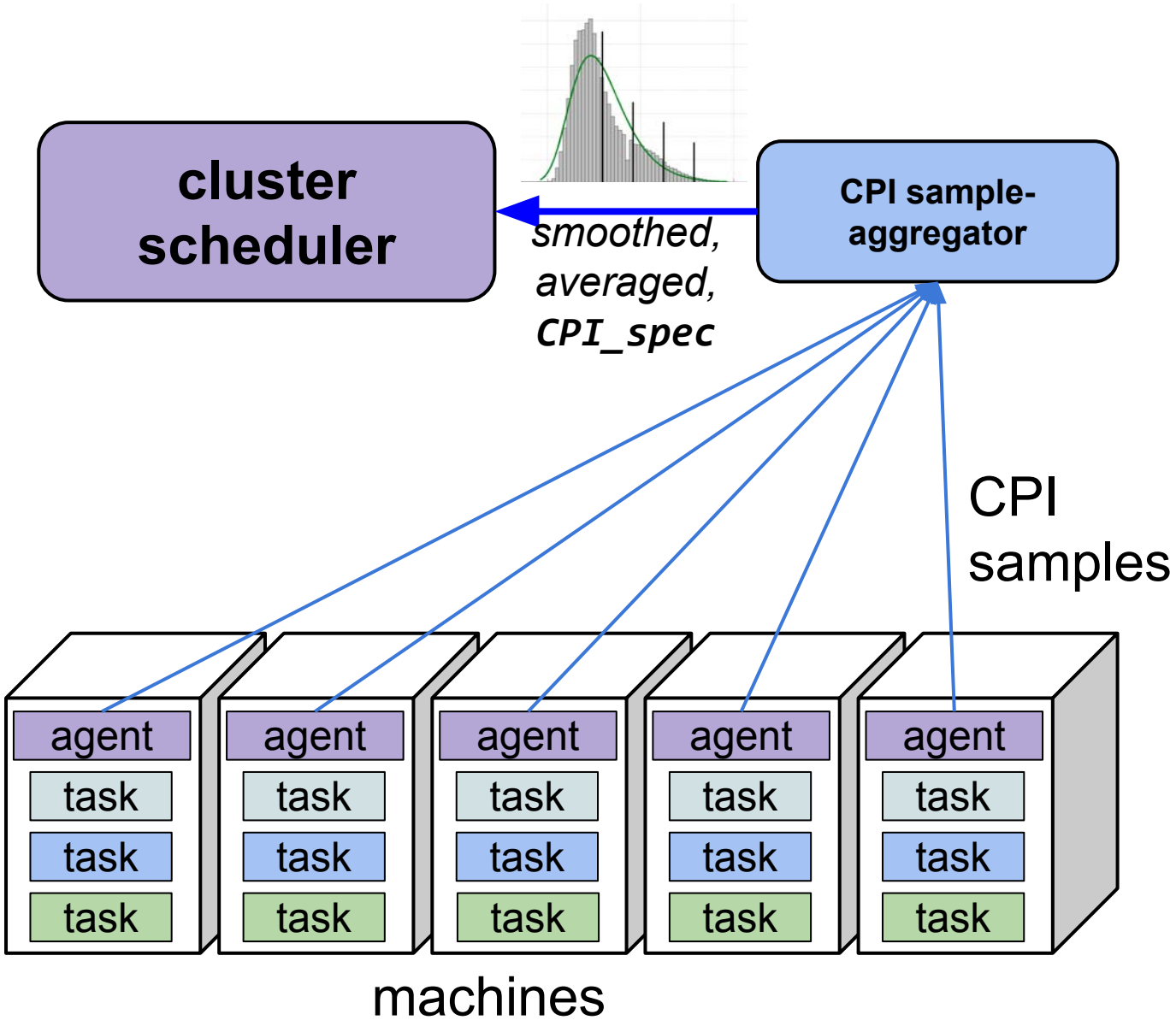
- per-cluster, per-platform
- mean (μ) & stddev (σ)



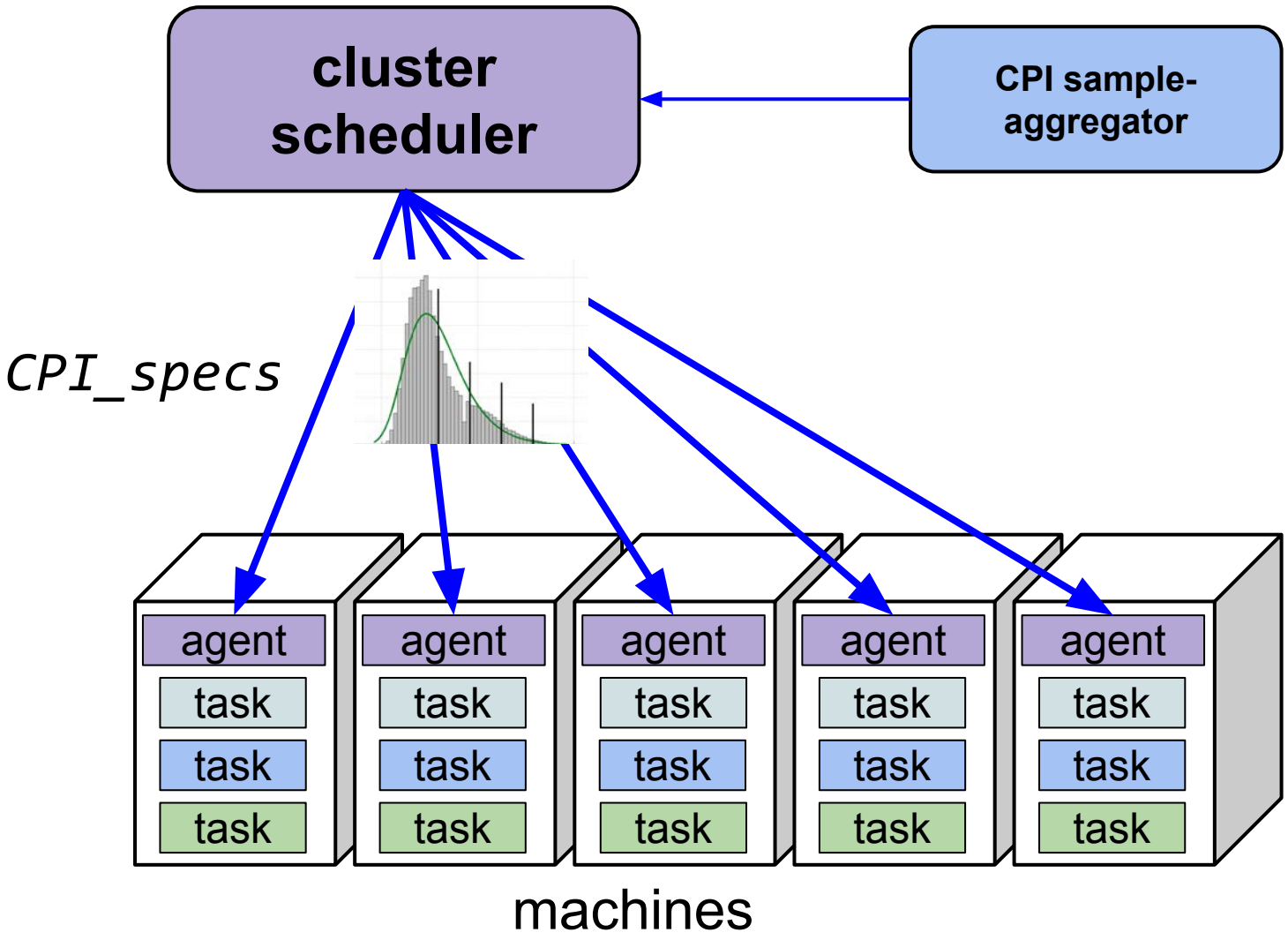
Gathering CPI



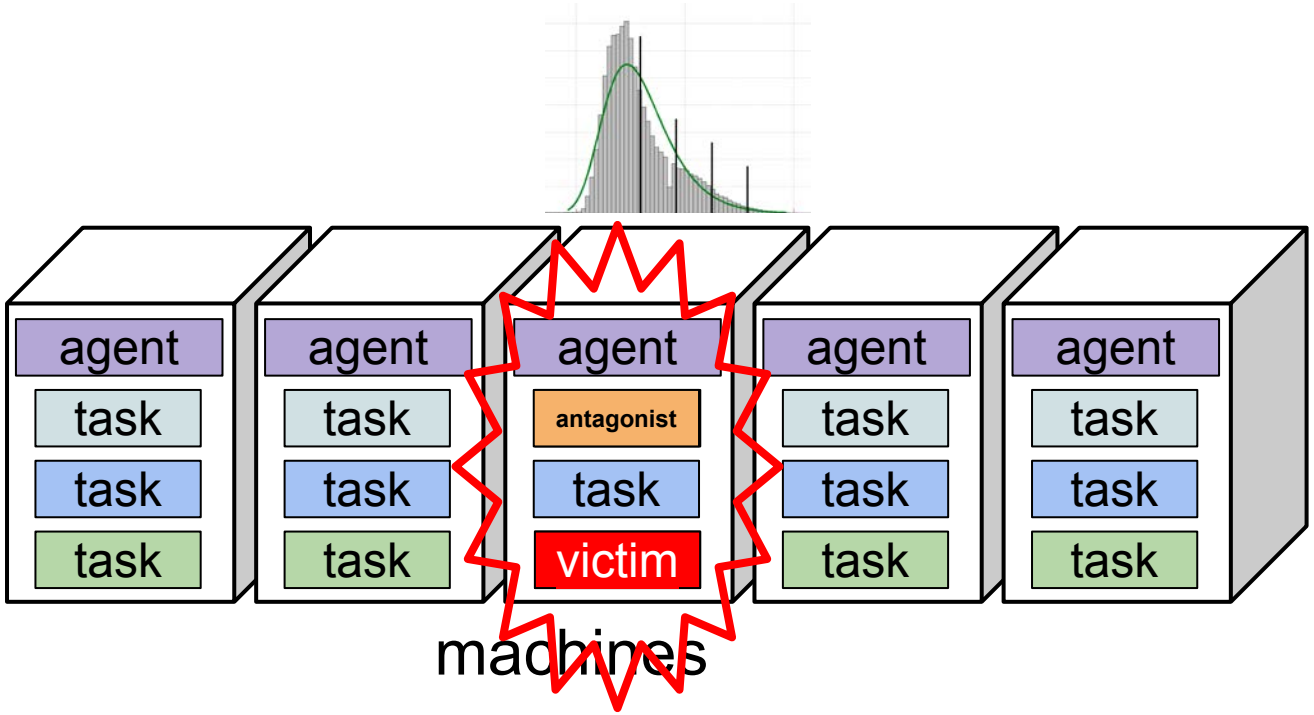
Gathering CPI



Using CPI to detect an anomaly



Using CPI to detect an anomaly



Now what?

Goal: reduce the effect of the antagonist

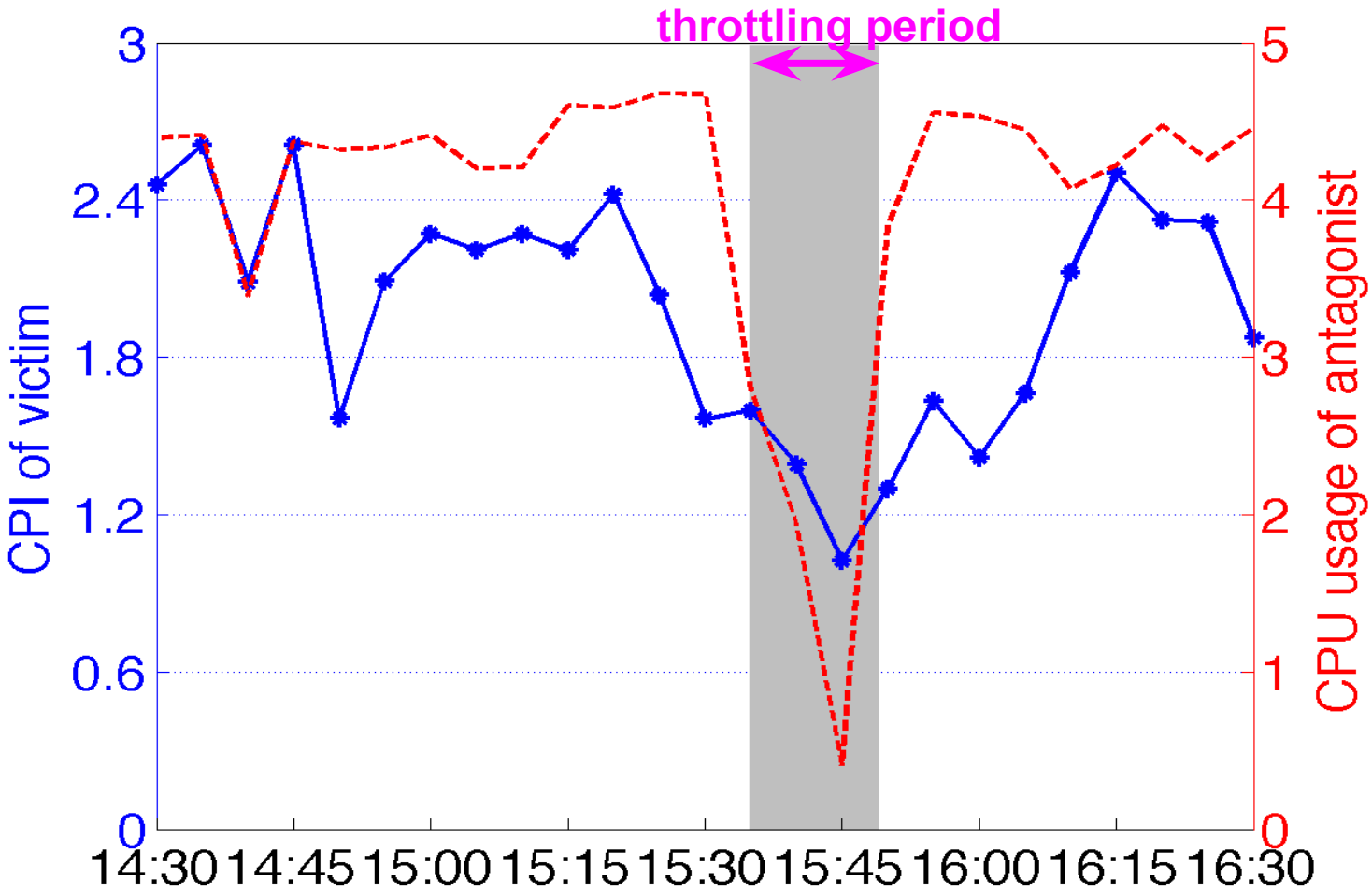
Let's **throttle** the antagonist!

- CPU hard-capping: 0.1 core for 5 minutes

Restrictions:

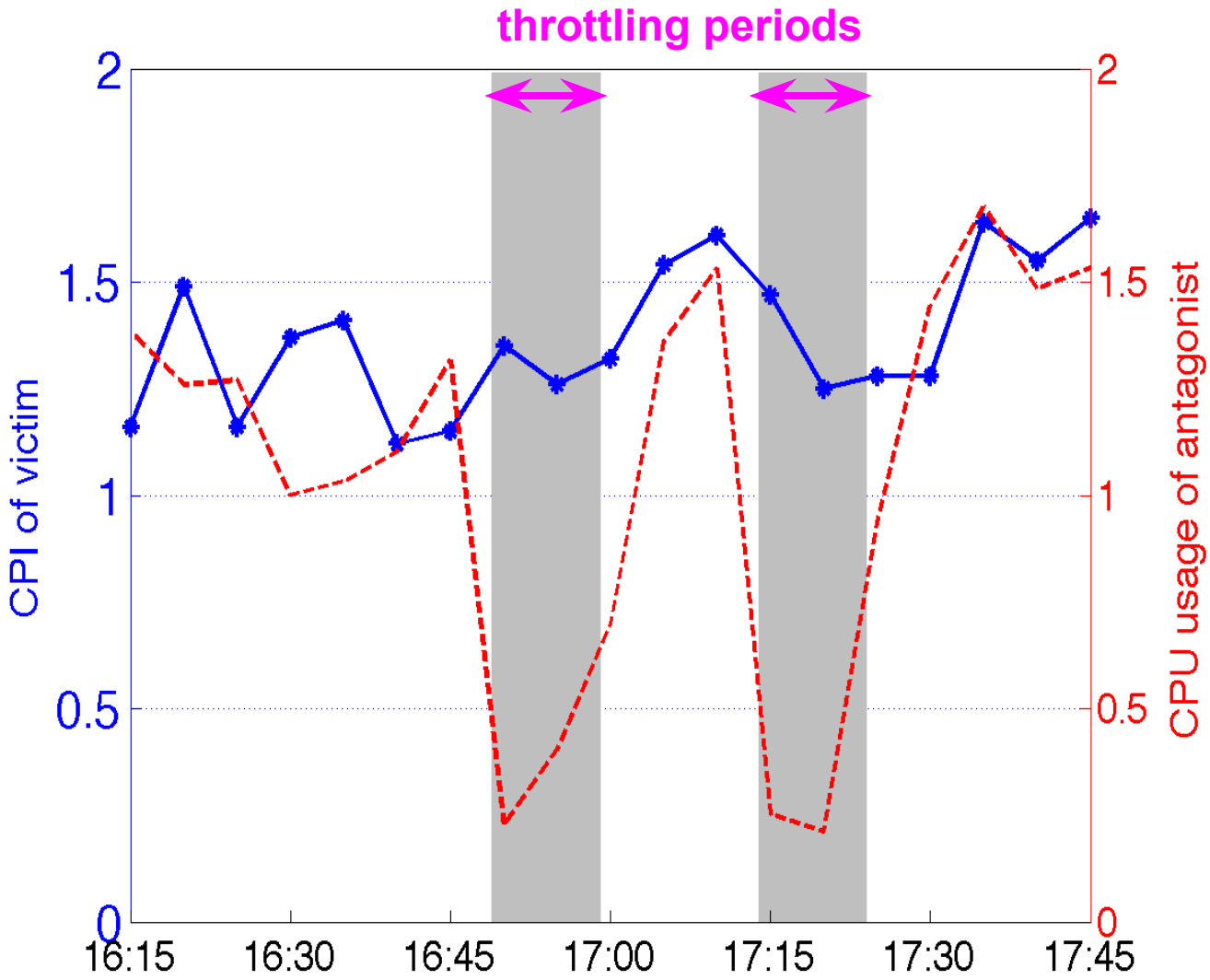
- only throttle batch jobs
- only help "important" victims

A motivating example



What could *possibly* go wrong?

A not so good example



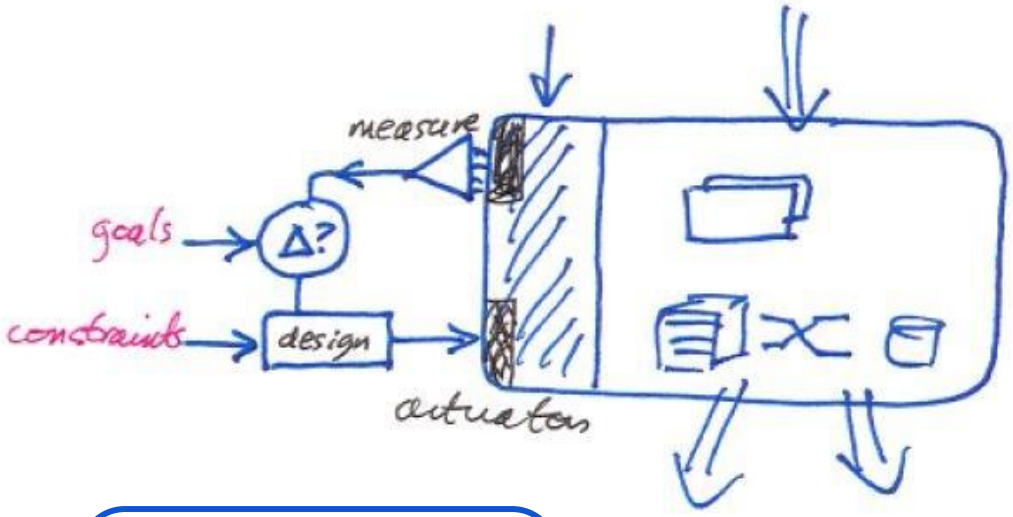
Maybe batch-only was a bad idea?
After all: LS tasks have *load balancing*

A control system to achieve:

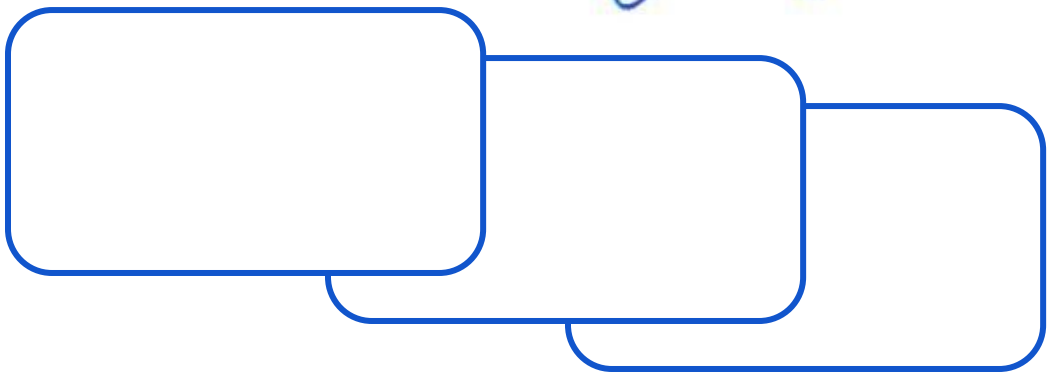
- failure tolerance (of server, of cluster)
- equal load (e.g., qps)
- equal performance (e.g., latency)

Maybe batch-only was a bad idea?

After all: LS tasks have *load balancing*



Load balancer



Service

Overload

What does your system do?

Tip: don't send all traffic to the first place on your list

Maybe batch-only was a bad idea?
After all: LS tasks have *load balancing*

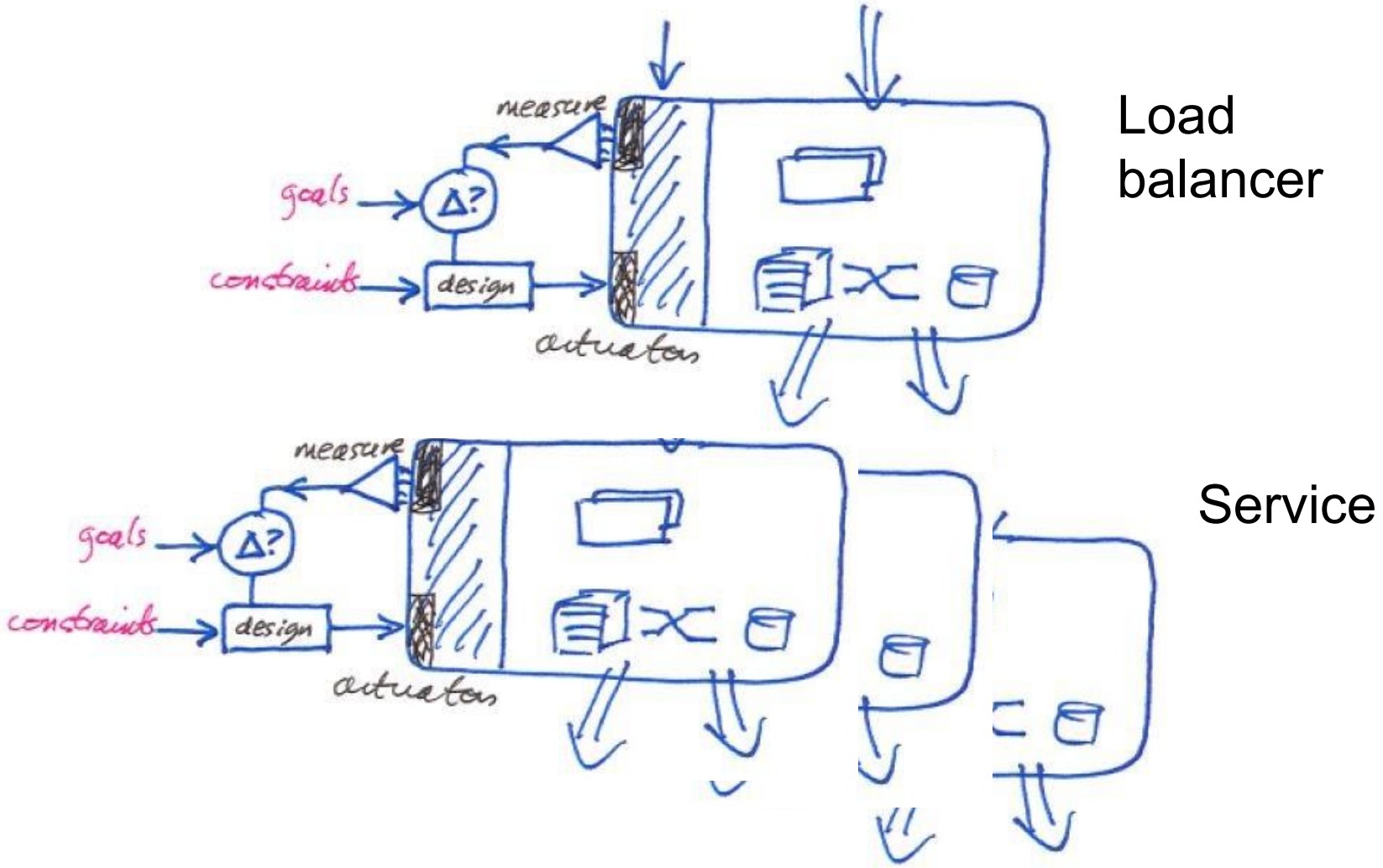
Cascading failures

1. Overload-induced outage
   - busy cluster => oops

2. No worries! Shunt load elsewhere!
   - busy cluster => much oops (repeat)
   - e.g., Gmail outage, 2009-02-24

Maybe batch-only was a bad idea?

After all: LS tasks have *load balancing*



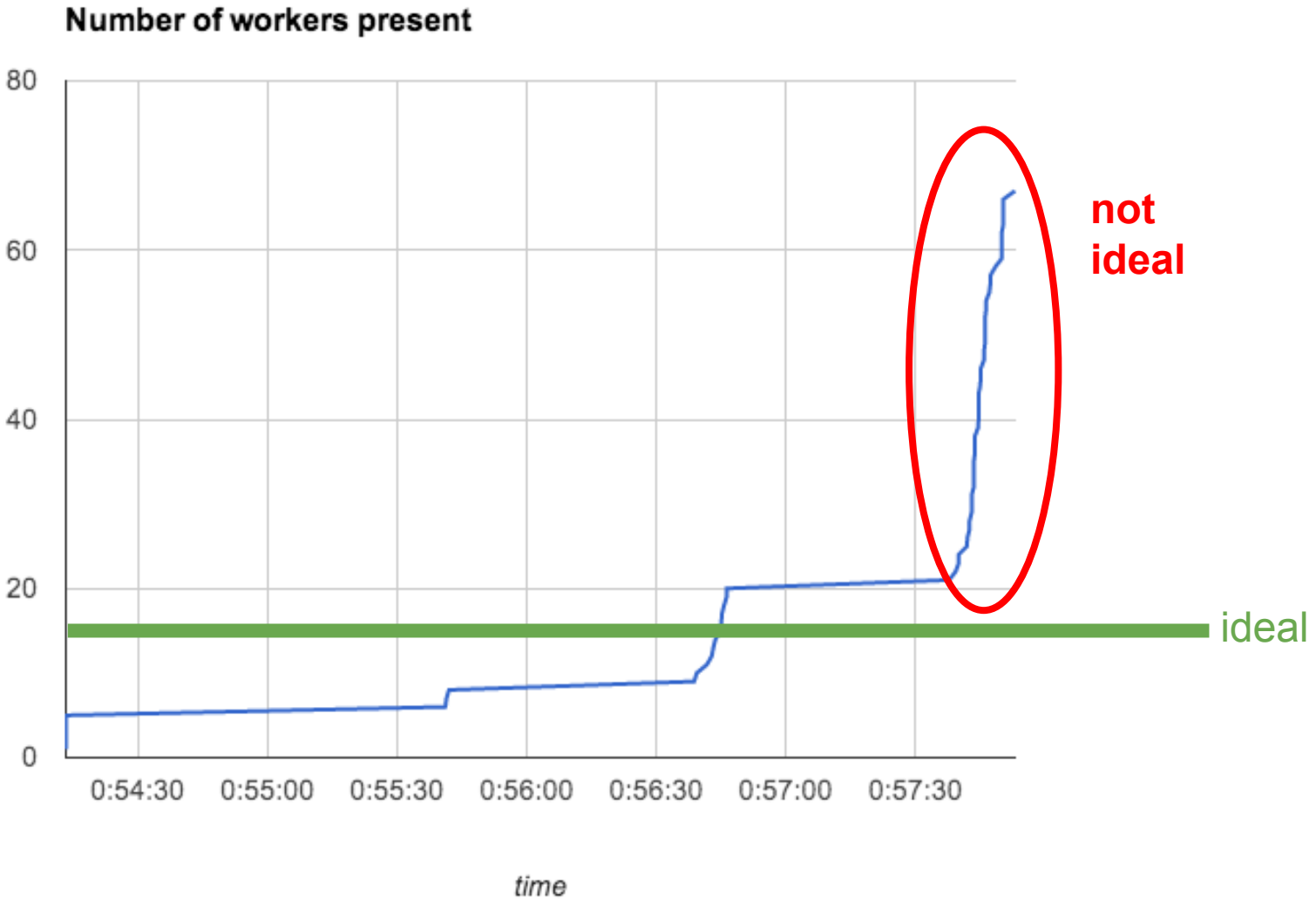
Interacting control loops

1. Load-placement
   - few-second response times

2. Number-of-workers
   - few tens-of-seconds response times

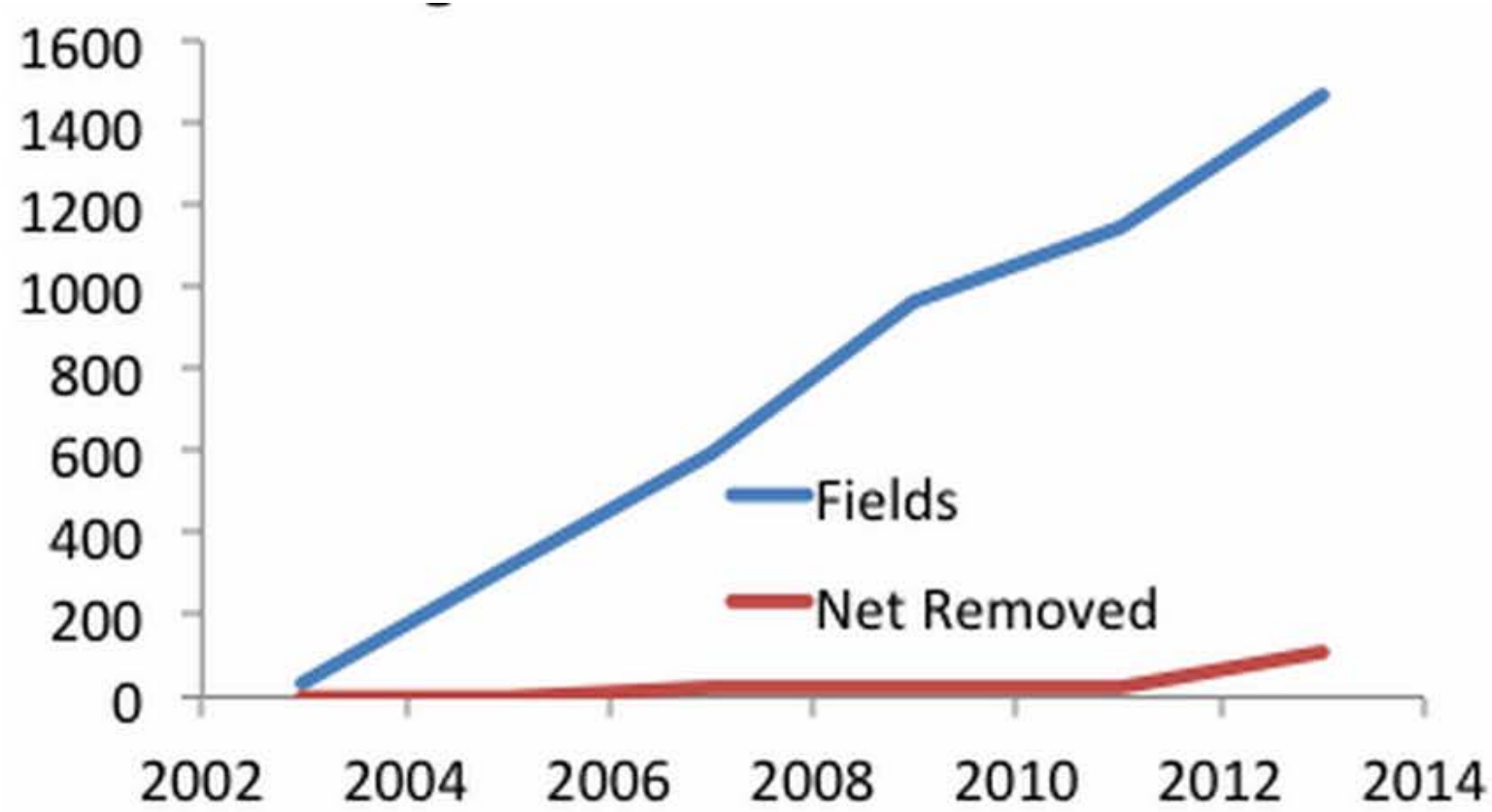
3. Add a little signalling delay ...

Auto-scaling to meet a job deadline



No worries!

Just add a few more knobs ...



Upload malformed configuration

What does your system do?

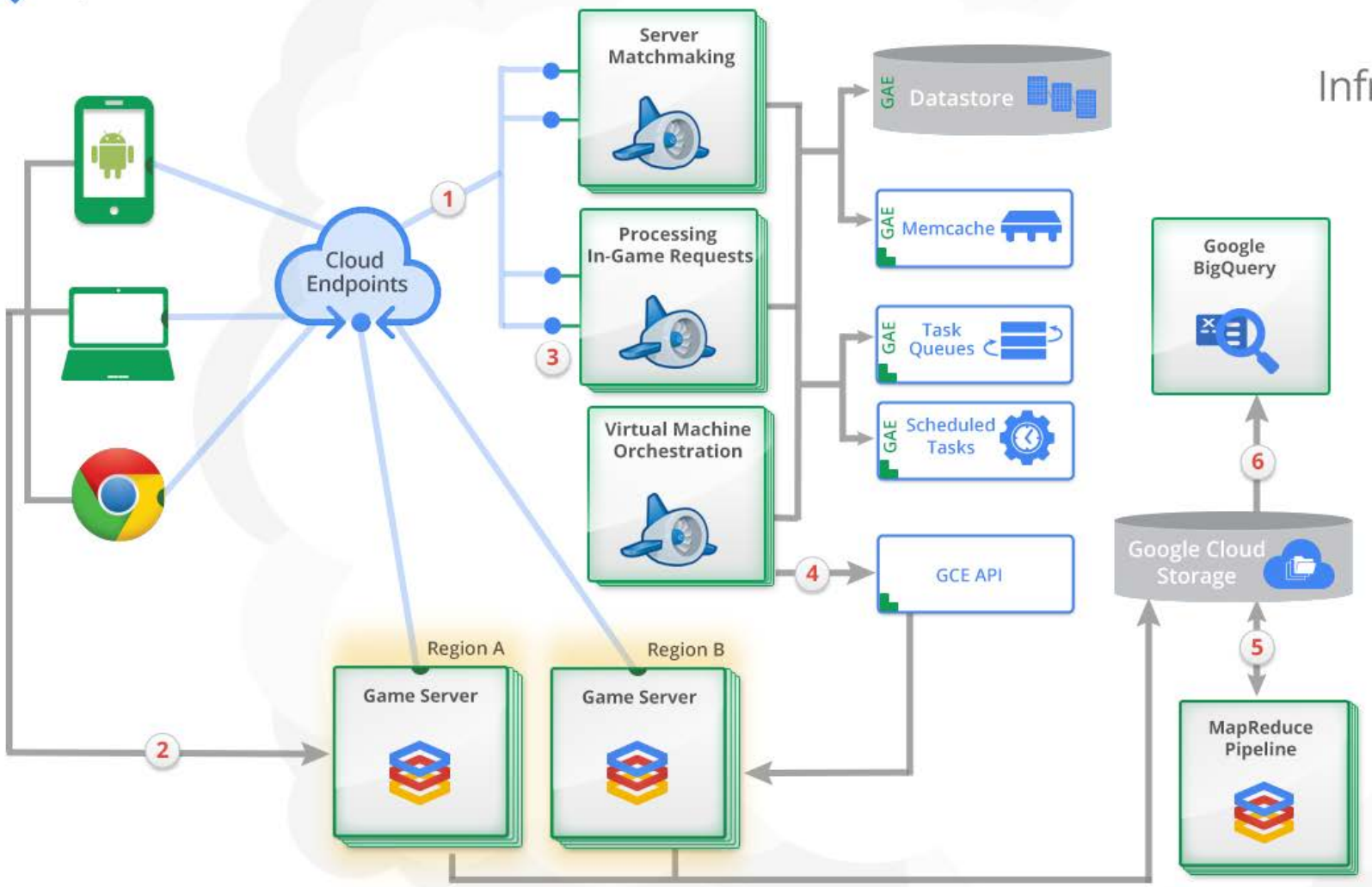
Tip: don’t just stop working

Dedicated Server Gaming Solution on the Google Cloud Platform

Your Application Code running on Google App Engine (GAE), Google Compute Engine (GCE), and Client Devices

Google Cloud Platform Services

Capabilities Included



Google Infrastructure

- Load balancing across GAE Instances
- Auto Scaling
- Static content serving and caching
- DoS protection
- Monitoring and Management

GMail circa 2008

your browser

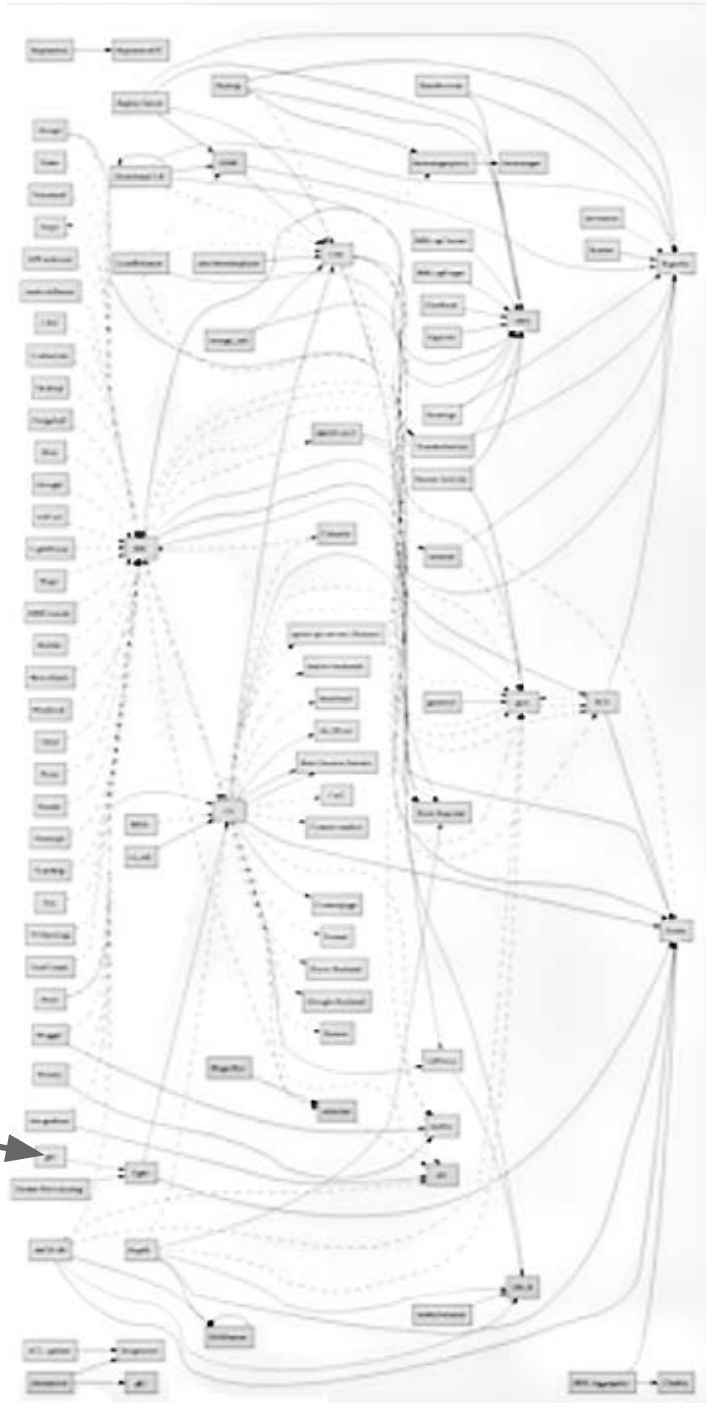
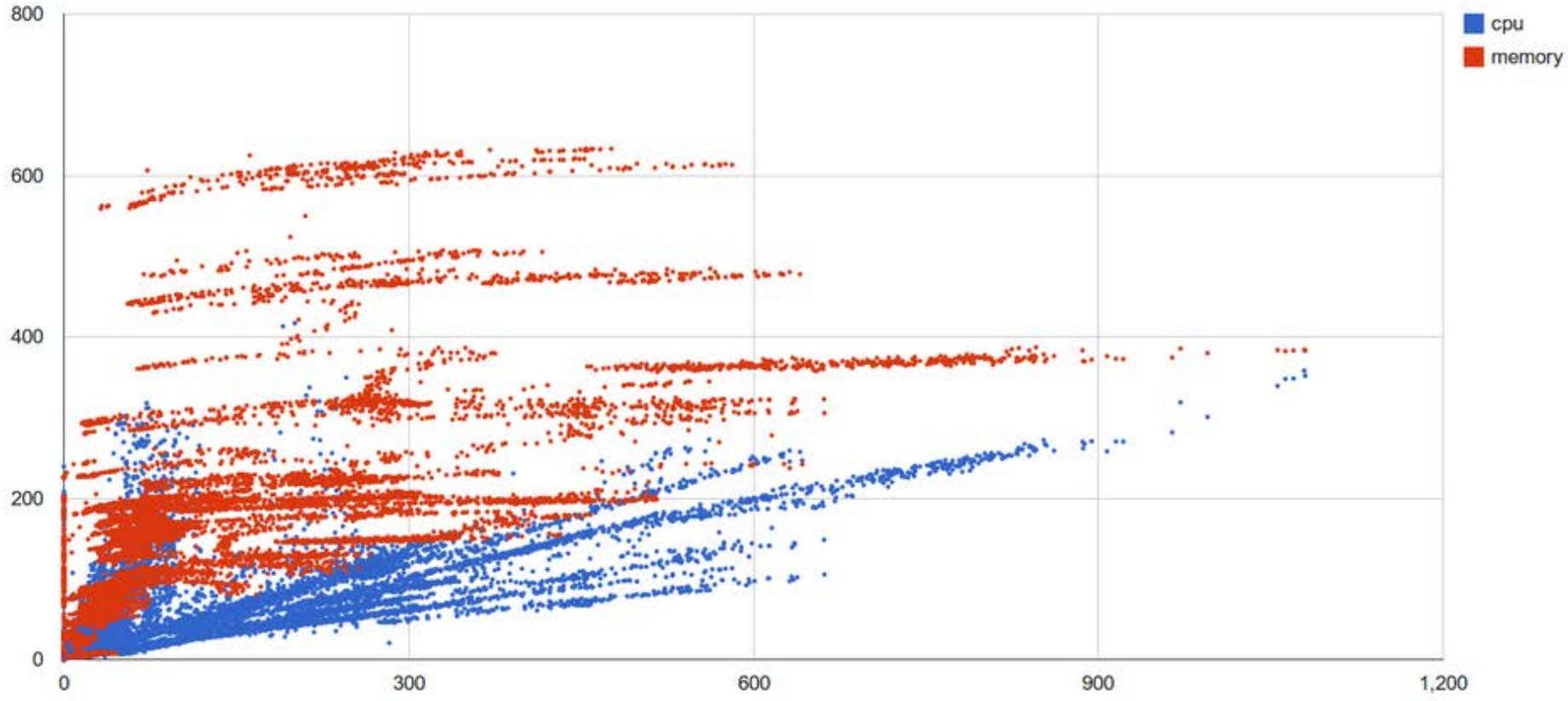


Image source: Hareesh Nagarajan

Model building is hard

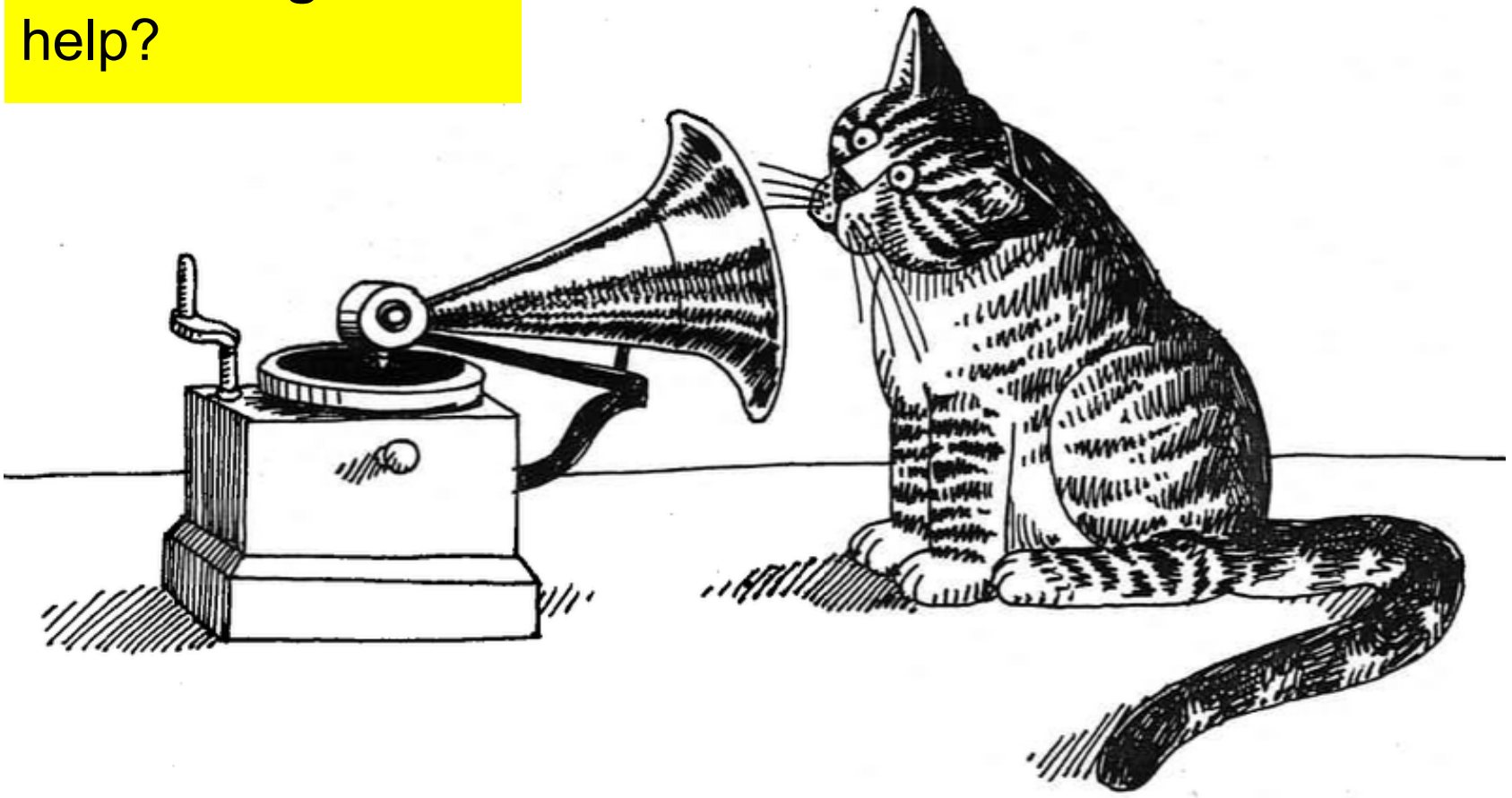
CPU, RAM usage
(arbitrary units)



Load

Is it doing what it should be doing?

Maybe **more monitoring** would help?



```
umask 027
mkdir -p -m 0755 $release/usr/bin
```

“The scariest outage ever”
15-20% of Google's
production fleet was affected


Google
google.com/datacenters

It's 3am and your pager goes off

-- are we in trouble?

-- are we about to get into trouble?

→ what should you do about it?

Delegation is hard

be careful what you ask for

Summary

Control systems do not run in isolation

1. Do no harm
2. Make things better
3. **Assume the world is out to get you**

   “any sufficiently advanced incompetence is indistinguishable from malice”

   -- Grey's Law