Building/Running Distributed Systems with Apache Mesos

Philly ETE

April 8, 2015

Benjamin Hindman – @benh

$ whoami

Berkeley
UNIVERSITY OF CALIFORNIA

2007 - 2012

2009 -

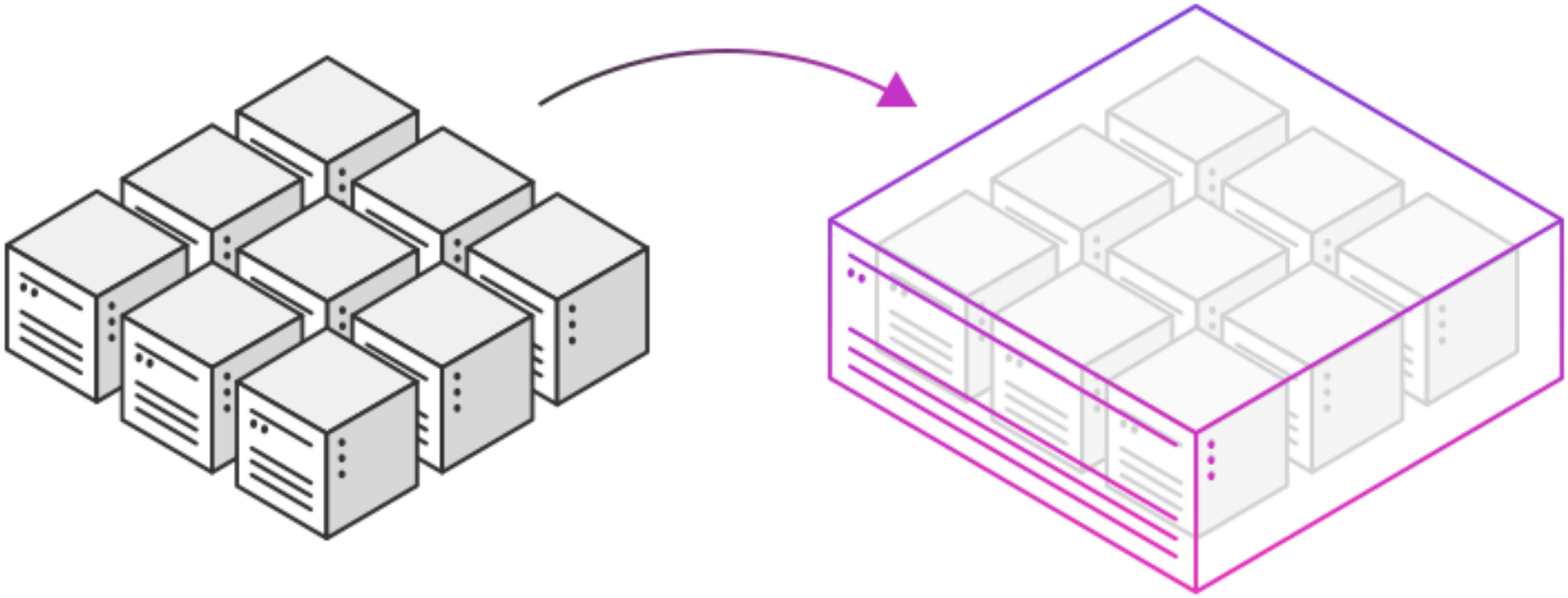
2010 - 2014

my other computer

my other computer is a datacenter

my other computer is a datacenter*

* collection of physical and/or virtual machines



how should we run applications on the datacenter computer?

how do we program applications for the datacenter computer?

what are datacenter applications?

agenda

① what are datacenter applications?

② how should we run datacenter applications?

③ how should we program datacenter applications?

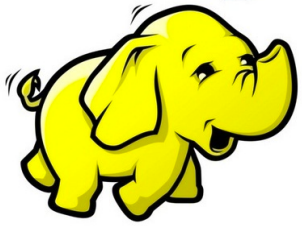
agenda

① what are datacenter applications?

② how should we run datacenter applications?

③ how should we program datacenter applications?

distributed systems!



kafka

cassandra

HDFS

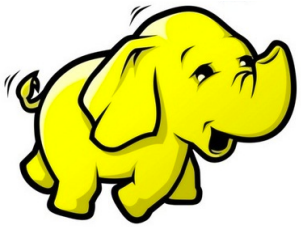
elasticsearch.

MEMCACHED

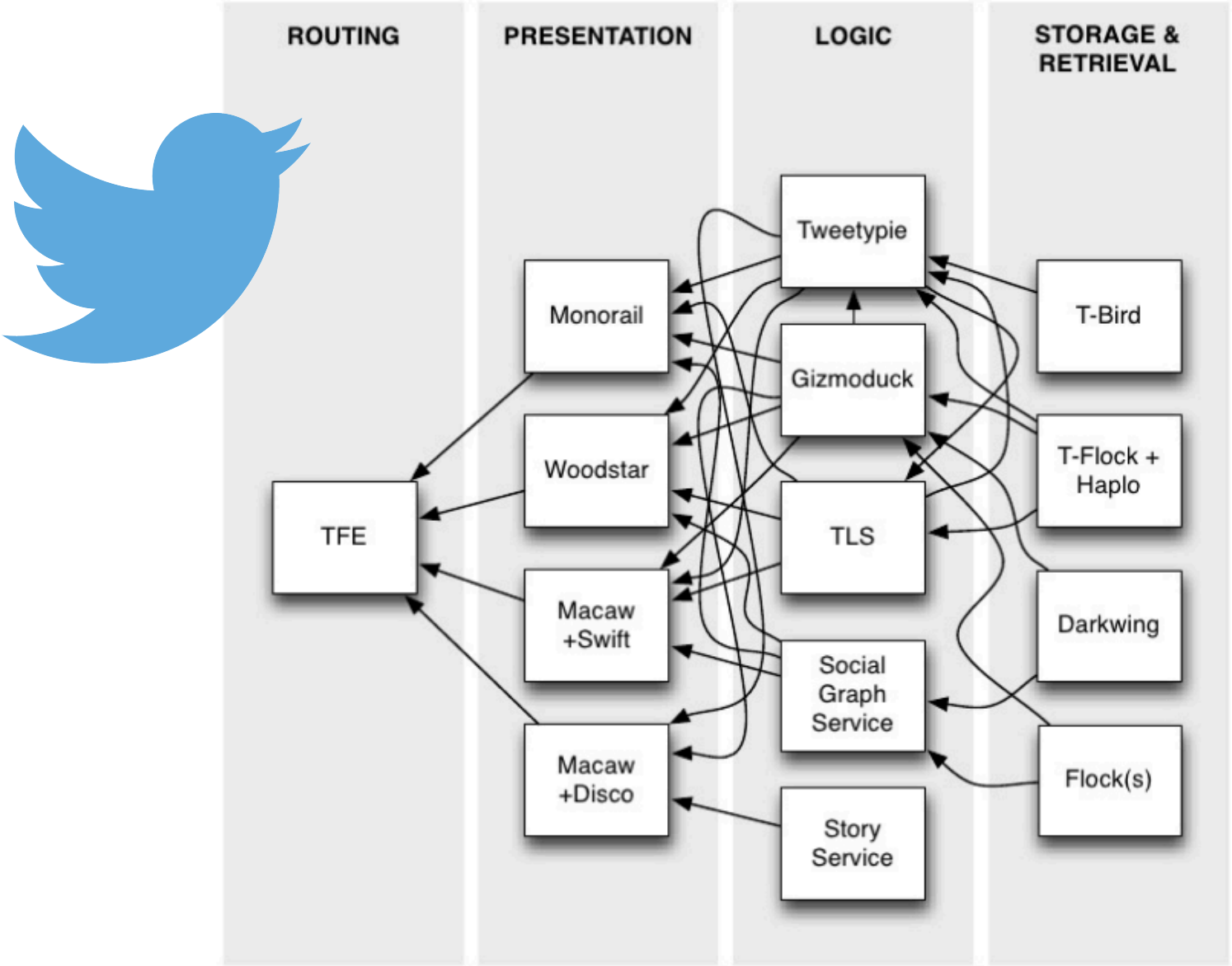
APACHE HBASE

Spark

accumulo™

stateless	stateful
	elasticsearch.

other distributed systems?


ROUTING
PRESENTATION
LOGIC
STORAGE & RETRIEVAL
TFE
Monorail
Woodstar
Macaw +Swift
Macaw +Disco
Tweetypie
Gizmoduck
TLS
Social Graph Service
Story Service
T-Bird
T-Flock + Haplo
Darkwing
Flock(s)

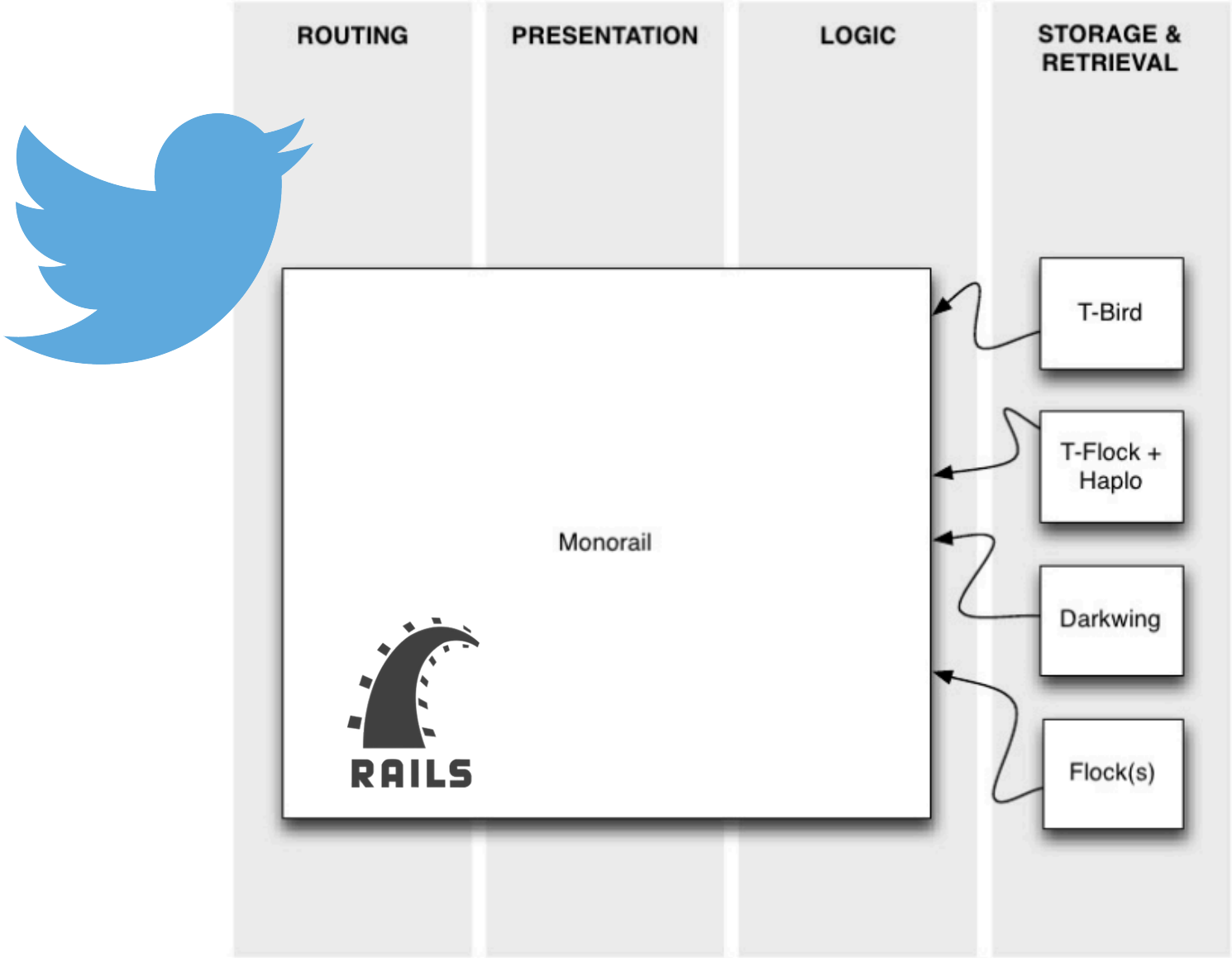
(micro)services

① do one thing and do it well (UNIX)

② compose!

③ build/commit in isolation, test in isolation, deploy in isolation (with easy rollback)

④ captures organizational structure (many teams working in parallel)


ROUTING
PRESENTATION
LOGIC
STORAGE & RETRIEVAL
Monorail
RAILS
T-Bird
T-Flock + Haplo
Darkwing
Flock(s)

There's Just No Getting Around It: You're Building a Distributed System

acmqueue

Association for Computing Machinery

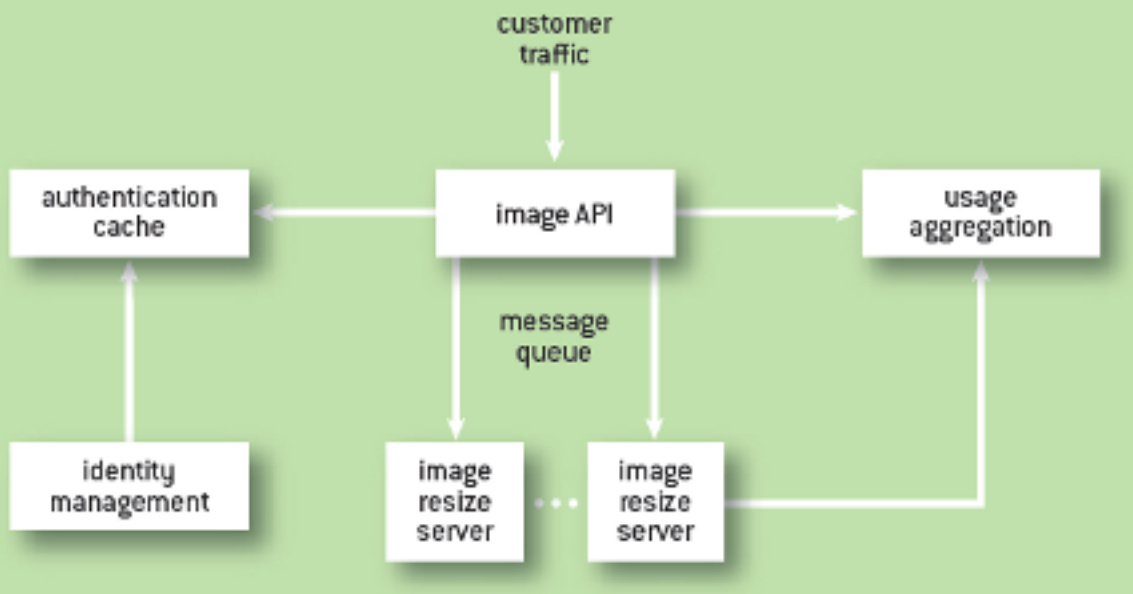
There's Just No Getting Around It: You're Building a Distributed System

by Mark Cavage | May 3, 2013

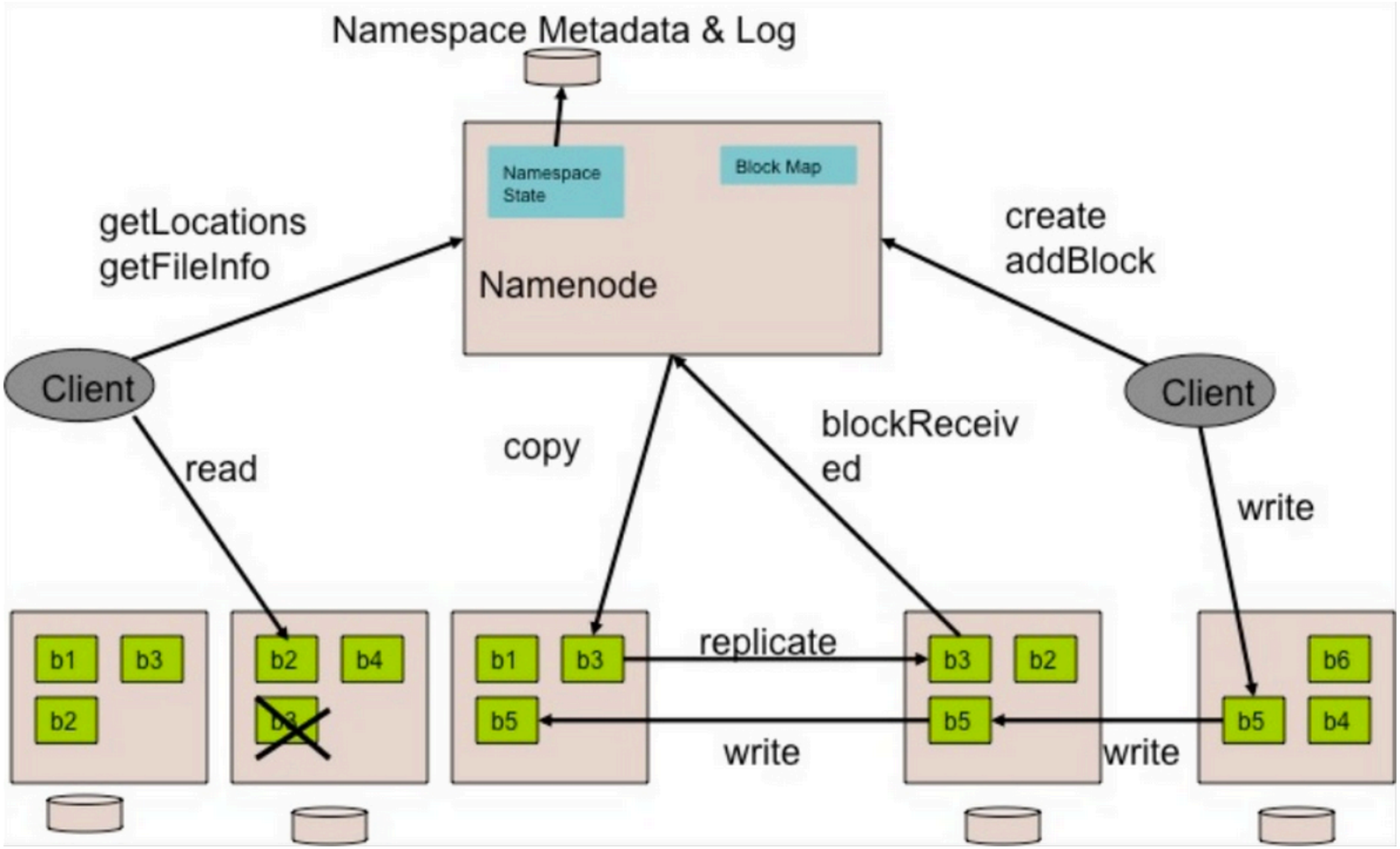
https://queue.acm.org/detail.cfm?id=2482856

FIGURE 1

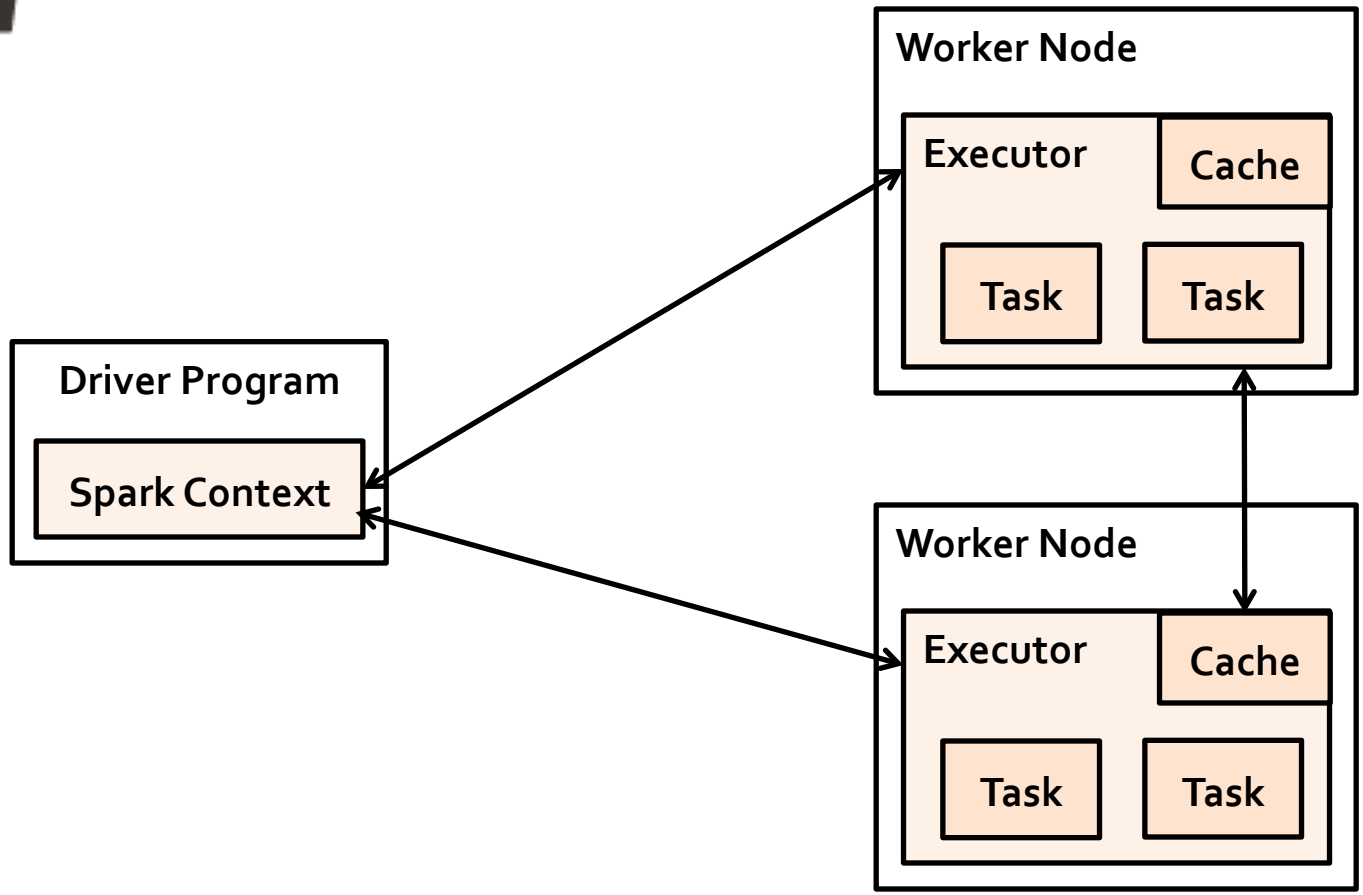
The Distributed Services of an Image Resize Service

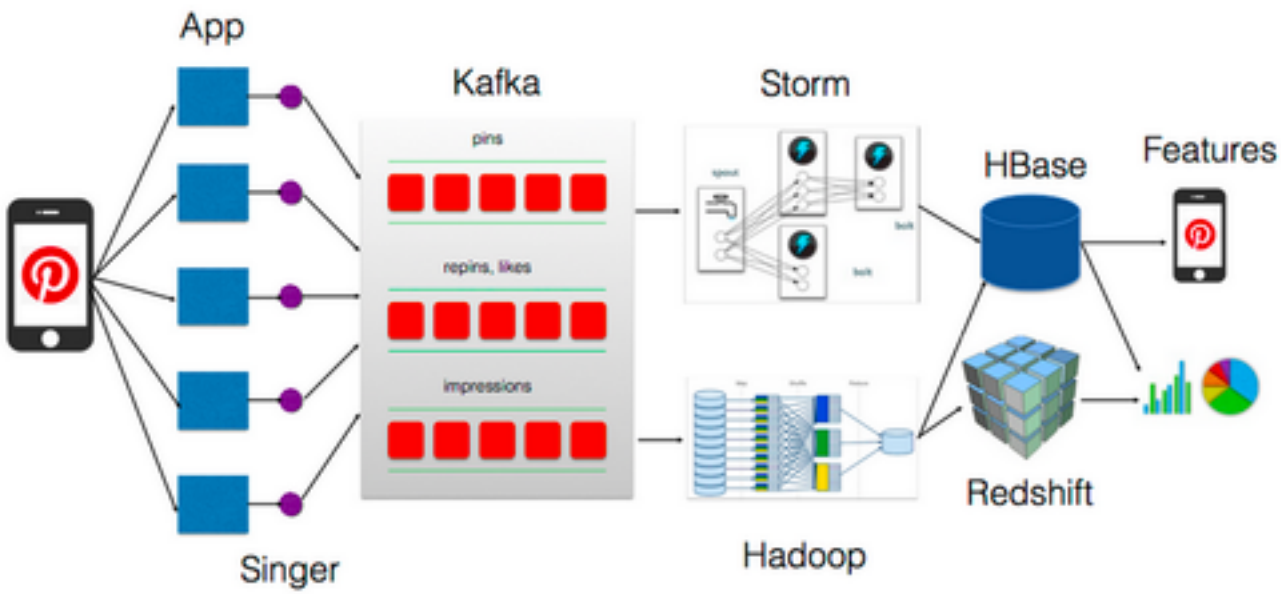


HDFS


Namespace Metadata & Log
Namespace State
Block Map
Namenode
getLocations
getFileInfo
create
addBlock
Client
Client
read
copy
blockReceiv
ed
write
b1
b3
b2
b2
b4
b1
b3
b5
replicate
write
b3
b2
b5
write
b6
b5
b4

Spark


Worker Node
Executor
Cache
Task
Task
Driver Program
Spark Context
Worker Node
Executor
Cache
Task
Task



Data Architecture overview

agenda

① what are datacenter applications?

② how should we run datacenter applications?

③ how should we program datacenter applications?

considerations

① configuration/package management

② deployment

③ service discovery

considerations

① configuration/package management

② deployment

③ service discovery

④ monitoring

considerations

① configuration/package management

② deployment

③ service discovery

④ monitoring

ops

considerations

① configuration/package management

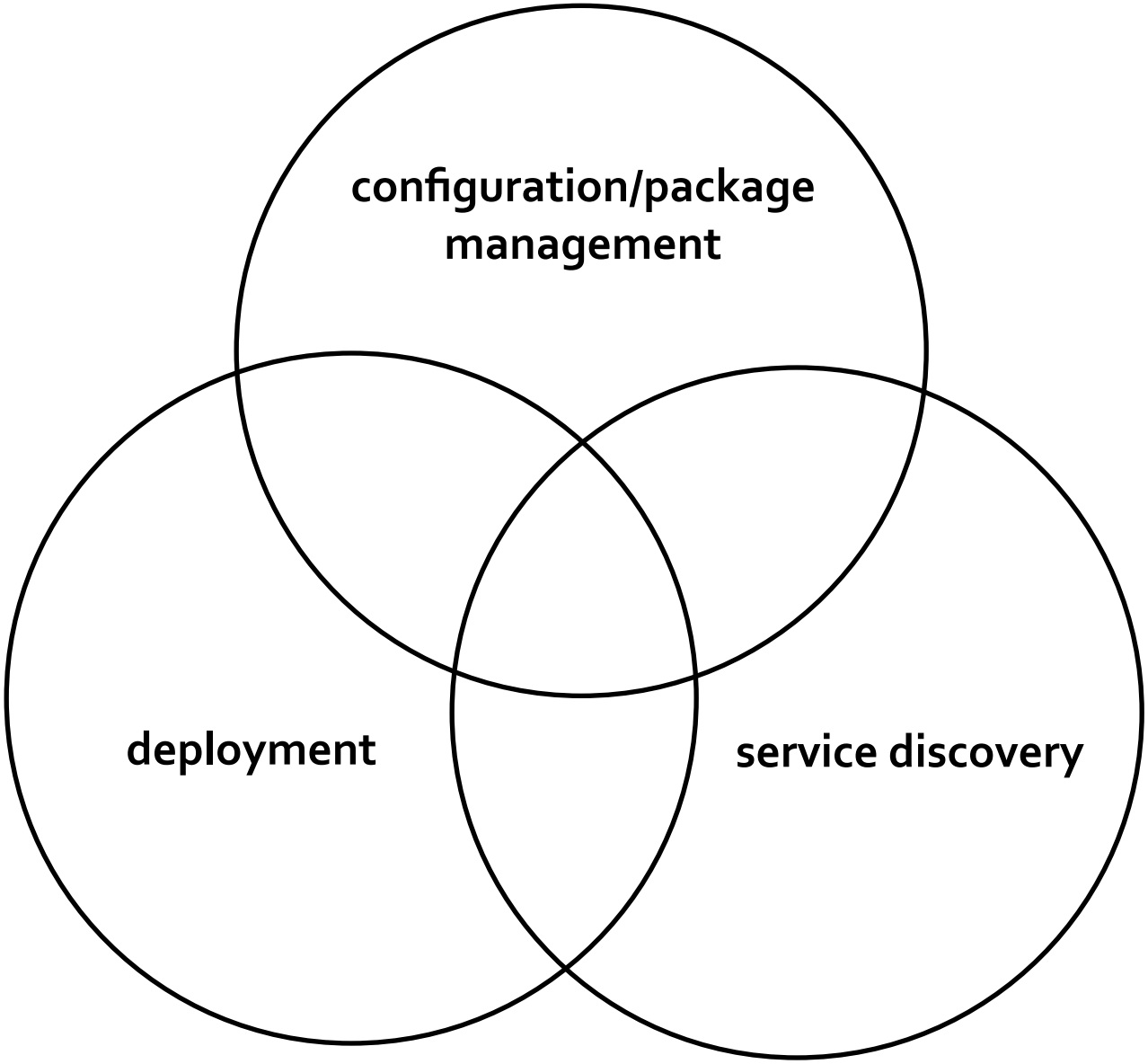
② deployment

③ service discovery

④ monitoring

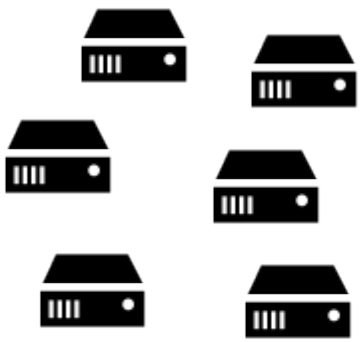
developers

ops


configuration/package management
deployment
service discovery

configuration/package management

"what/how do things get installed?"



(10's of machines)

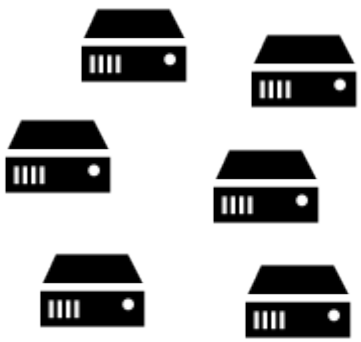
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

hosts.txt

$ ssh host ./configure && make install

configuration/package management

"what/how do things get installed?"



(10's of machines)

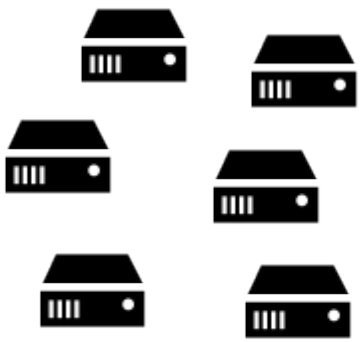
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

hosts.txt

$ ssh host rpm -ivh pkg-x.y.z.rpm

deployment

"what should run where?"
"how should it be started/stopped?"



(10's of machines)

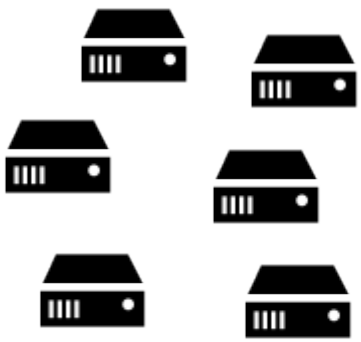
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

hosts.txt

$ ssh host nohup myapp

deployment

"what should run where?"
"how should it be started/stopped?"



(10's of machines)

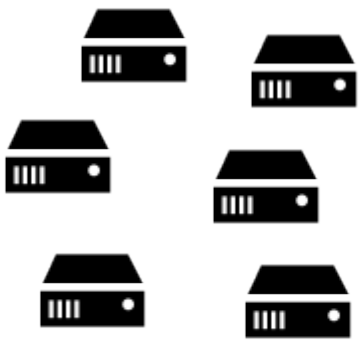
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

hosts.txt

$ ssh host monit start myapp

deployment

"what should run where?"
"how should it be started/stopped?"



(10's of machines)

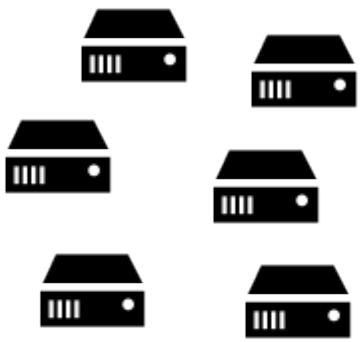
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

hosts.txt

```
$ scp myapp host
$ ssh host monit myapp
```

deployment

"what should run where?"
"how should it be started/stopped?"



(10's of machines)

web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

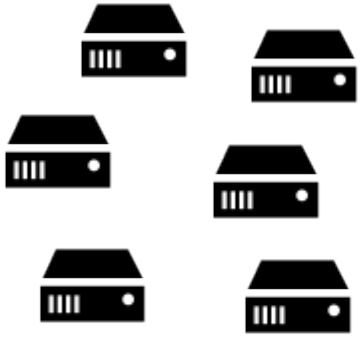
hosts.txt

git

```
$ ssh host git pull && \
  monit myapp
```

service discovery

"how should apps find each other?"



(10's of machines)

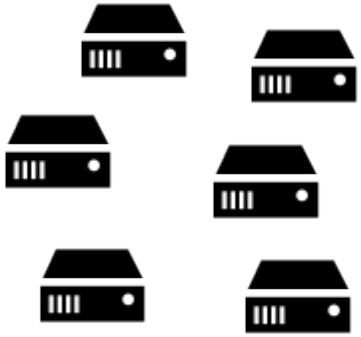
web1.twttr.com
web2.twttr.com
web3.twttr.com
web4.twttr.com

webhosts.txt

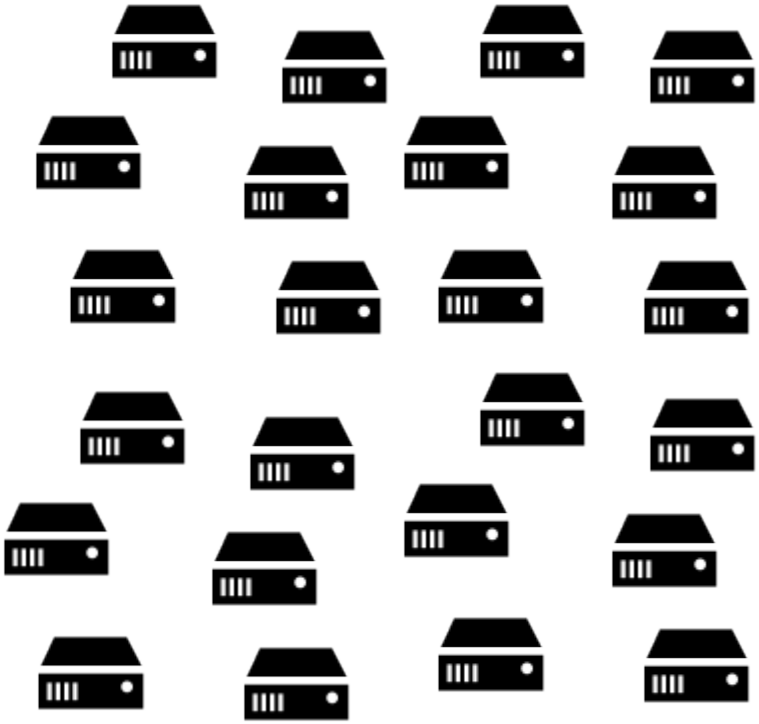
db1.twttr.com
db2.twttr.com
db3.twttr.com
db4.twttr.com

dbhosts.txt

to scale,
need less moving parts,
more automation



(10's of machines)



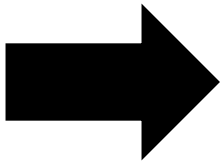
(100's -> 1000's of machines)

Twitter, circa 2010

dbhosts.txt

webhosts.txt

$ ssh host ...

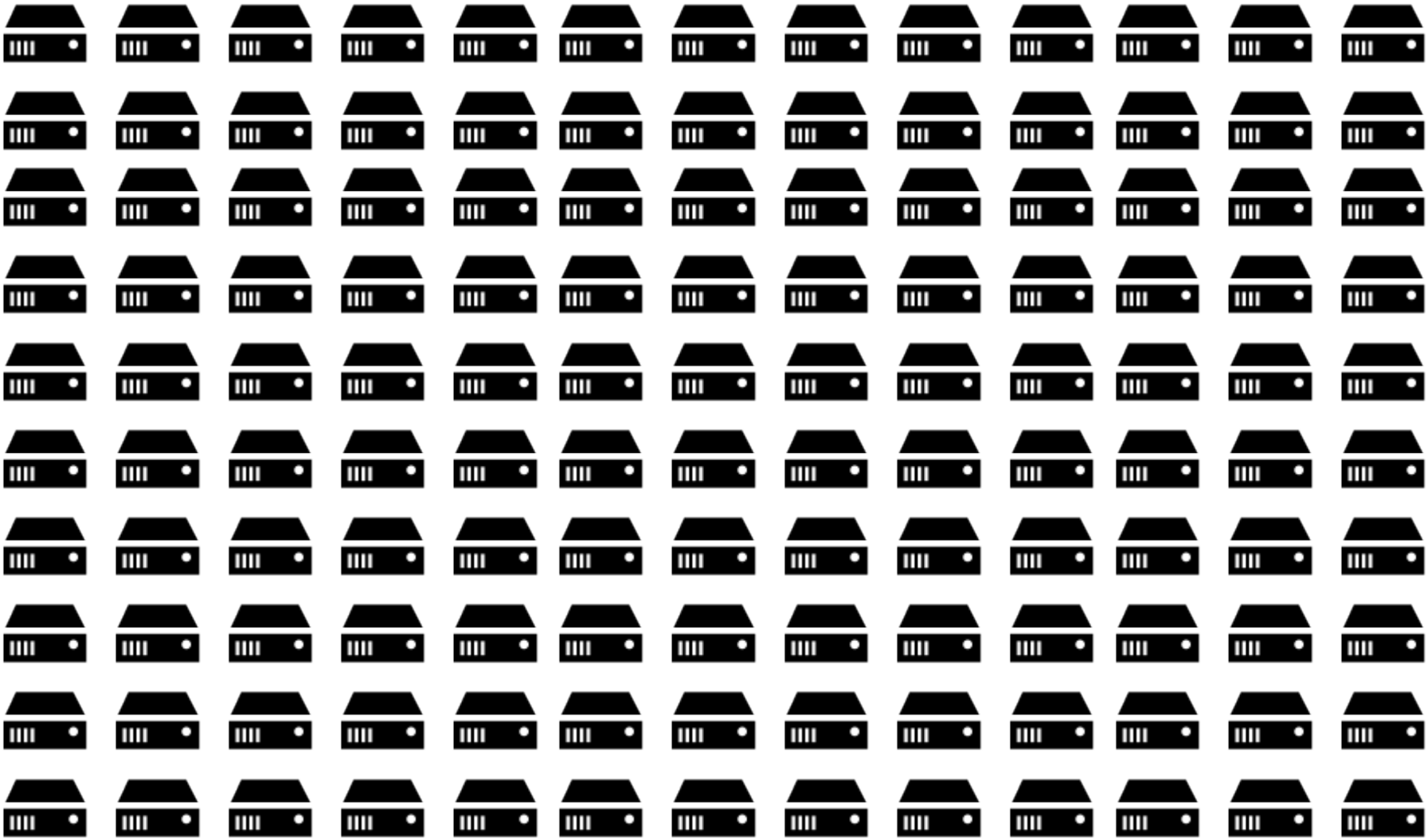


puppet labs

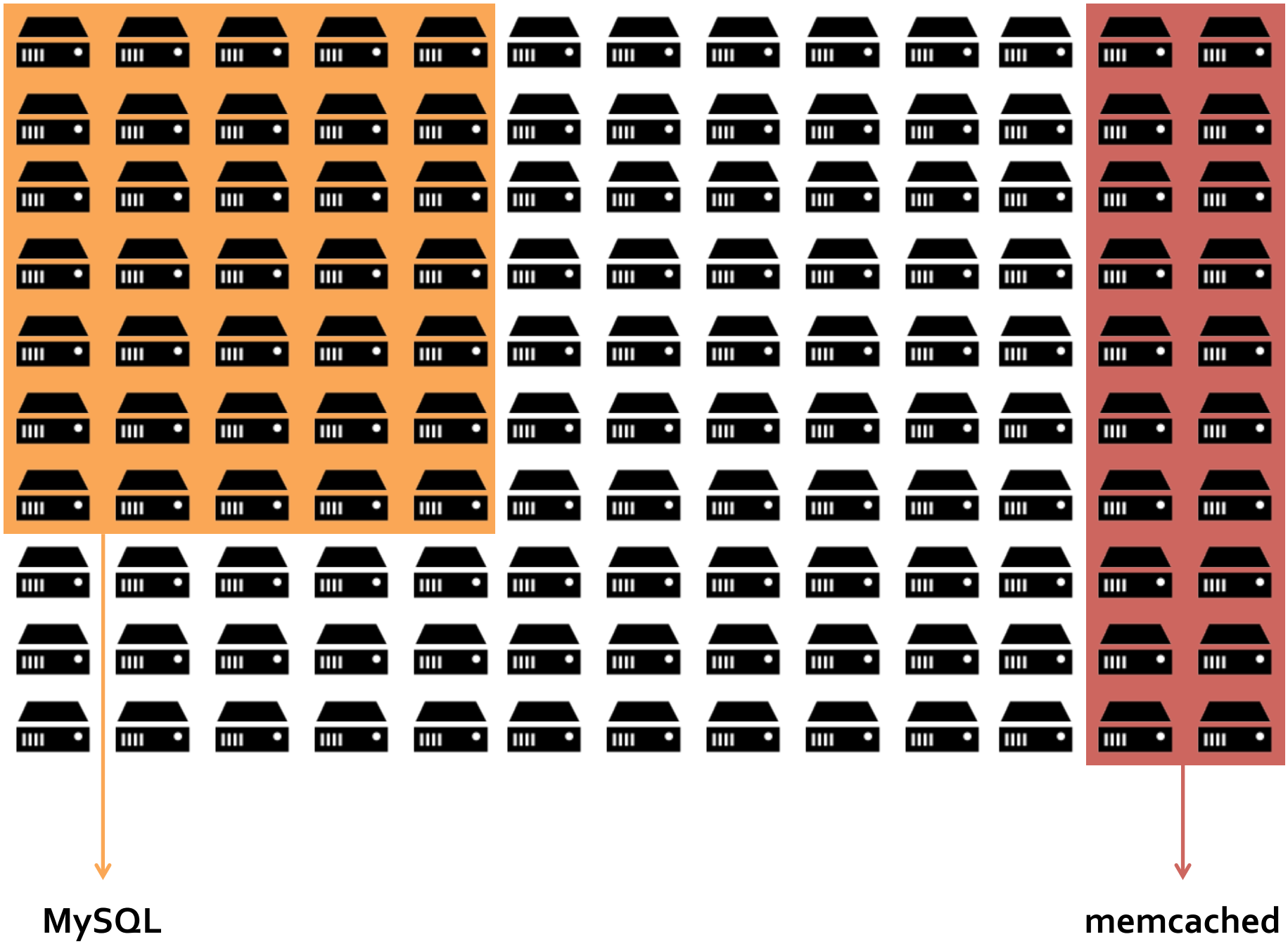
(configuration/package management)

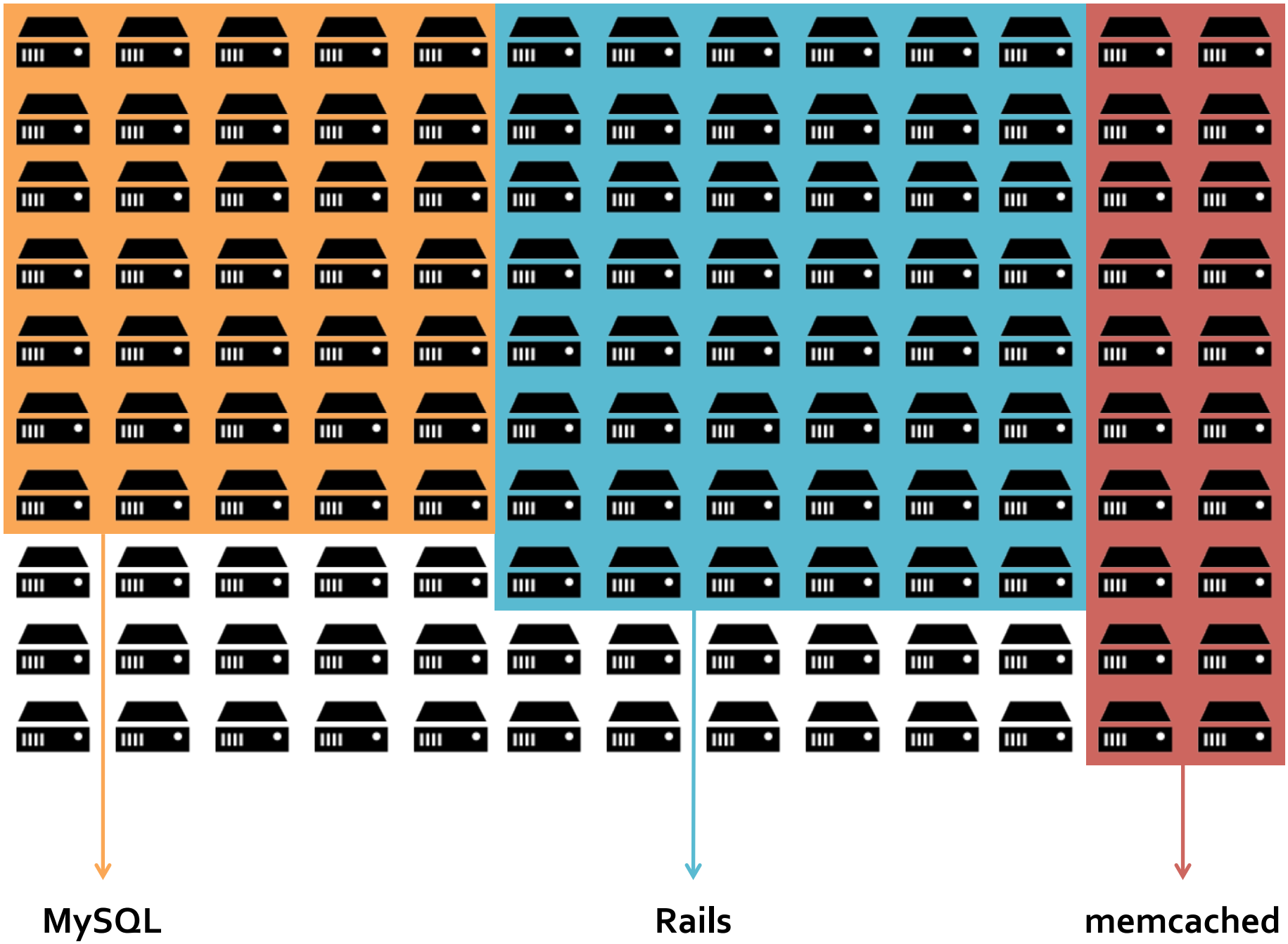
Capistrano

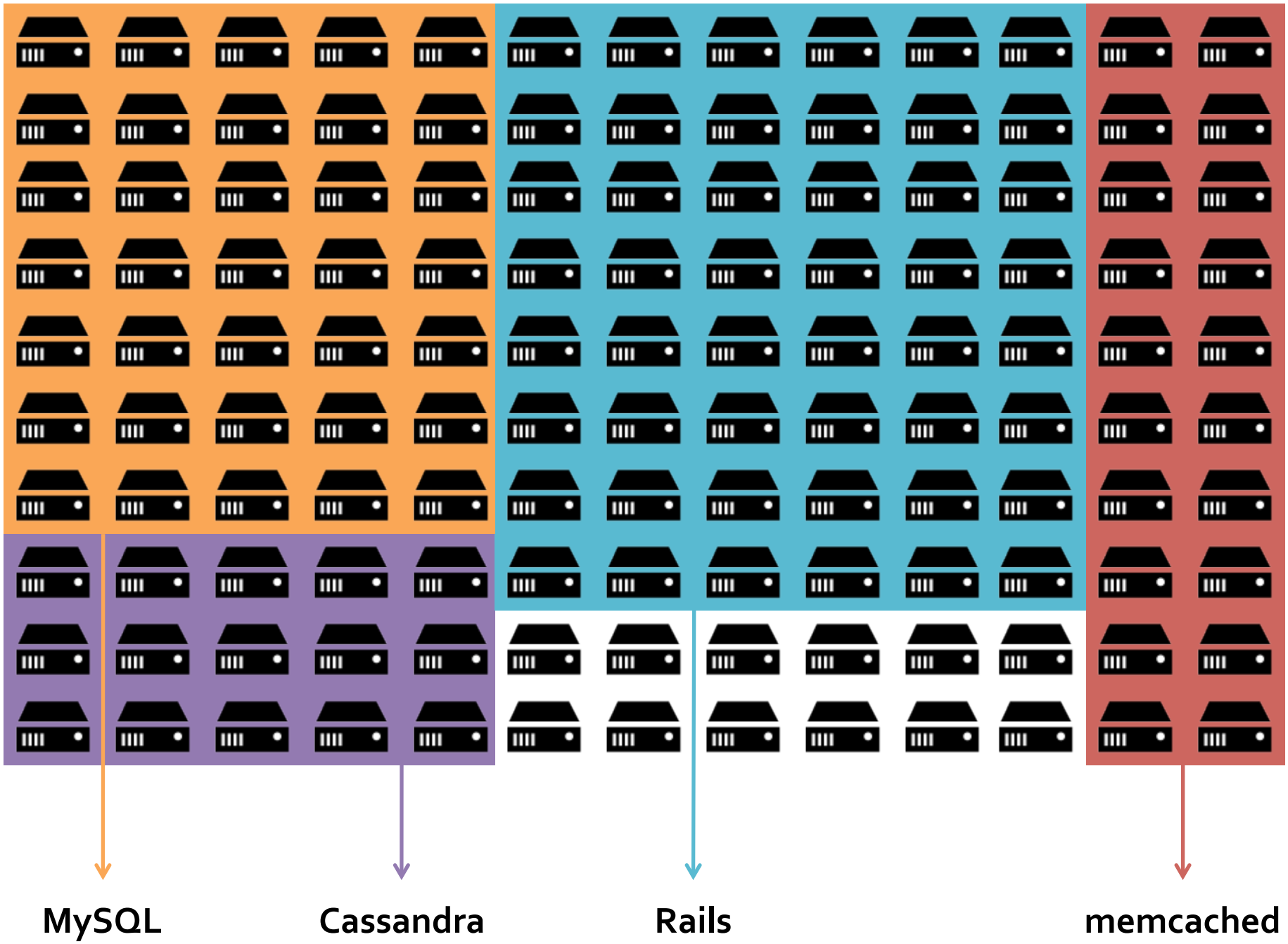
(deployment)

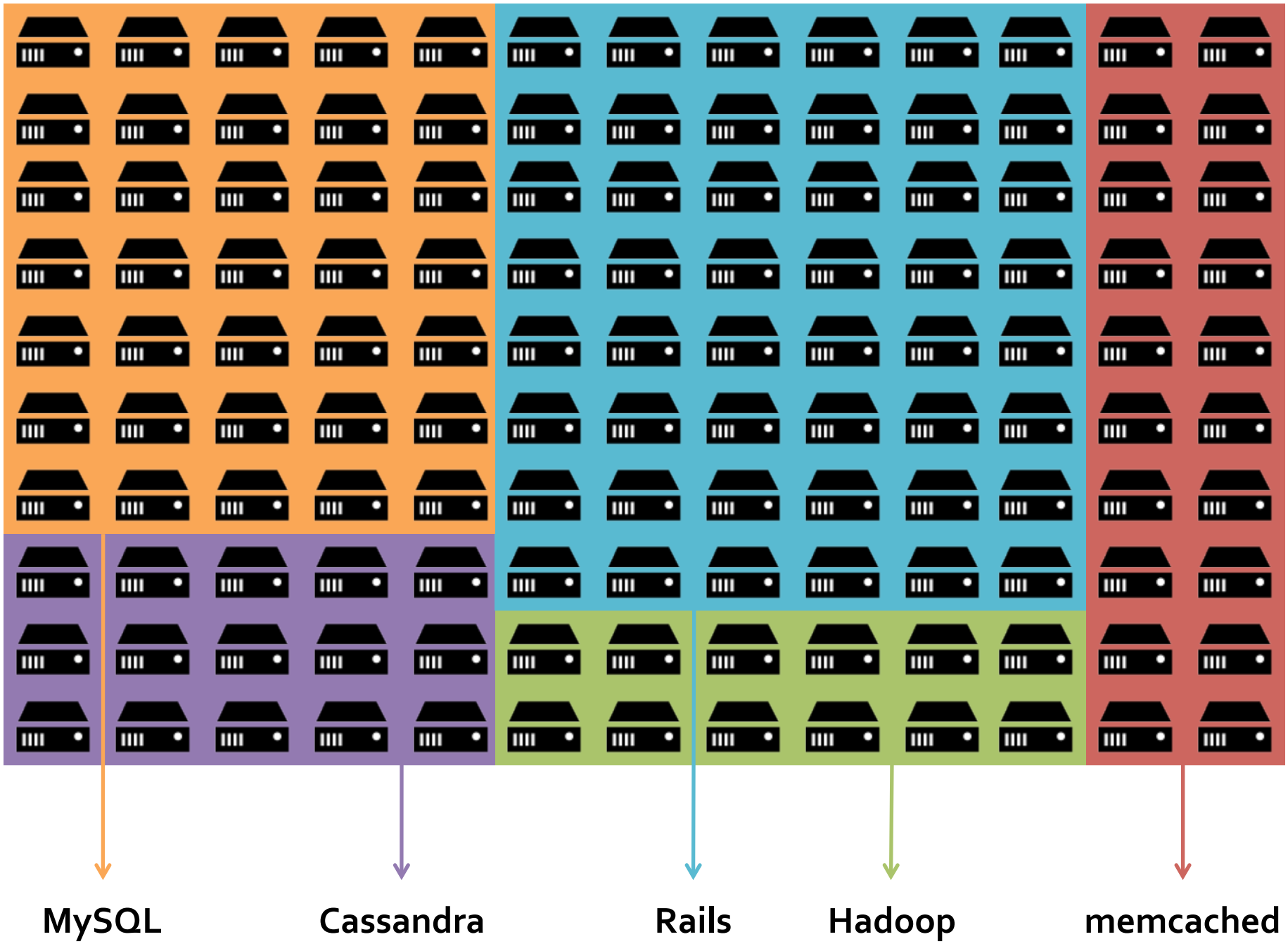


MySQL


MySQL
memcached


MySQL
Rails
memcached


MySQL
Cassandra
Rails
memcached


MySQL
Cassandra
Rails
Hadoop
memcached

challenges

challenges

① failures

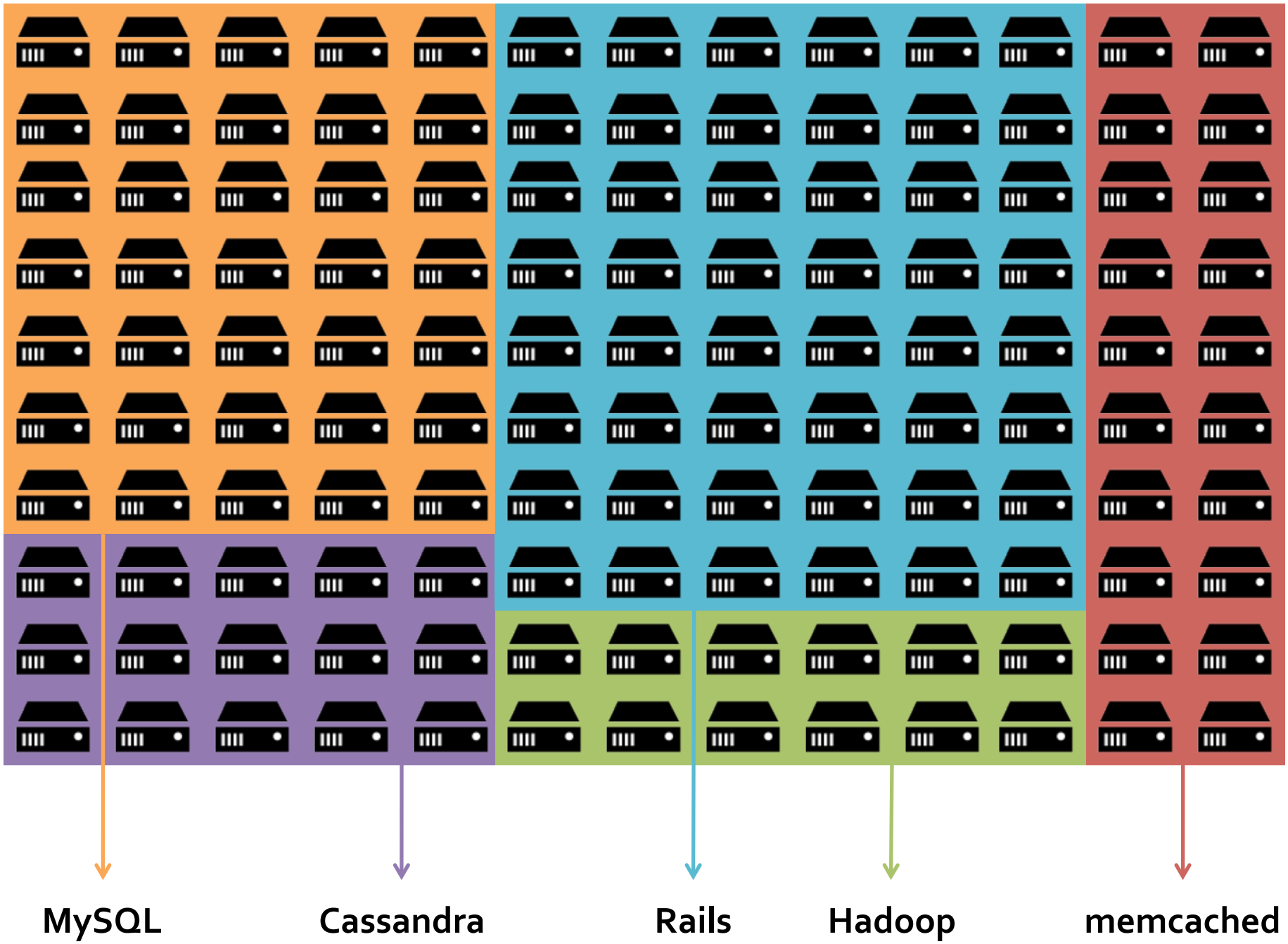
failures

sjc1a249 rebooted Inbox x

Roger Rabbit <rrabbit@twitter.com> 6/13/10 Reply to all

to research, Rion, Abdur, Operations

FYI, sjc1a249 had to be rebooted by NTTA. Were there any production services running on this machine?


MySQL
Cassandra
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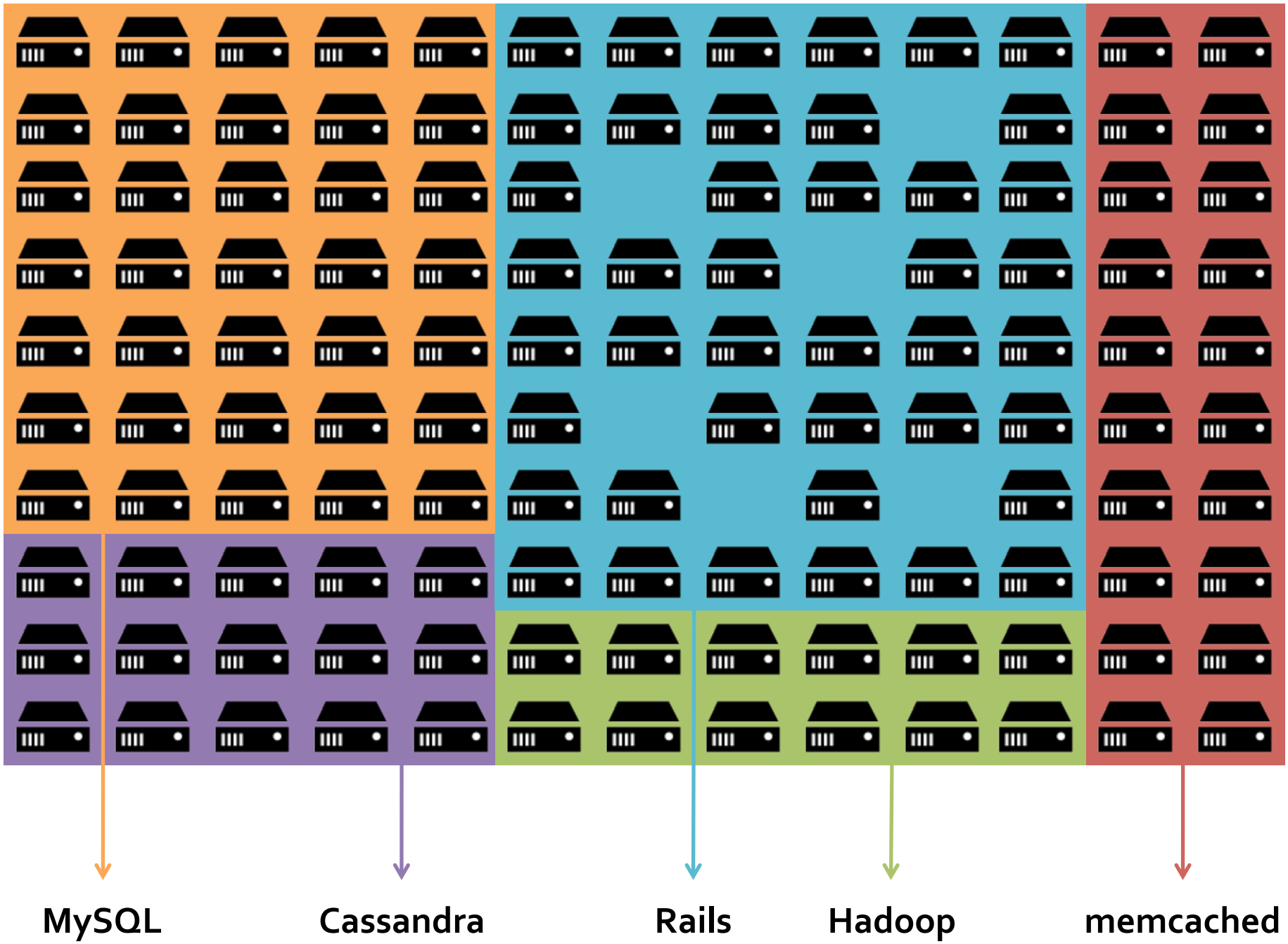
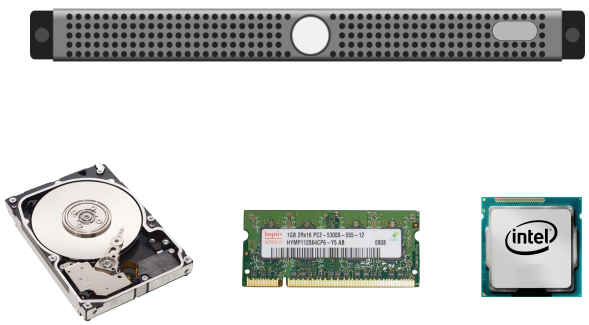

MySQL
Cassandra
Rails
Hadoop
memcached

types of failure: fault domains



machine
(disk, memory, CPU, etc)

rack
(switch, PDU)

datacenter

challenges

② maintenance

(aka “planned failures”)

maintenance

① upgrading software (i.e., the kernel)

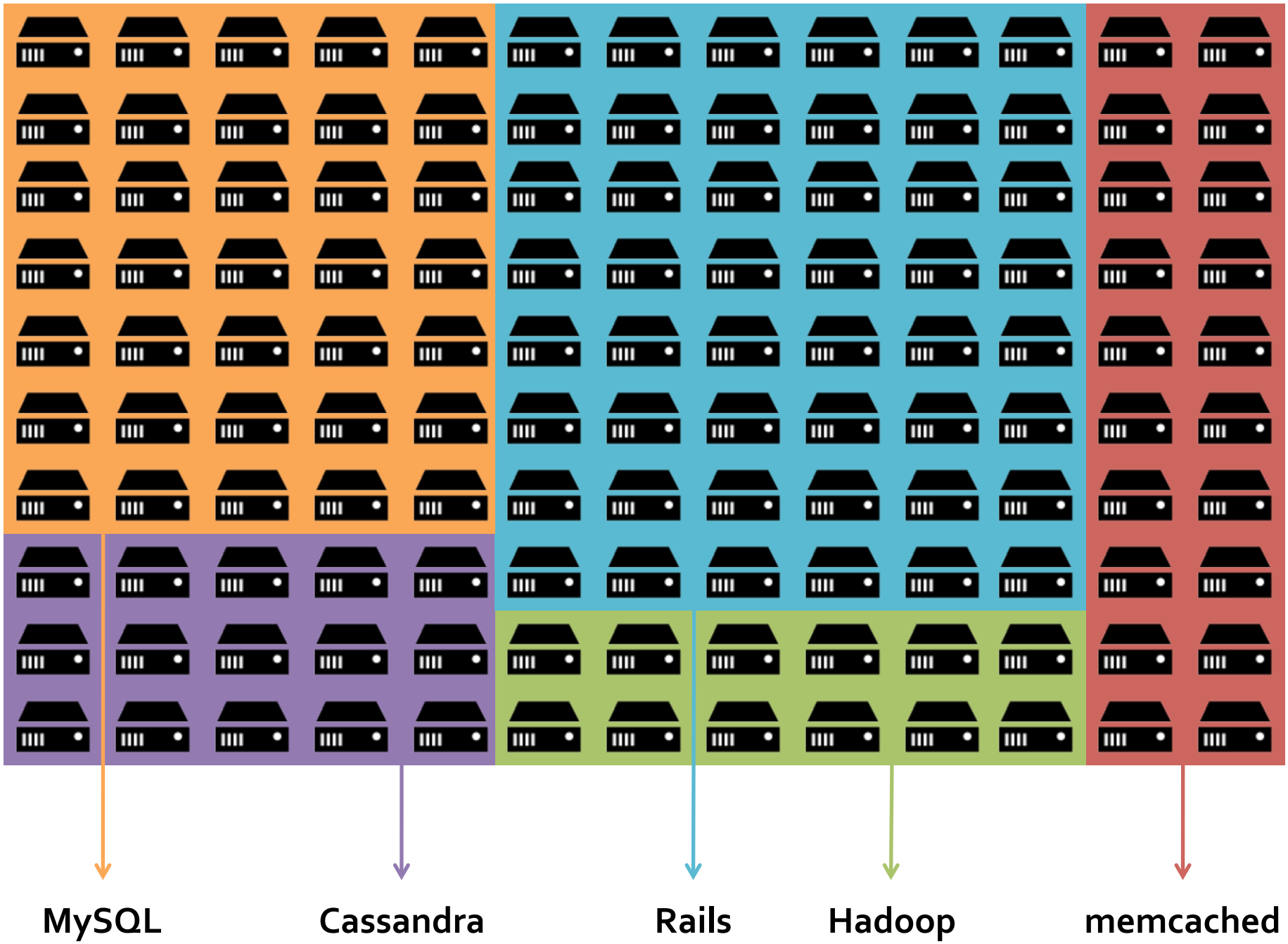
developers

ops

maintenance

① upgrading software (i.e., the kernel)

② replacing machines, switches, PDUs, etc


MySQL
Cassandra
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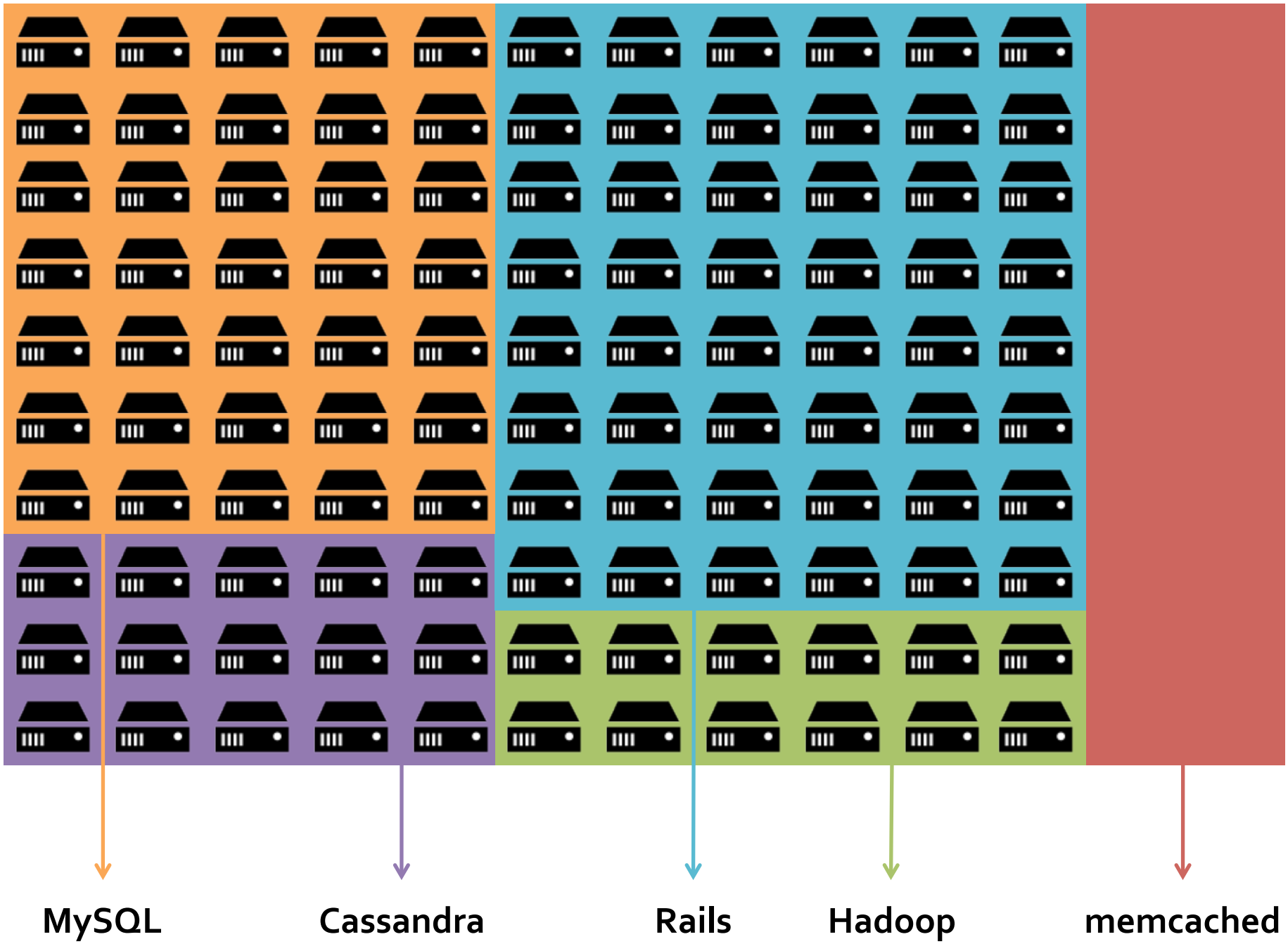
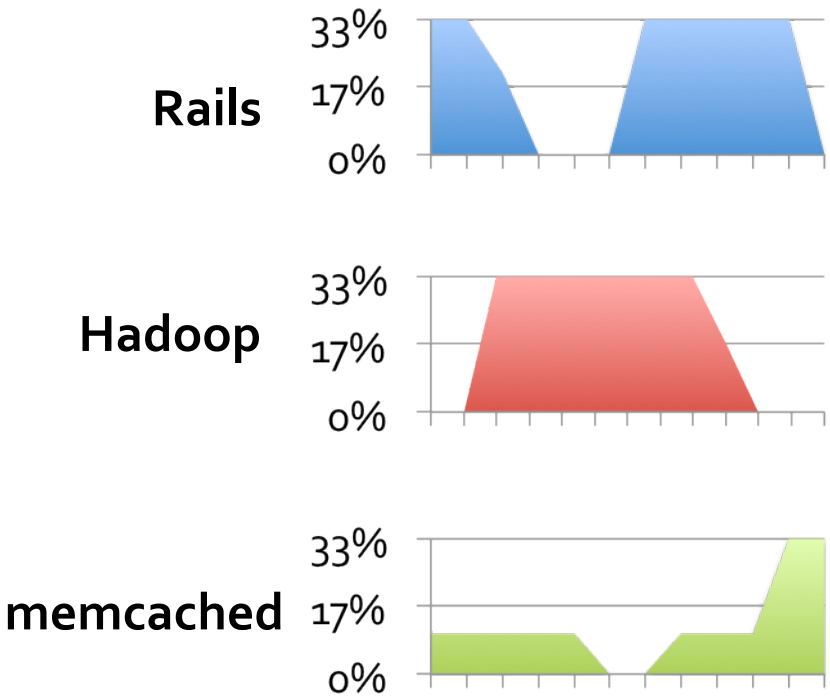
memcached


MySQL
Cassandra
Rails
Hadoop
memcached

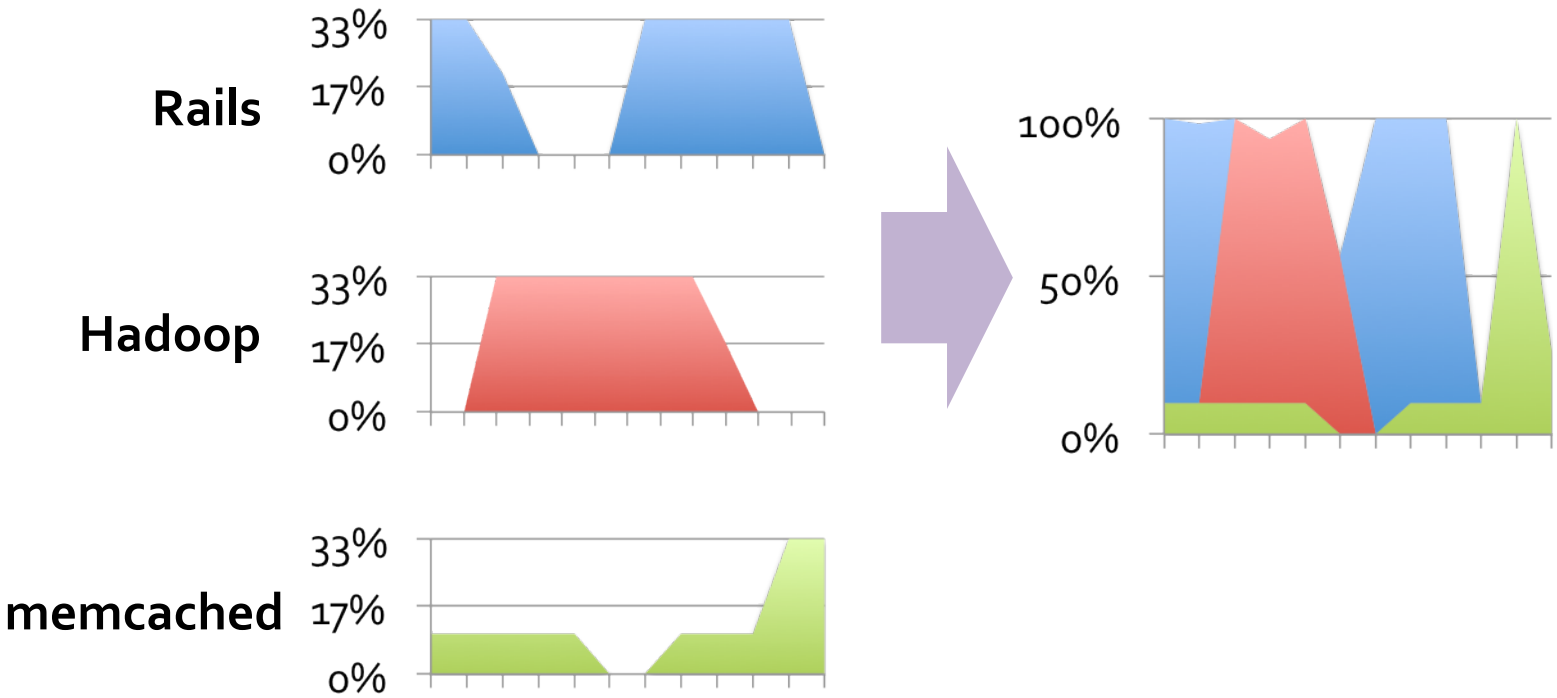
challenges

③ utilization

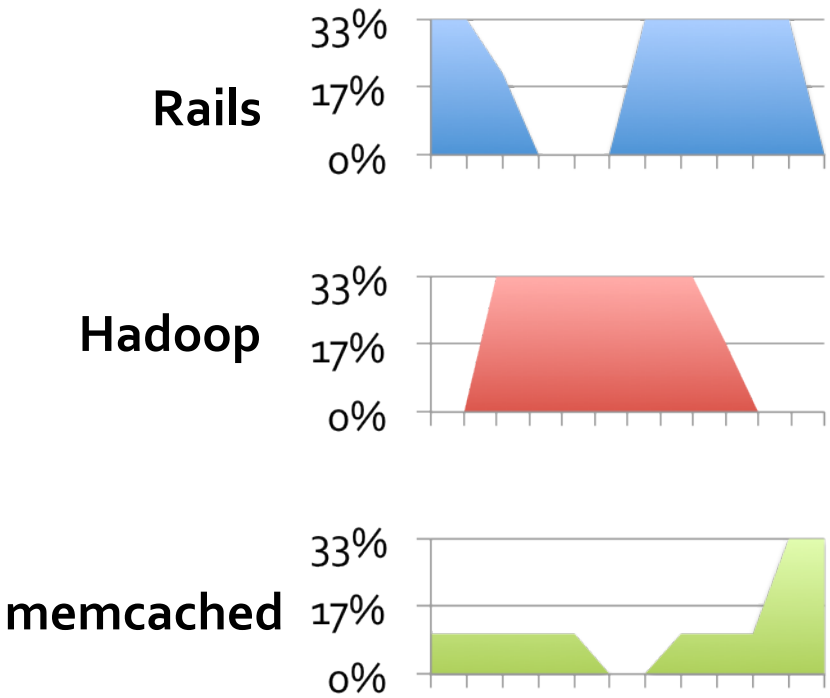
utilization

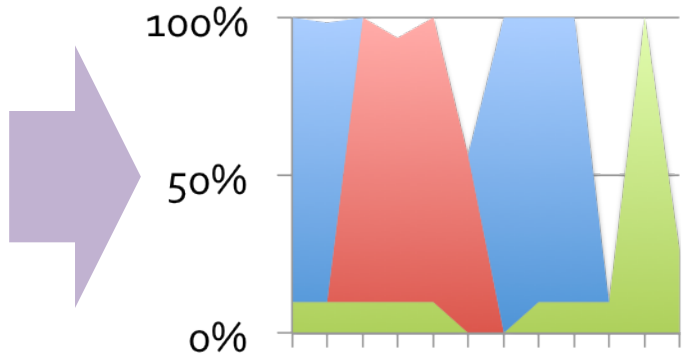


utilization



utilization





buy less machines
or
run more applications!

challenges

① failures

② maintenance

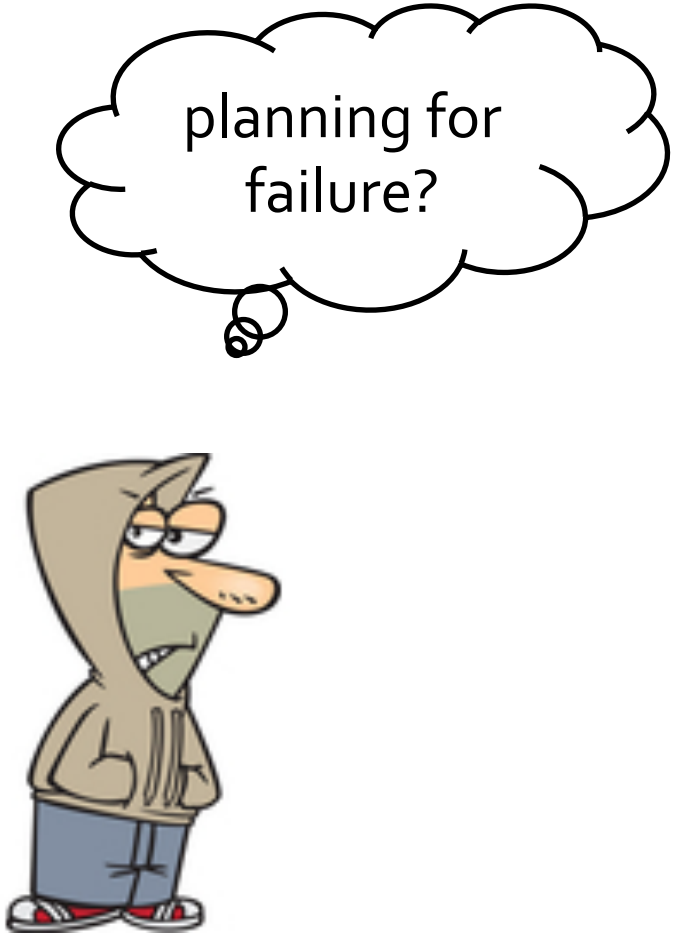
③ utilization

challenges

① failures

② maintenance

③ utilization



planning for failure

Which rack are these devices on? Inbox x signal x

George Washington <gwash@twitter.com> 2/1/10 Reply to all

to Sandra, William

Sandra, we are setting up a couple of DB masters and we'd like to know what rack, Switch, and PDU these devices are on.

db021.twitter.com	LFVSFCP29546	sjc1	twitter4	twitterdb
db028.twitter.com	LFVSFCP29579	sjc1	twitter4	twitterdb

Preferably they are on different racks, switches, and power feeds, so that they are fully redundant.

challenges

① failures

② maintenance

③ utilization

planning for utilization

intra-machine resource sharing:

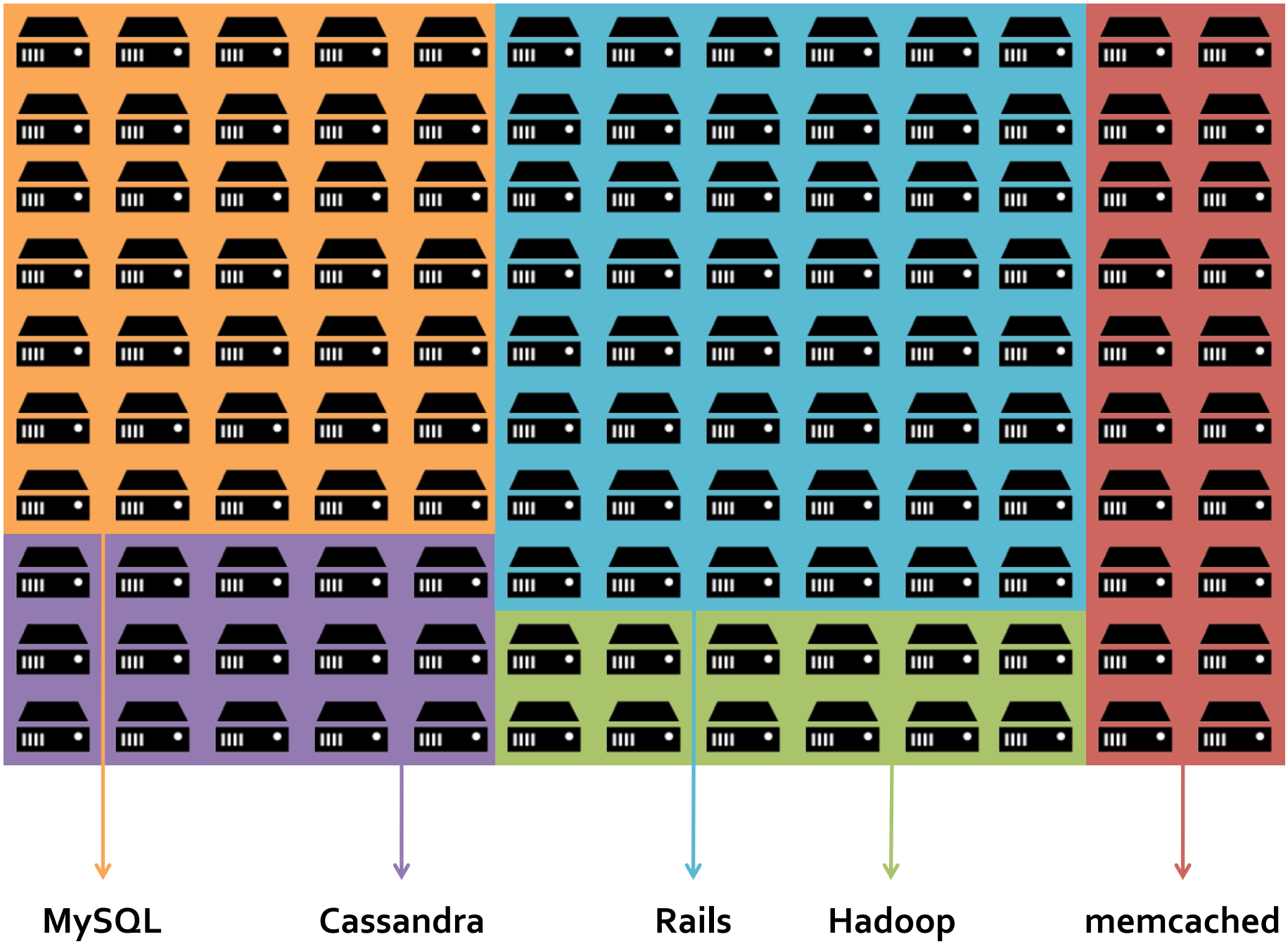
share a single machine's resources between multiple applications (multi-tenancy)

intra-datacenter resource sharing:

share multiple machine's resources between multiple applications

Twitter, circa 2010

cluster manager provides a level-of-indirection between hardware resources (machines) and applications/jobs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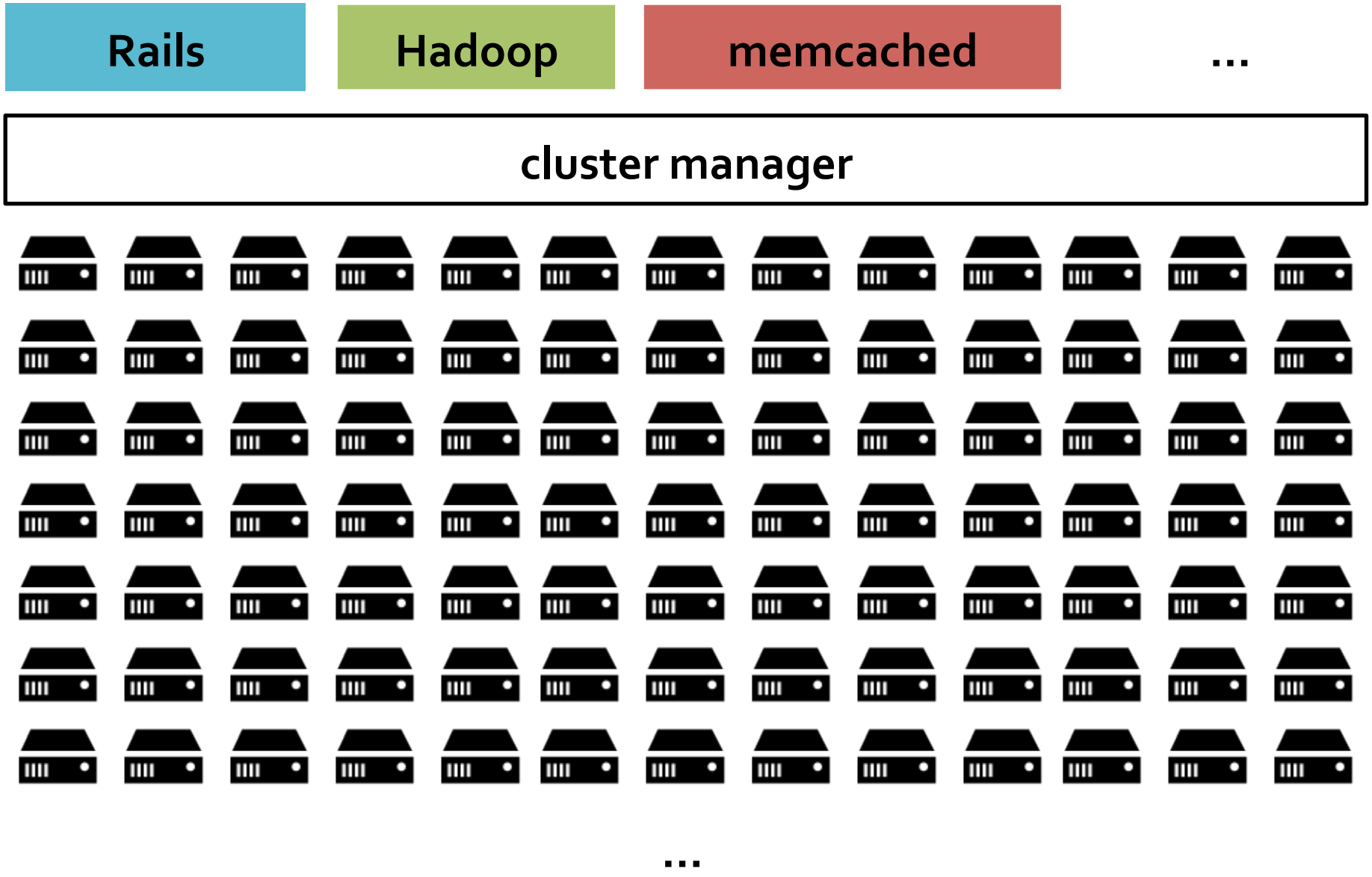
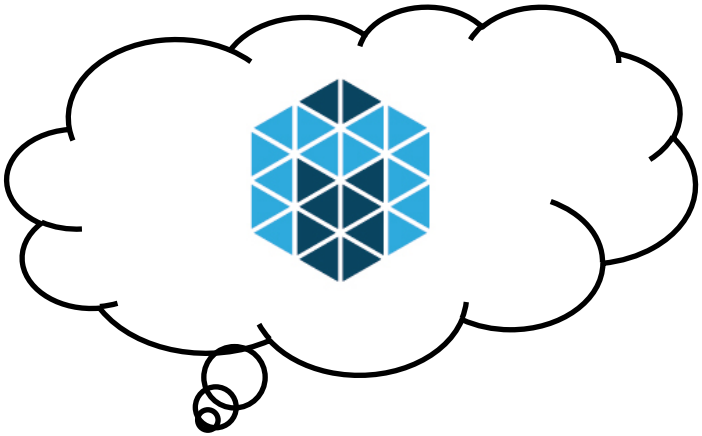

Rails
Hadoop
memcached
...
cluster manager
...

Twitter, circa 2010

Twitter, circa 2010

Twitter, circa 2010



Xoogler

Berkeley
UNIVERSITY OF CALIFORNIA

Apache Mesos is a modern *general purpose* cluster manager (i.e., not just focused on batch scheduling)

cluster management

academia

industry

different software

academia

- MPI (Message Passing Interface)

industry

- Apache (mod_perl, mod_php)
- web services (Java, Ruby, ...)

different scale (at first)

academia

- **100's of machines**

industry

- **10's of machines**

cluster management

academia

- PBS (Portable Batch System)
- TORQUE
- SGE (Sun Grid Engine)

cluster managers

industry

- ssh
- Puppet/Chef
- Capistrano/Ansible

different scale (converging)

academia

- 100's of machines

industry

- 10's of machines

1,000's of machines

cluster management

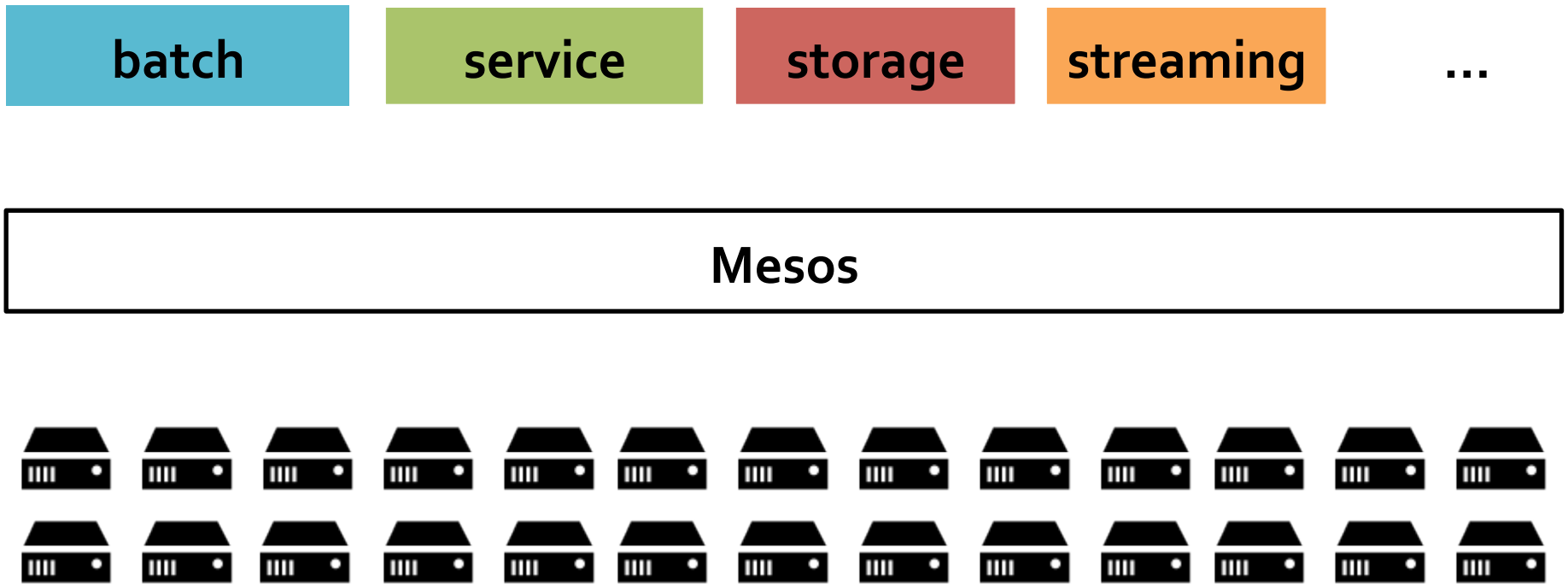
academia

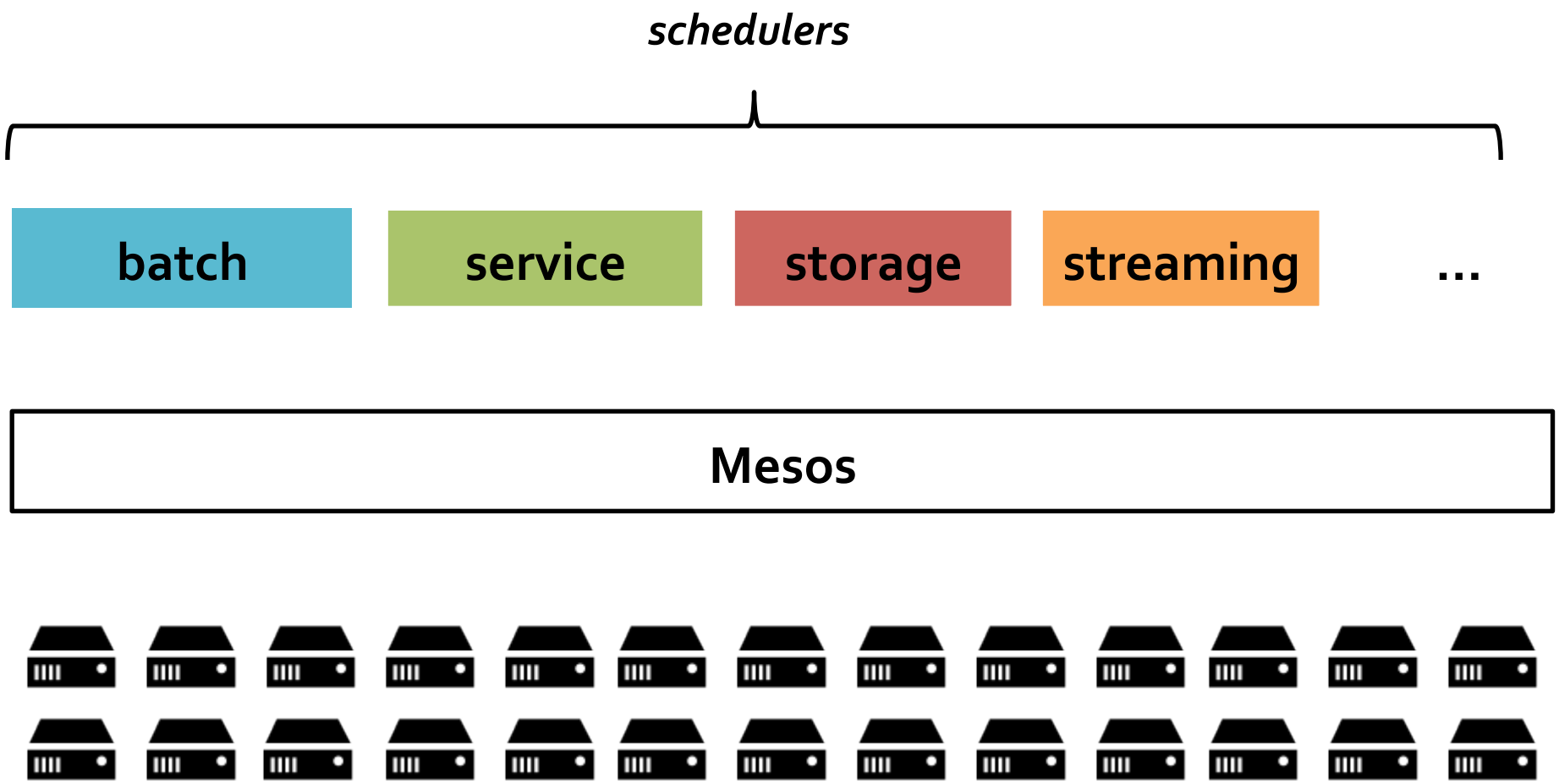
- PBS (Portable Batch System)
- TORQUE
- SGE (Sun Grid Engine)

batch computation!

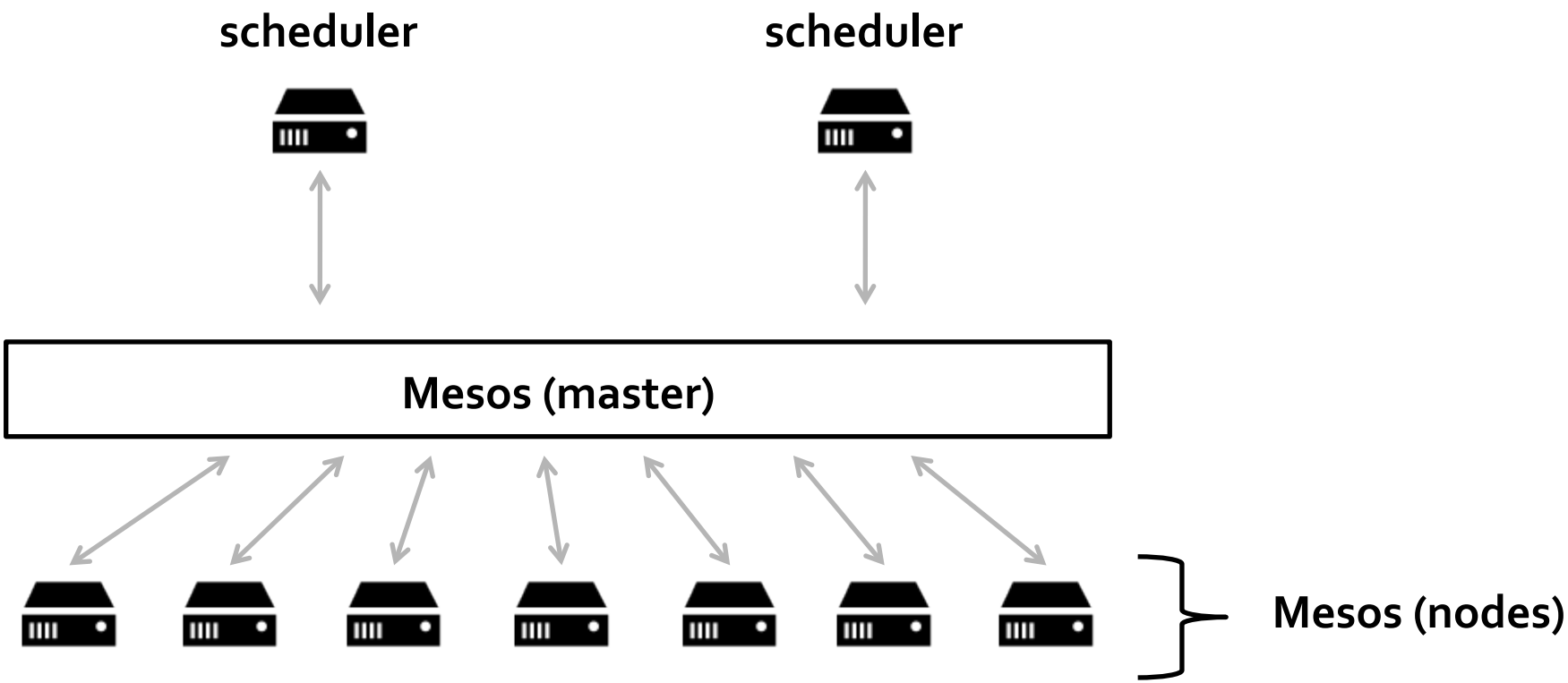
industry

- ssh
- Puppet/Chef
- Capistrano/Ansible

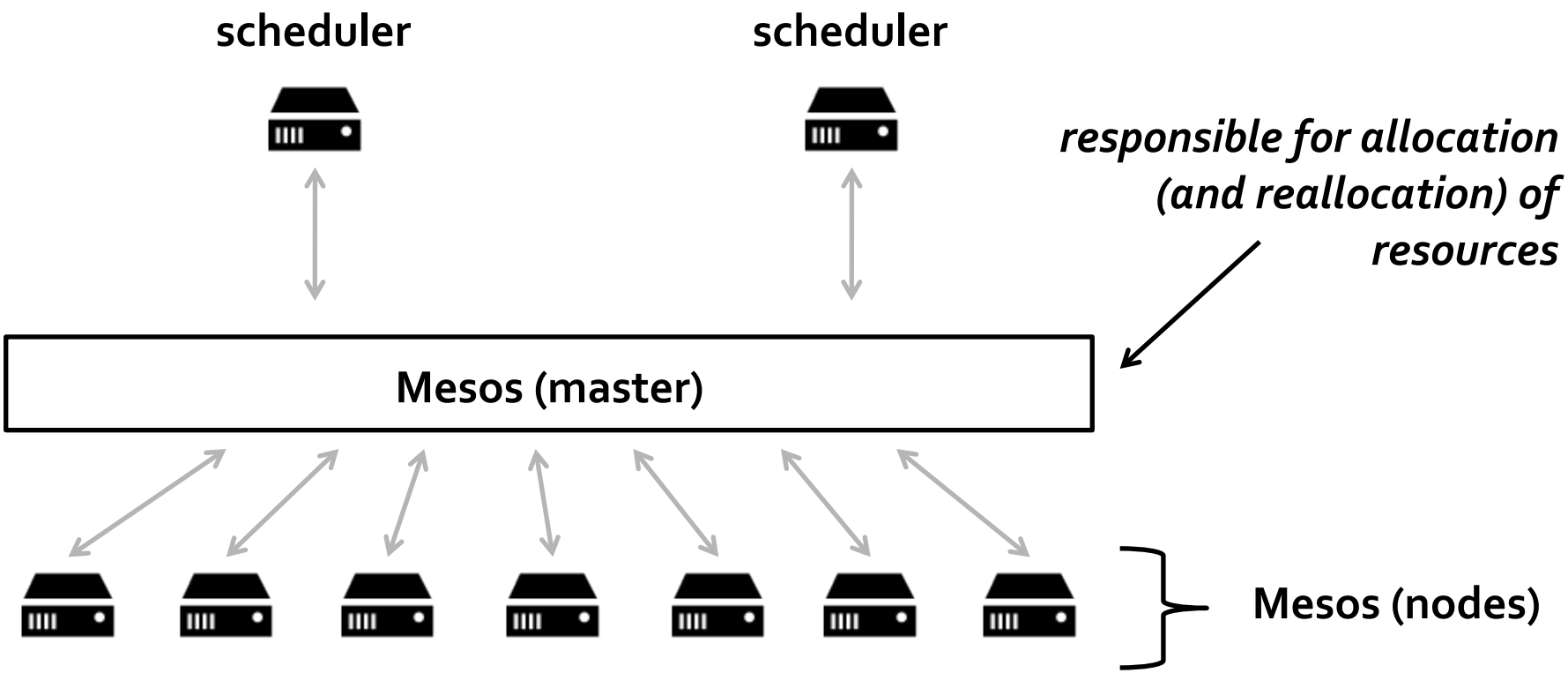

batch
service
storage
streaming
...
Mesos


schedulers
batch
service
storage
streaming
...
Mesos

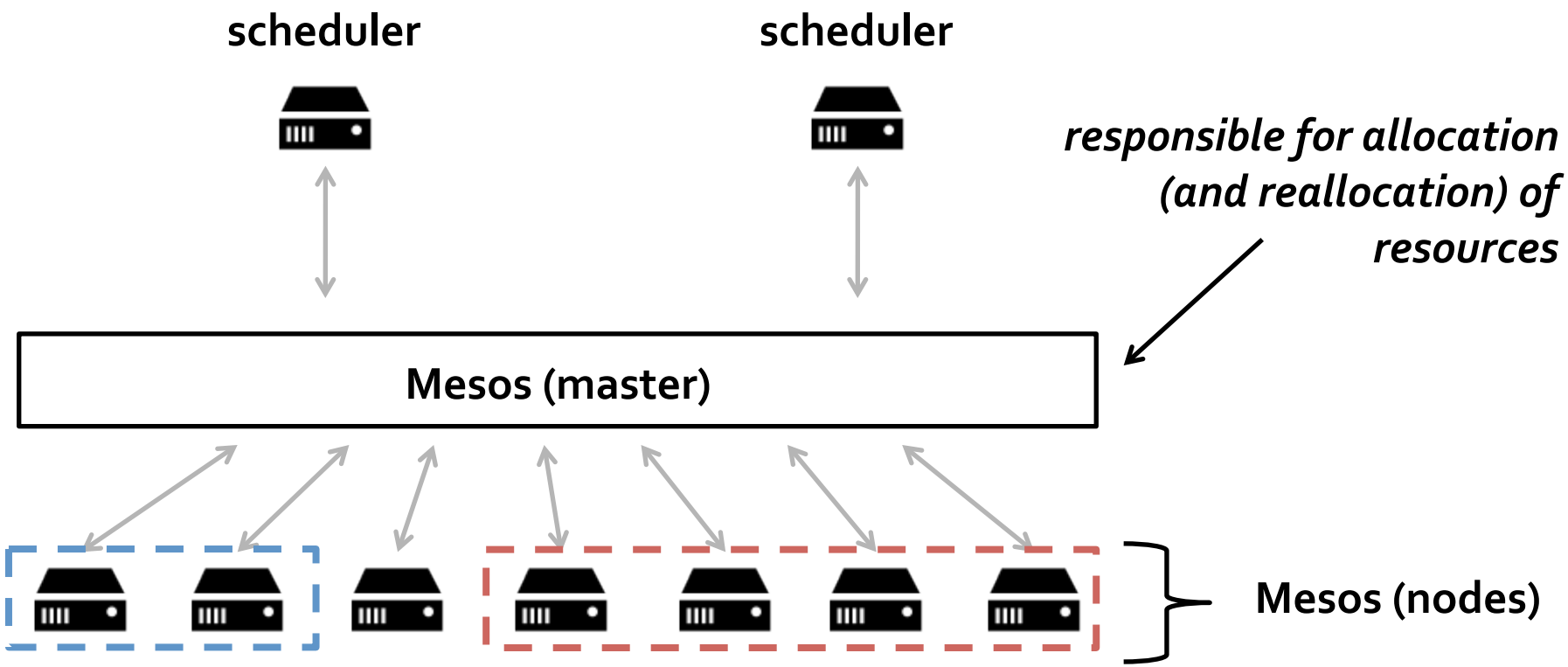
Mesos: level of indirection



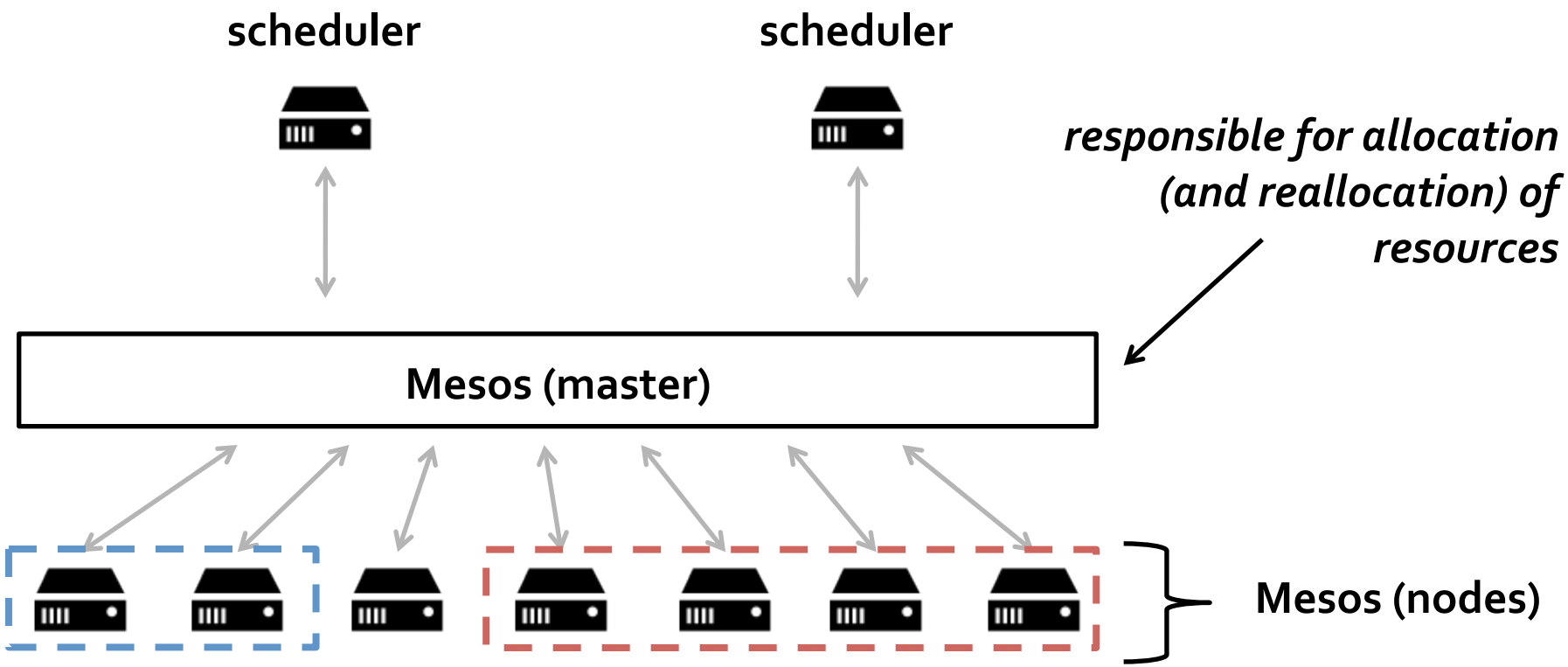
Mesos: level of indirection



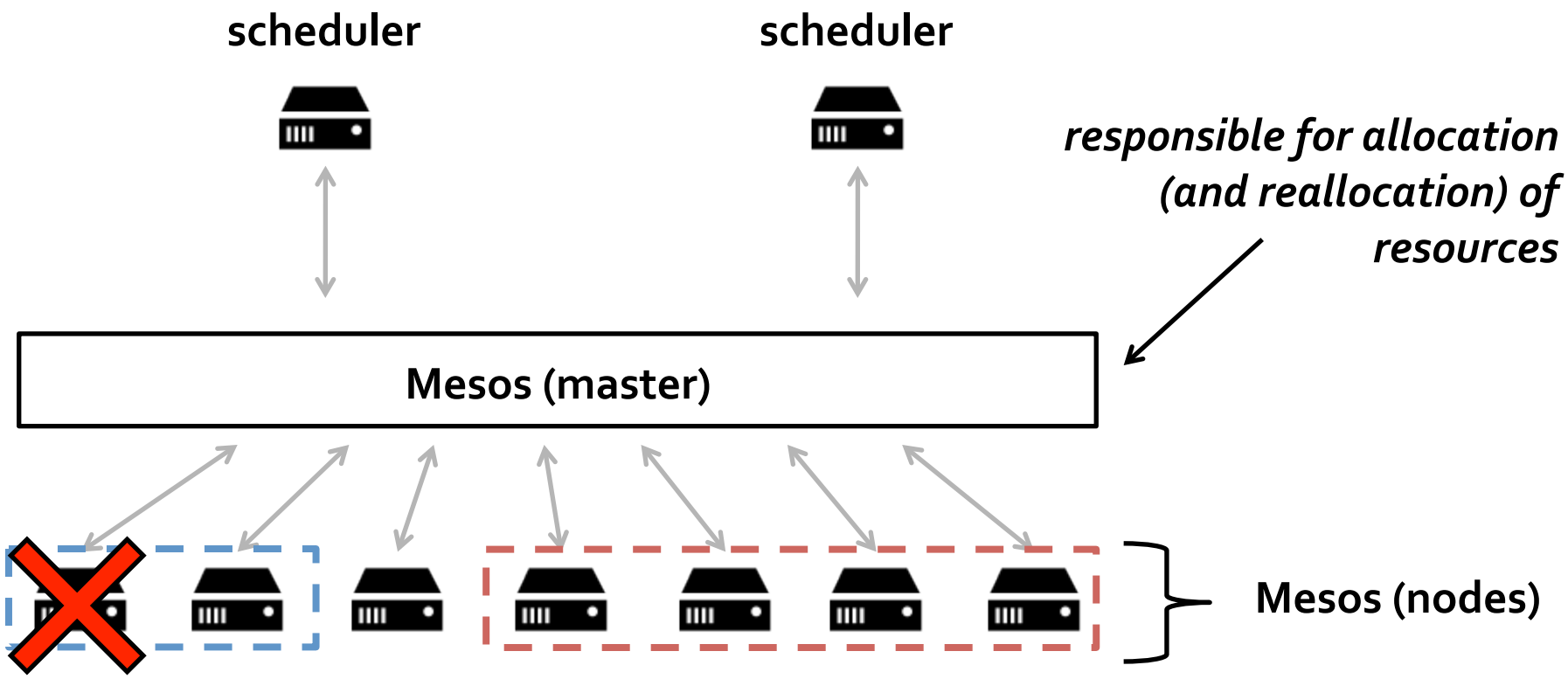
Mesos: level of indirection



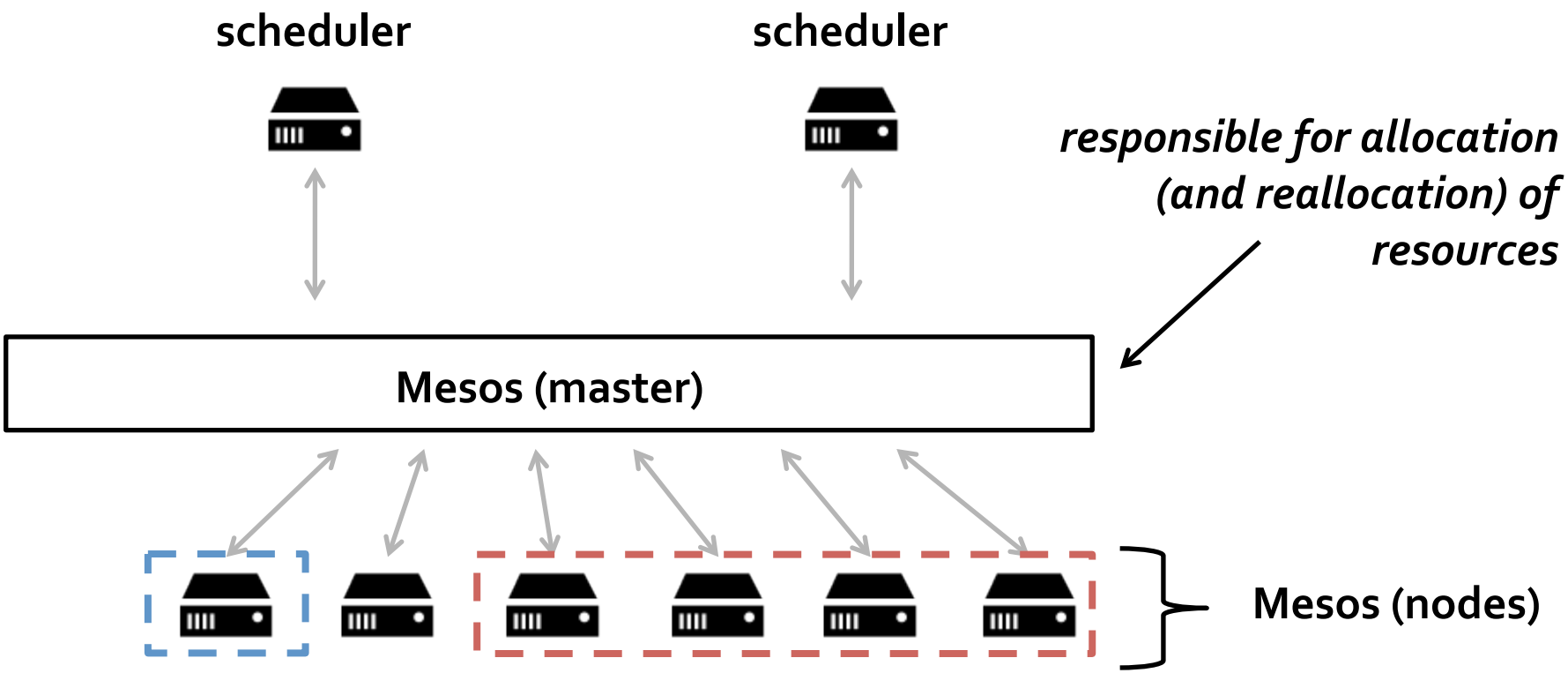
challenges: failures/maintenance



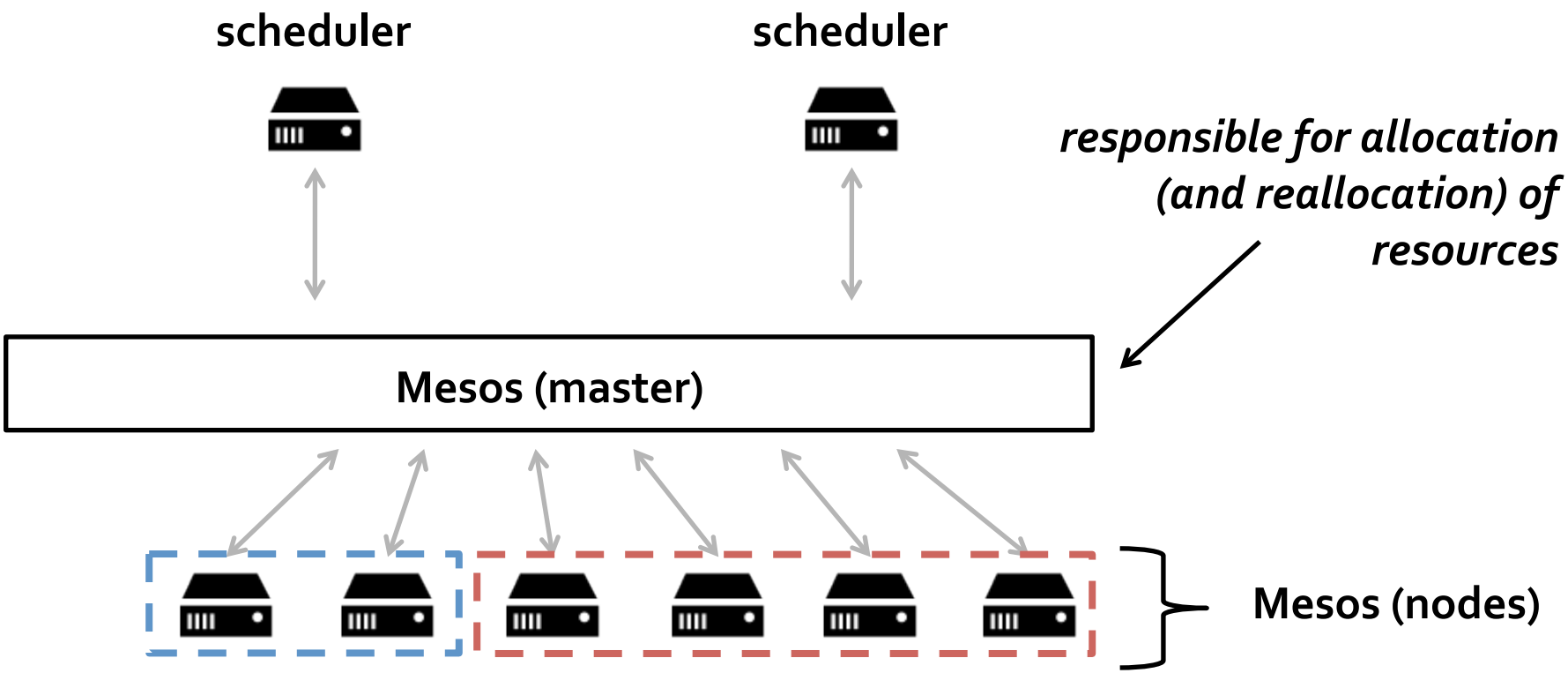
challenges: failures/maintenance



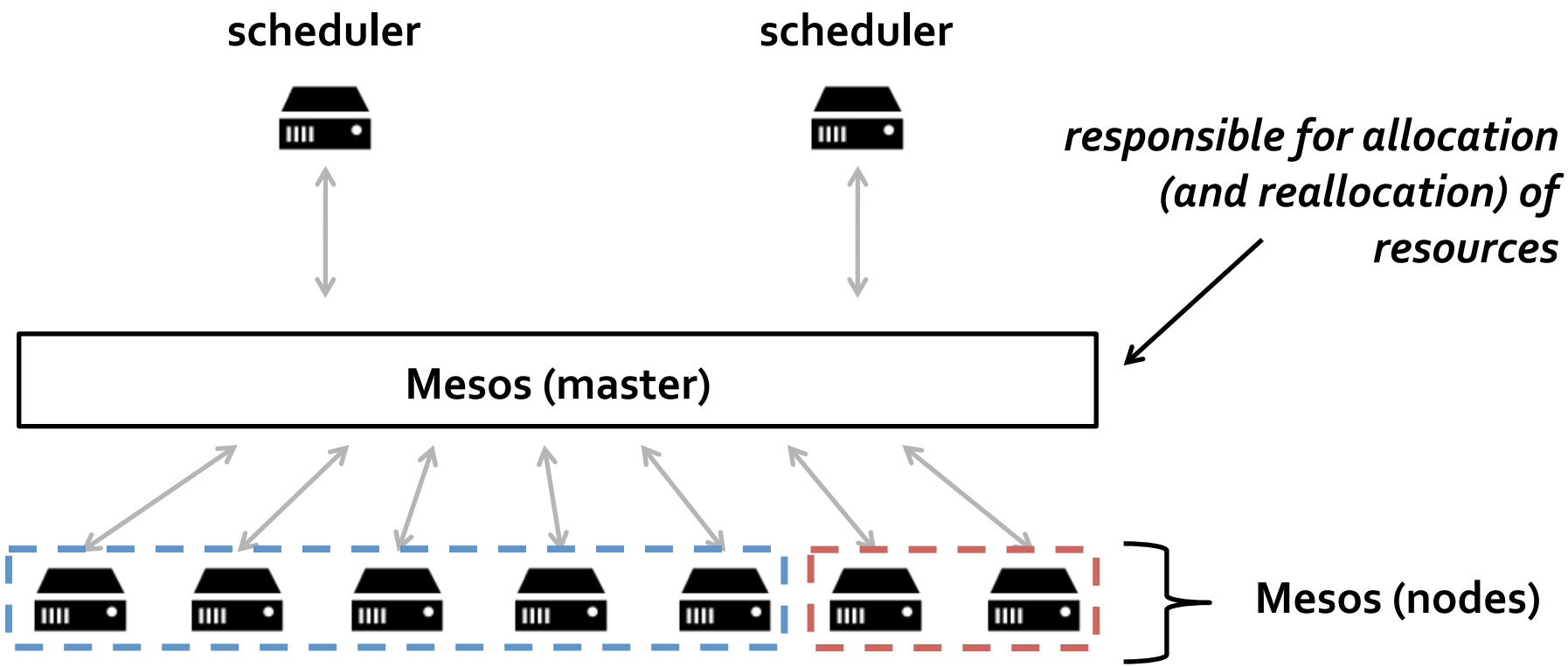
challenges: failures/maintenance



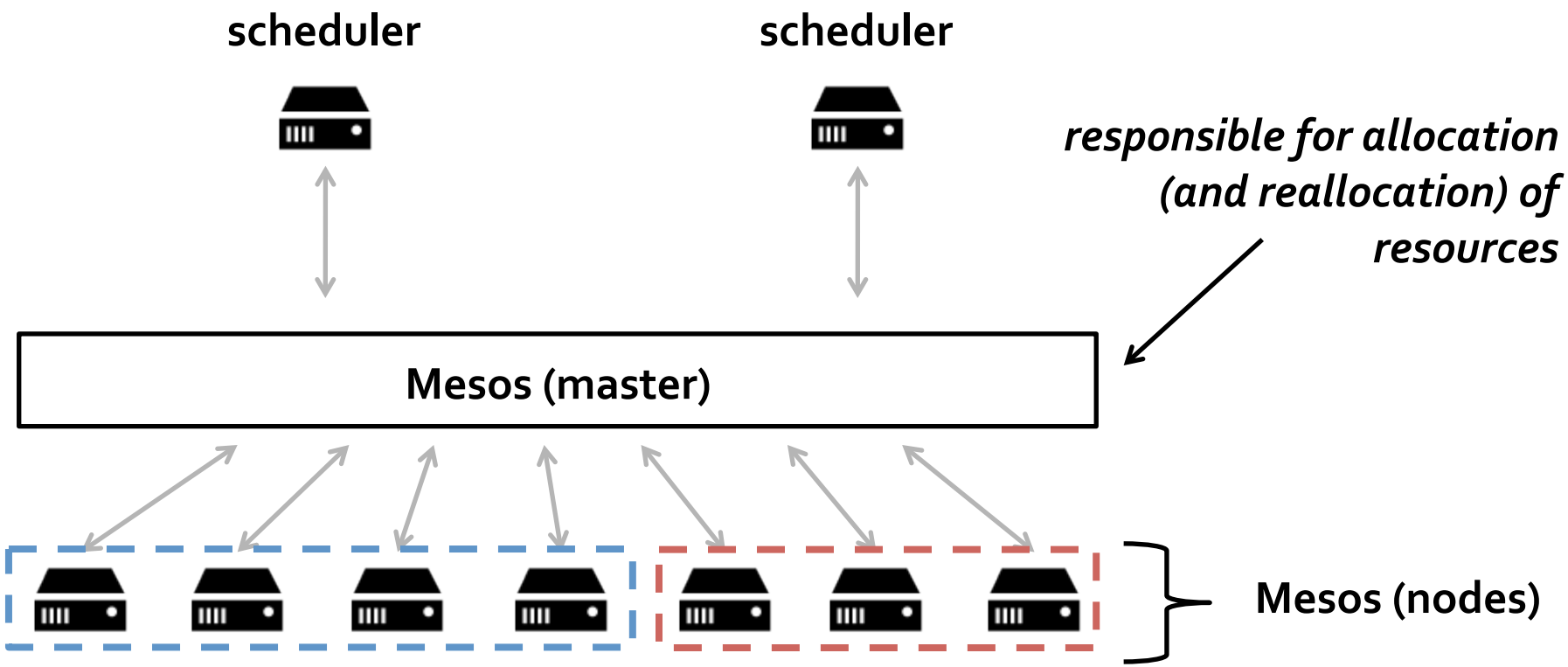
challenges: failures/maintenance



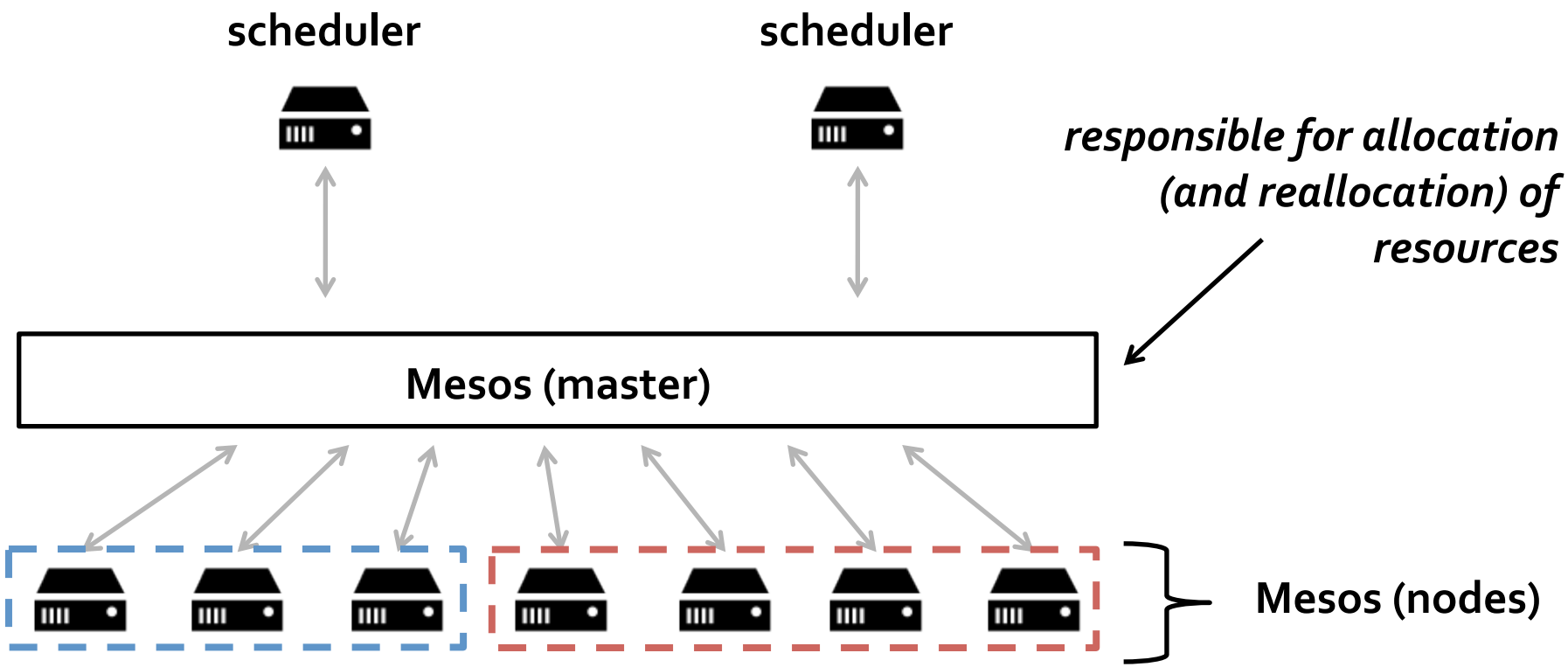
challenges: utilization



challenges: utilization



challenges: utilization



two-level scheduling

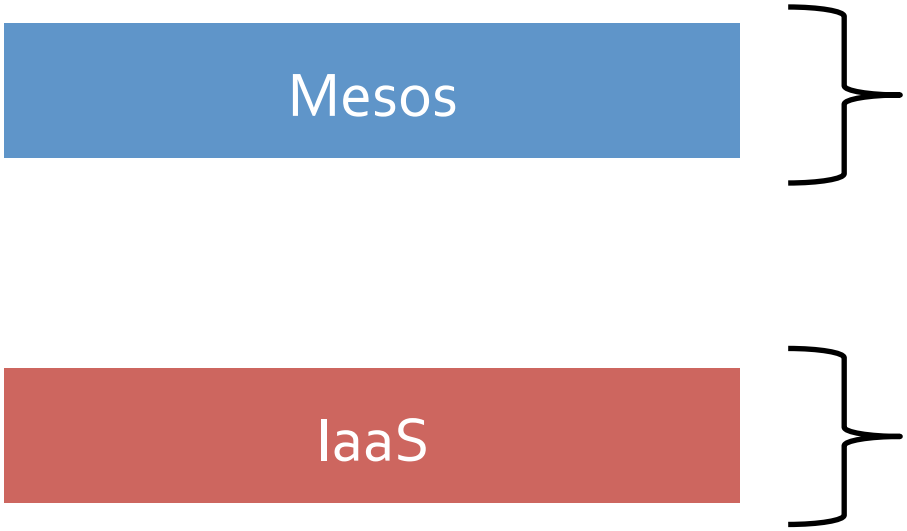
Mesos influenced by operating system supported *user-space scheduling* (and scheduler activations)

Mesos is designed less like a "cluster manager" and more like an operating system kernel

Mesos: level of abstraction

build and run distributed systems using *resources*

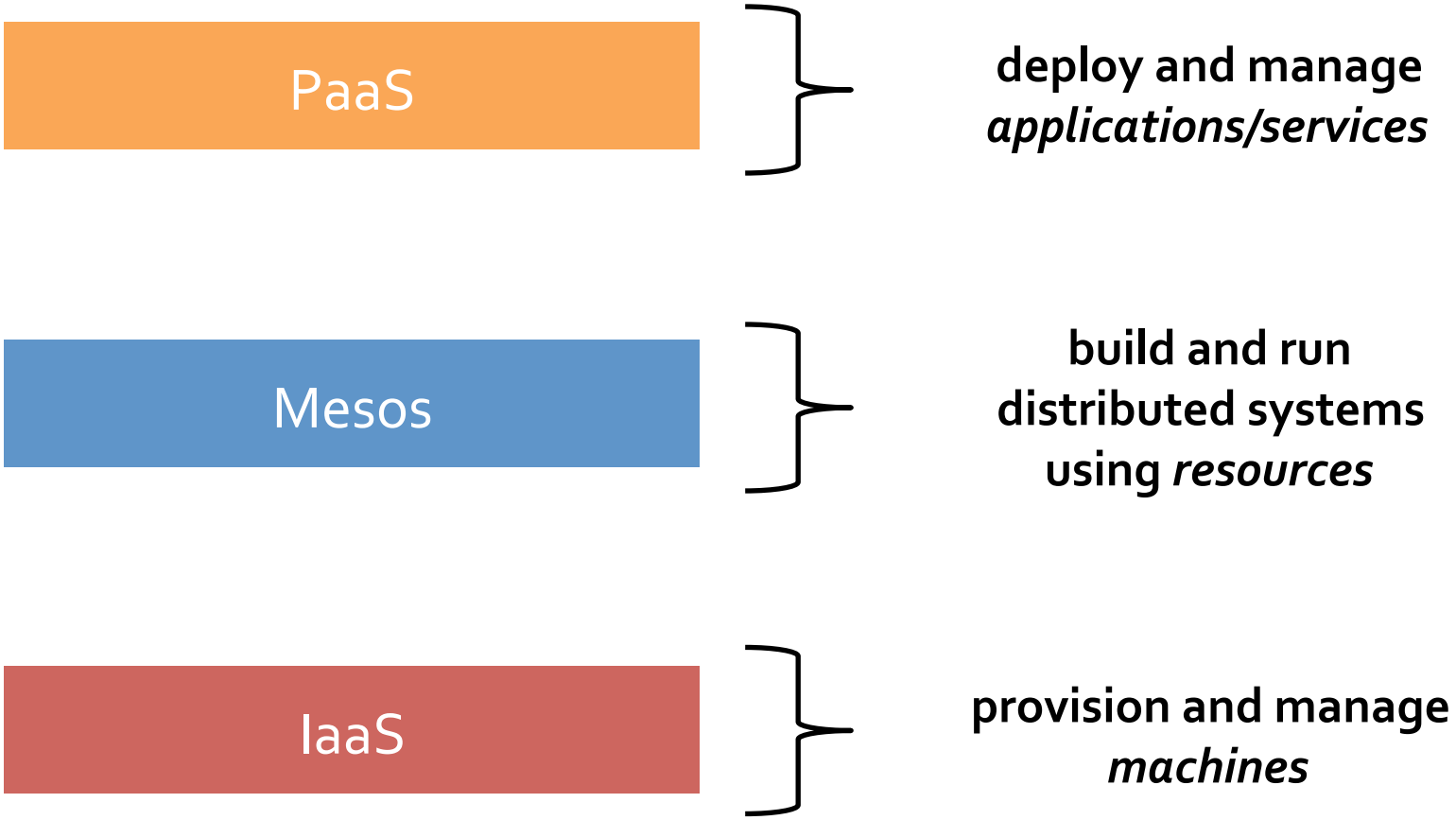
Mesos: level of abstraction



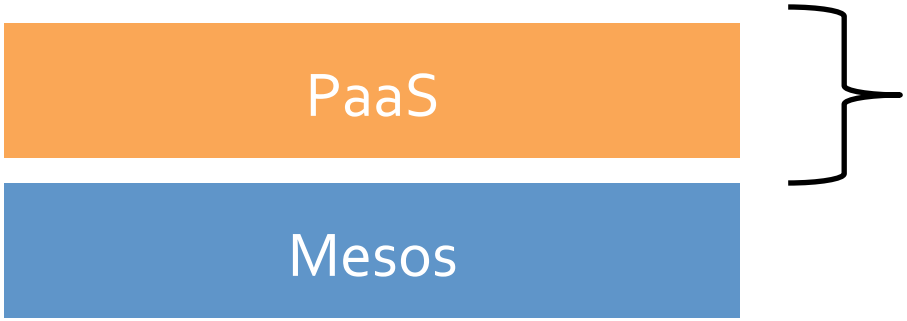
build and run distributed systems using *resources*

provision and manage *machines*

Mesos: level of abstraction

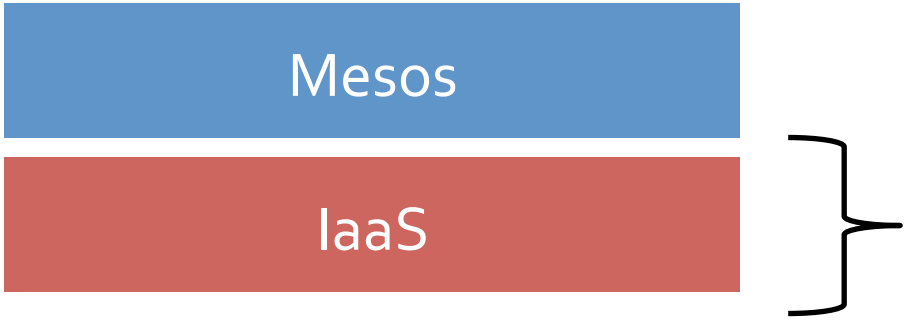


PaaS on Mesos



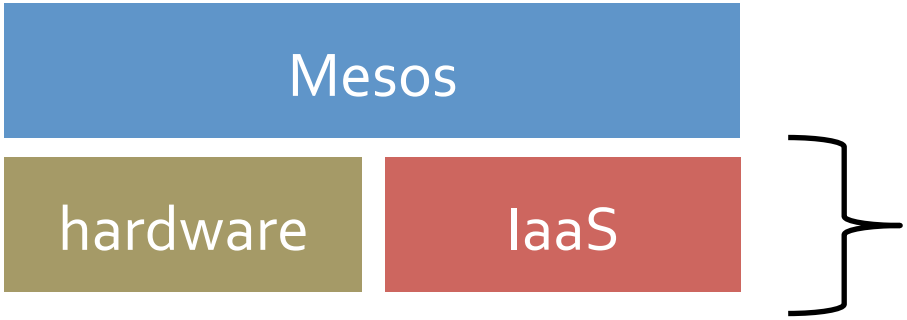
build and run a PaaS on top of Mesos: Marathon

Mesos on IaaS



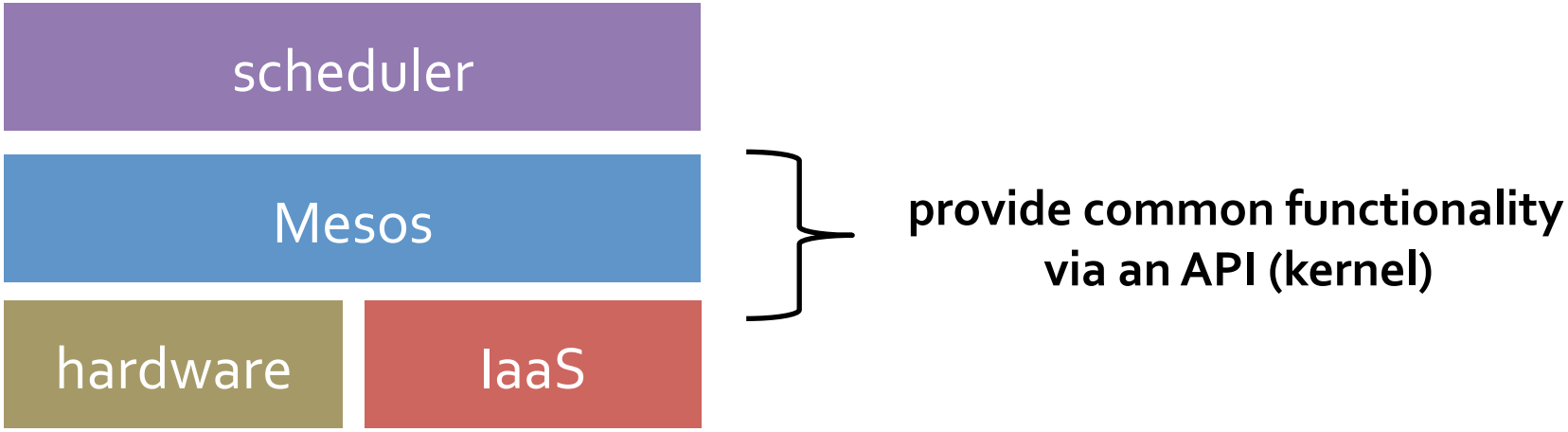
use OpenStack or EC2 to run Mesos

Mesos on IaaS/bare metal

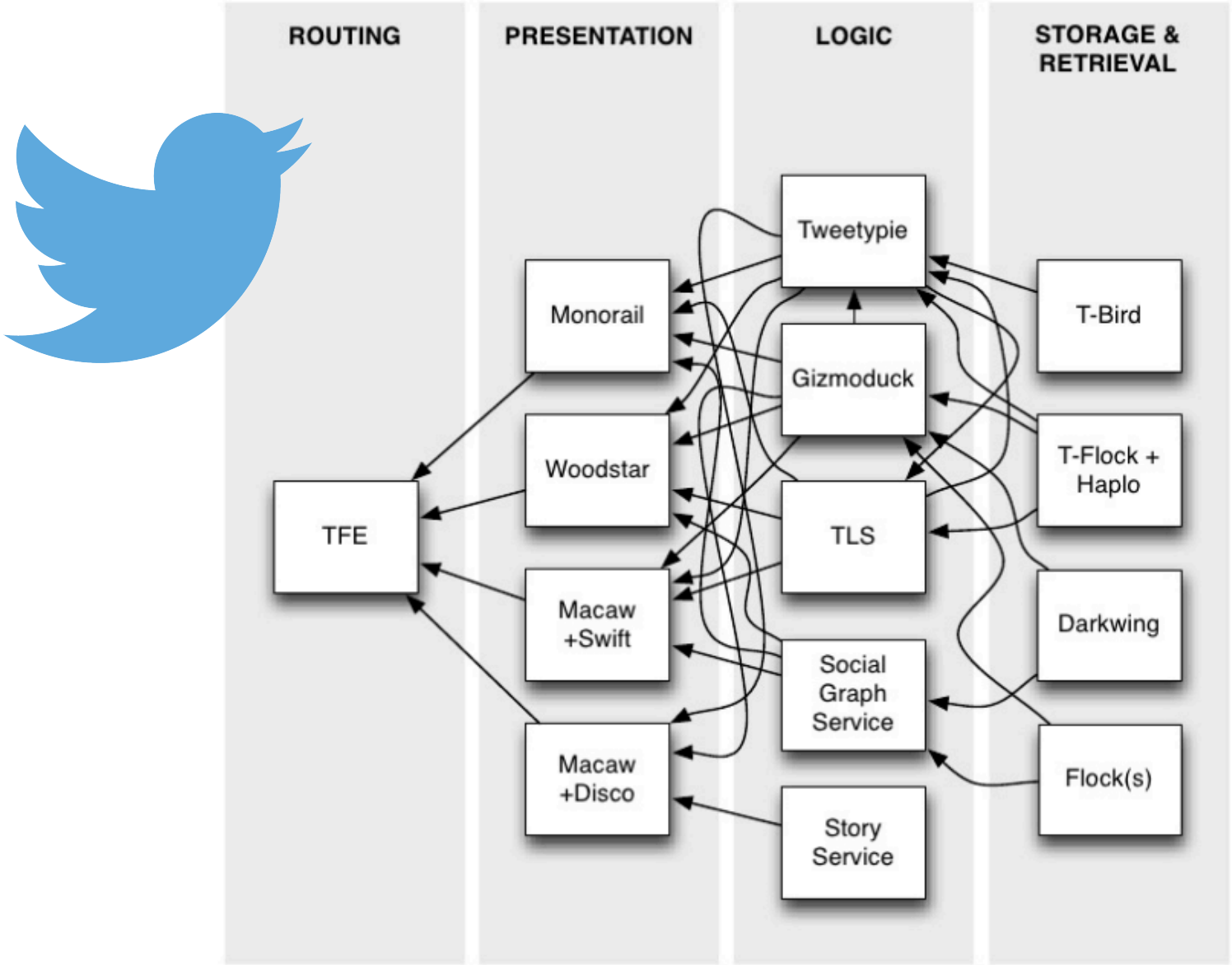


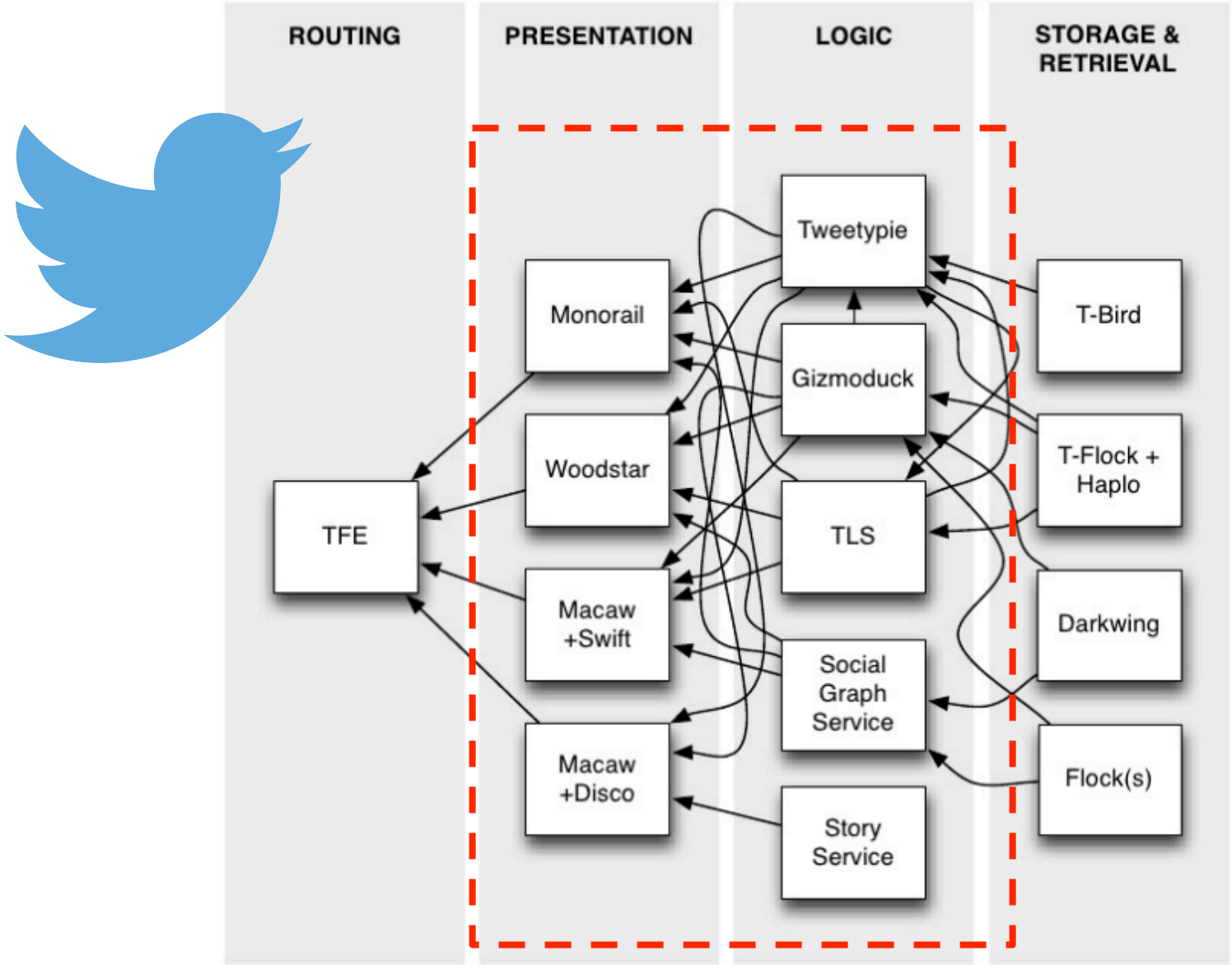
use OpenStack or EC2
or physical machines
to run Mesos

Mesos: datacenter kernel



but **how should we run datacenter applications?**


ROUTING
PRESENTATION
LOGIC
STORAGE & RETRIEVAL
TFE
Monorail
Woodstar
Macaw +Swift
Macaw +Disco
Tweetypie
Gizmoduck
TLS
Social Graph Service
Story Service
T-Bird
T-Flock + Haplo
Darkwing
Flock(s)


ROUTING
PRESENTATION
LOGIC
STORAGE & RETRIEVAL
TFE
Monorail
Woodstar
Macaw +Swift
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Gizmoduck
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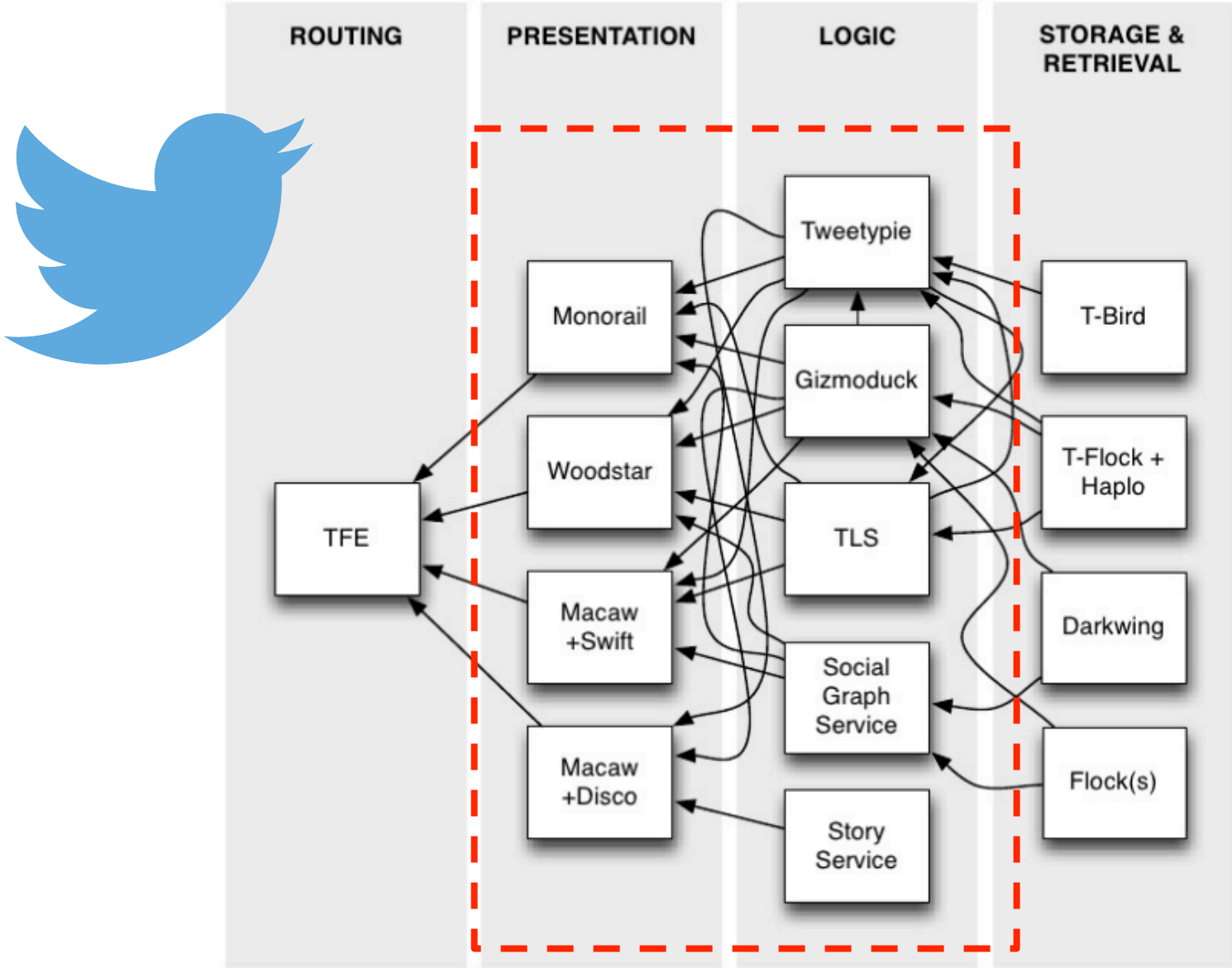
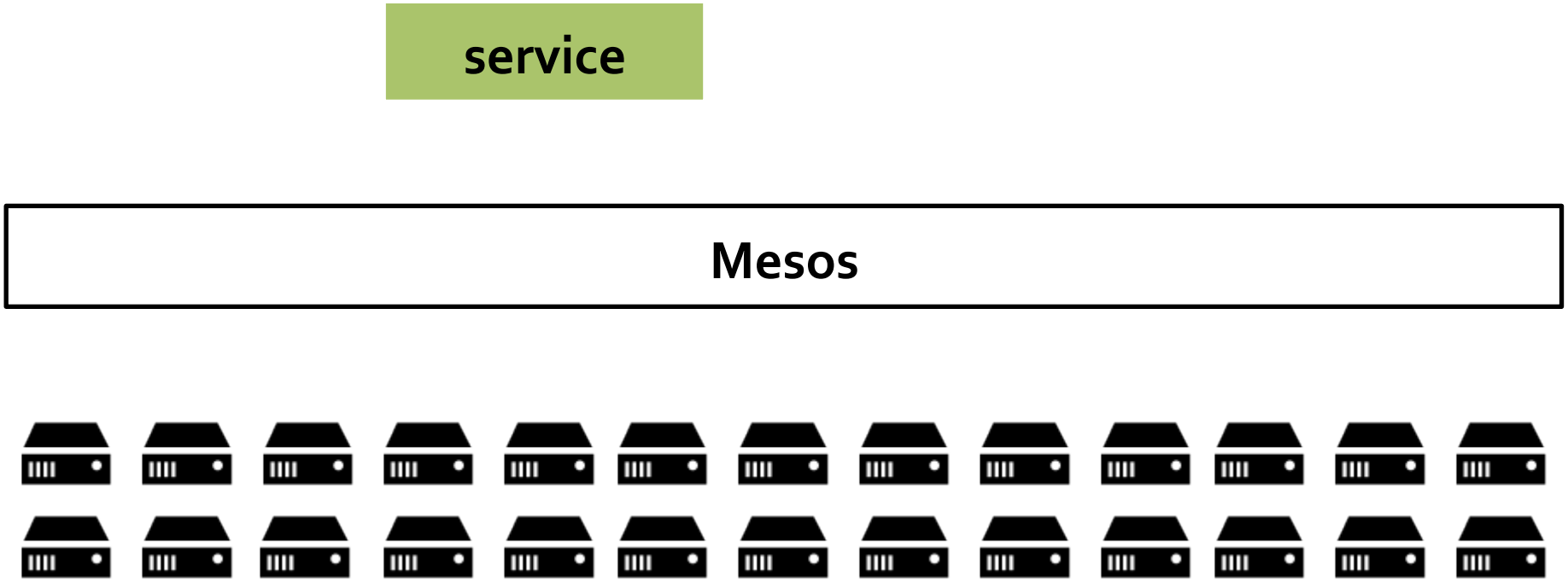
Social Graph Service
Story Service
T-Bird
T-Flock + Haplo
Darkwing
Flock(s)



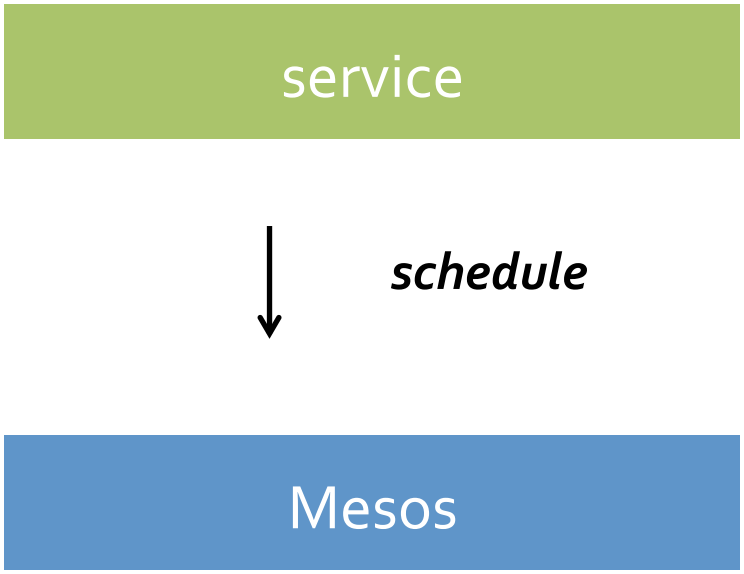
***stateless* services!**


service
Mesos

service scheduler (PaaS)

orchestrate services on top of Mesos

orchestration vs scheduling



orchestration vs scheduling

↓ *orchestrate*

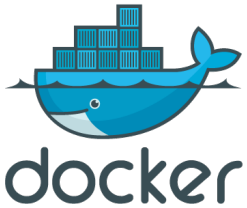
service

↓ *schedule*

Mesos

orchestration with Marathon

① configuration/package management



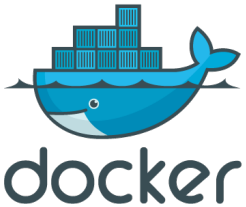
② deployment

③ service discovery

configuration/package management

developers

(1) bundle services as jar, tar/gzip, or using Docker



(2) upload to HDFS (or use a Docker registry)

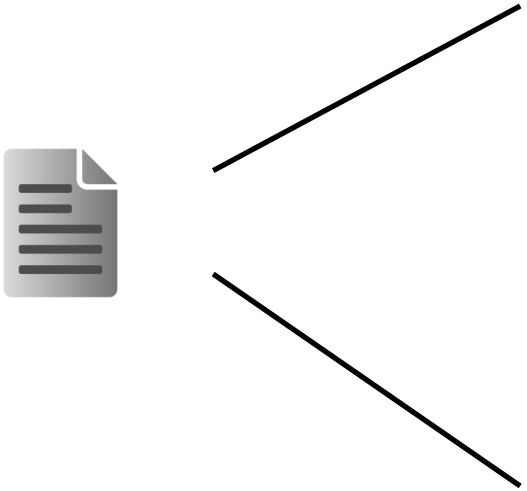
deployment

developers

(1) describe services using JSON

(2) submit services to Marathon via REST

example-docker.json



```
{
  "container": {
    "type": "DOCKER",
    "docker": {
      "image": "libmesos/ubuntu"
    },
    "volumes" : [
      {
        "containerPath": "/etc/a",
        "hostPath": "/var/data/a",
        "mode": "RO"
      },
      {
        "containerPath": "/etc/b",
        "hostPath": "/var/data/b",
        "mode": "RW"
      }
    ]
  },
  "id": "ubuntu",
  "instances": 1,
  "cpus": 0.5,
  "mem": 512,
  "cmd": "while sleep 10; do date -u +%T; done"
}
```

service discovery

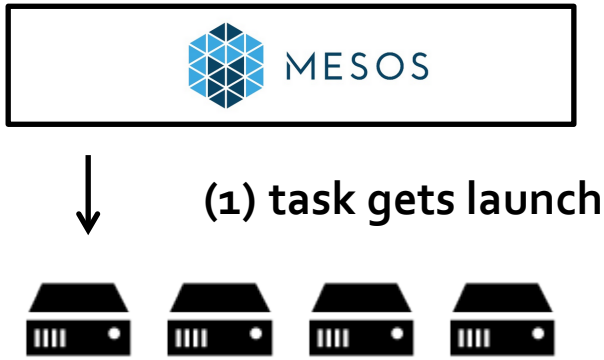
using Apache ZooKeeper and *server sets* (github.com/twitter/commons)

Apache ZooKeeper

service discovery

using Apache ZooKeeper and *server sets* (github.com/twitter/commons)

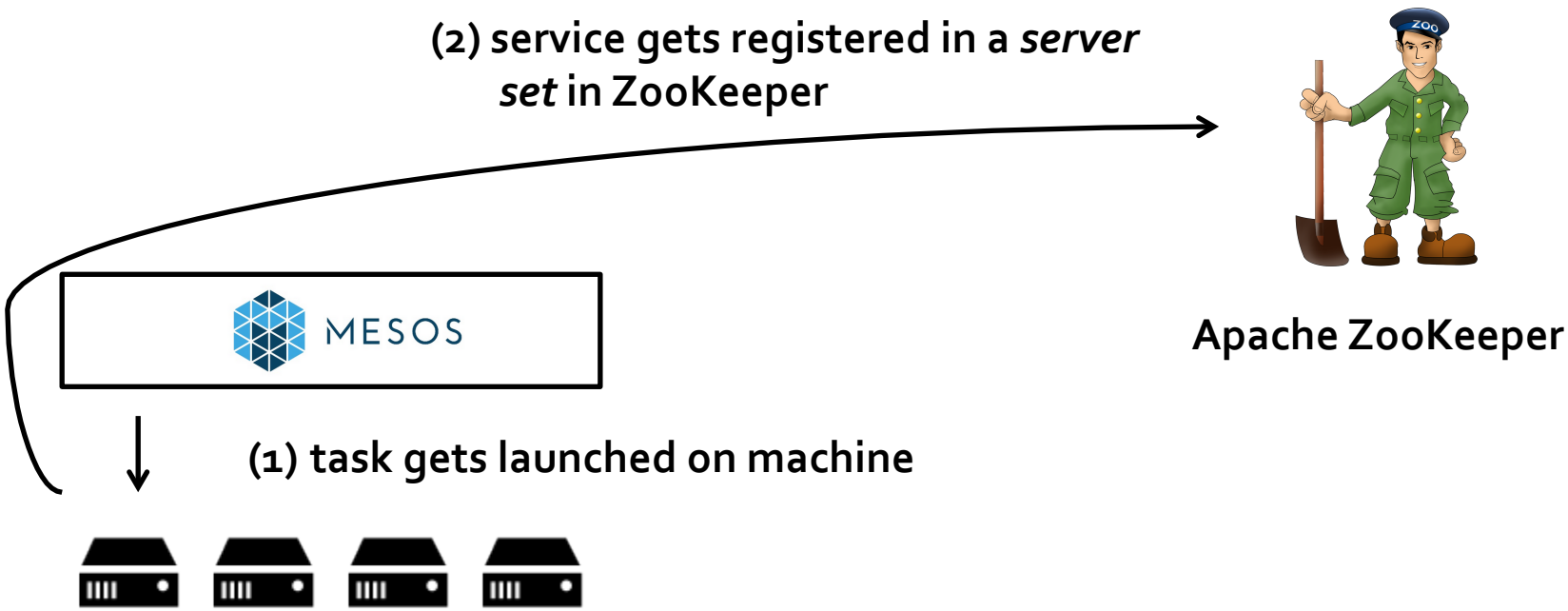
Apache ZooKeeper



(1) task gets launched on machine

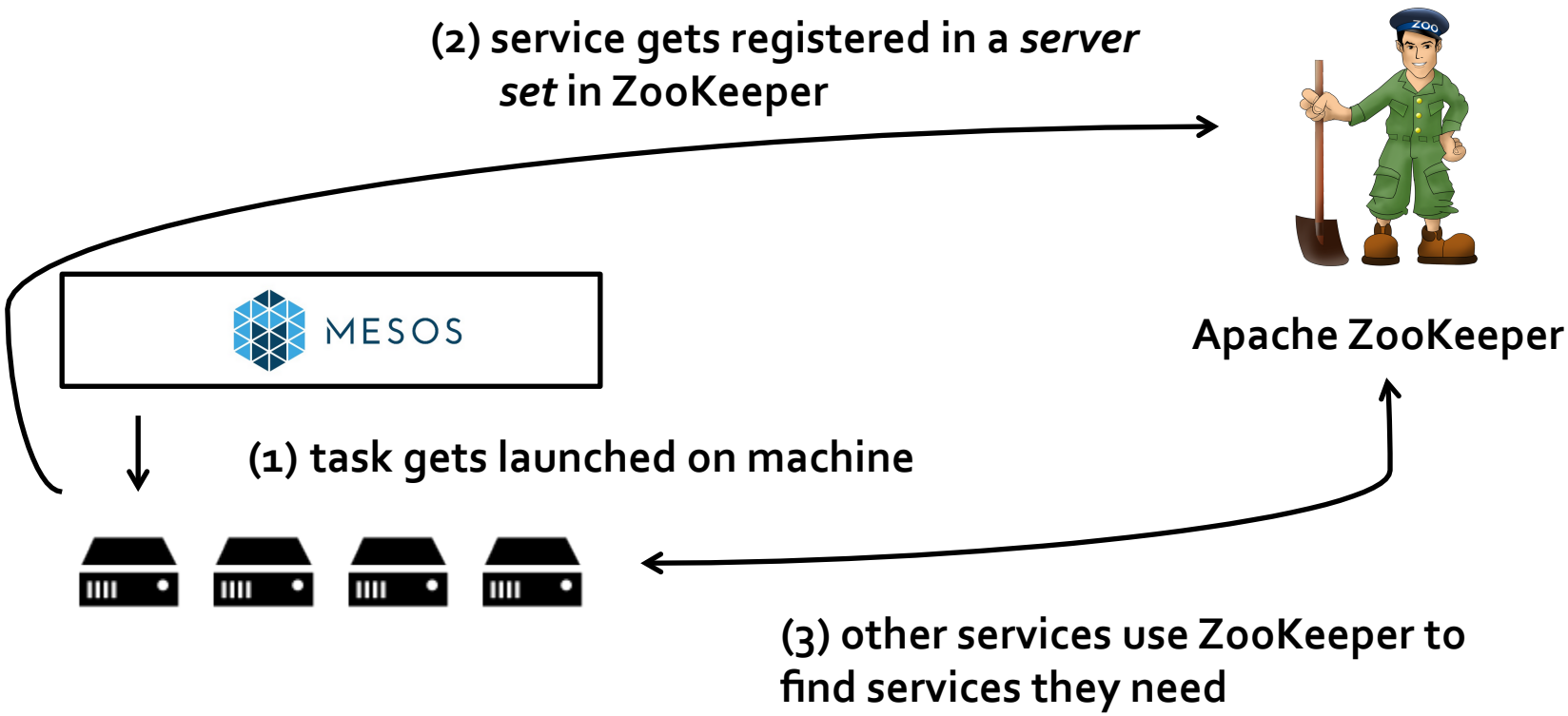
service discovery

using Apache ZooKeeper and *server sets* (github.com/twitter/commons)



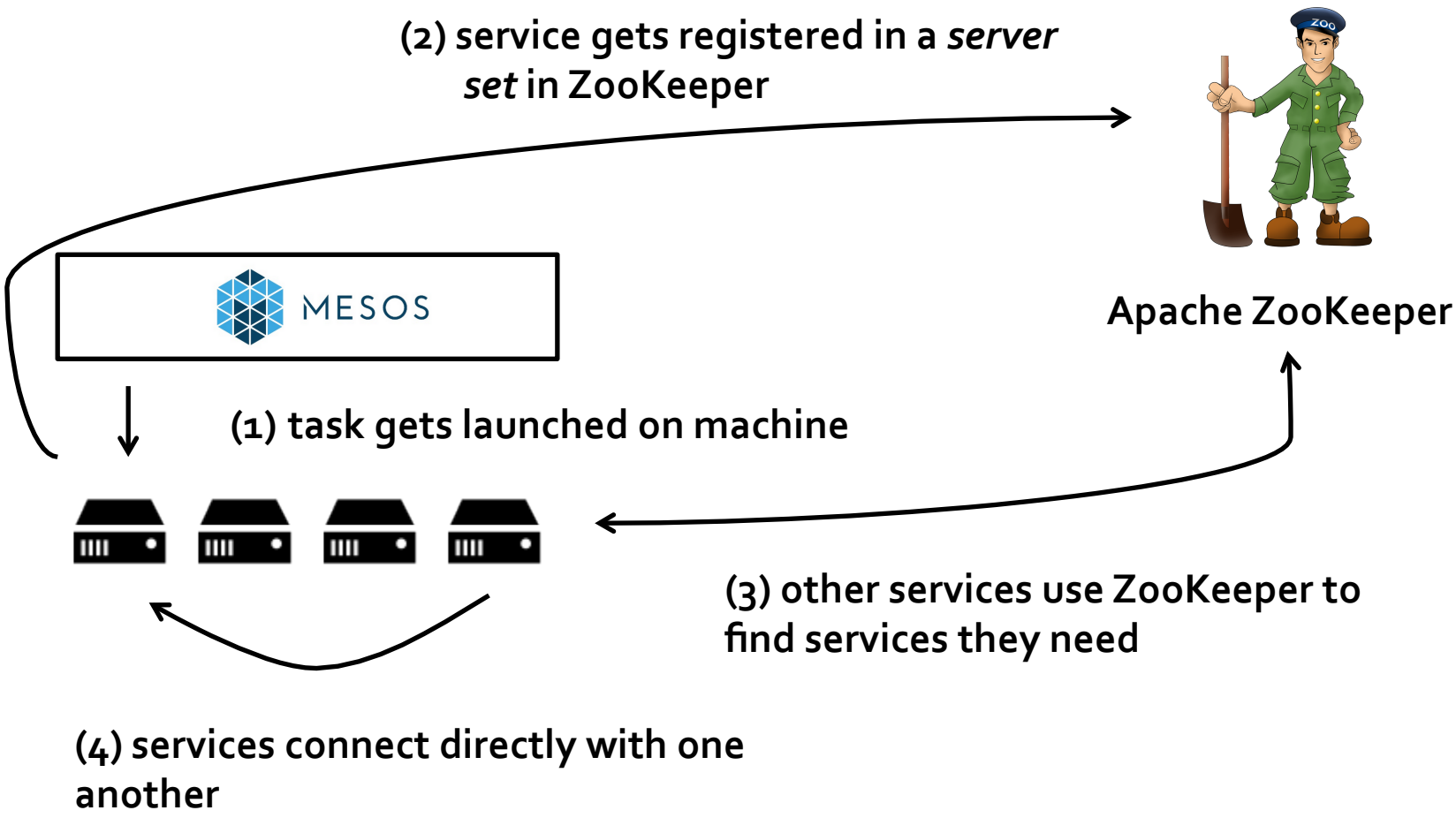
service discovery

using Apache ZooKeeper and *server sets* (github.com/twitter/commons)



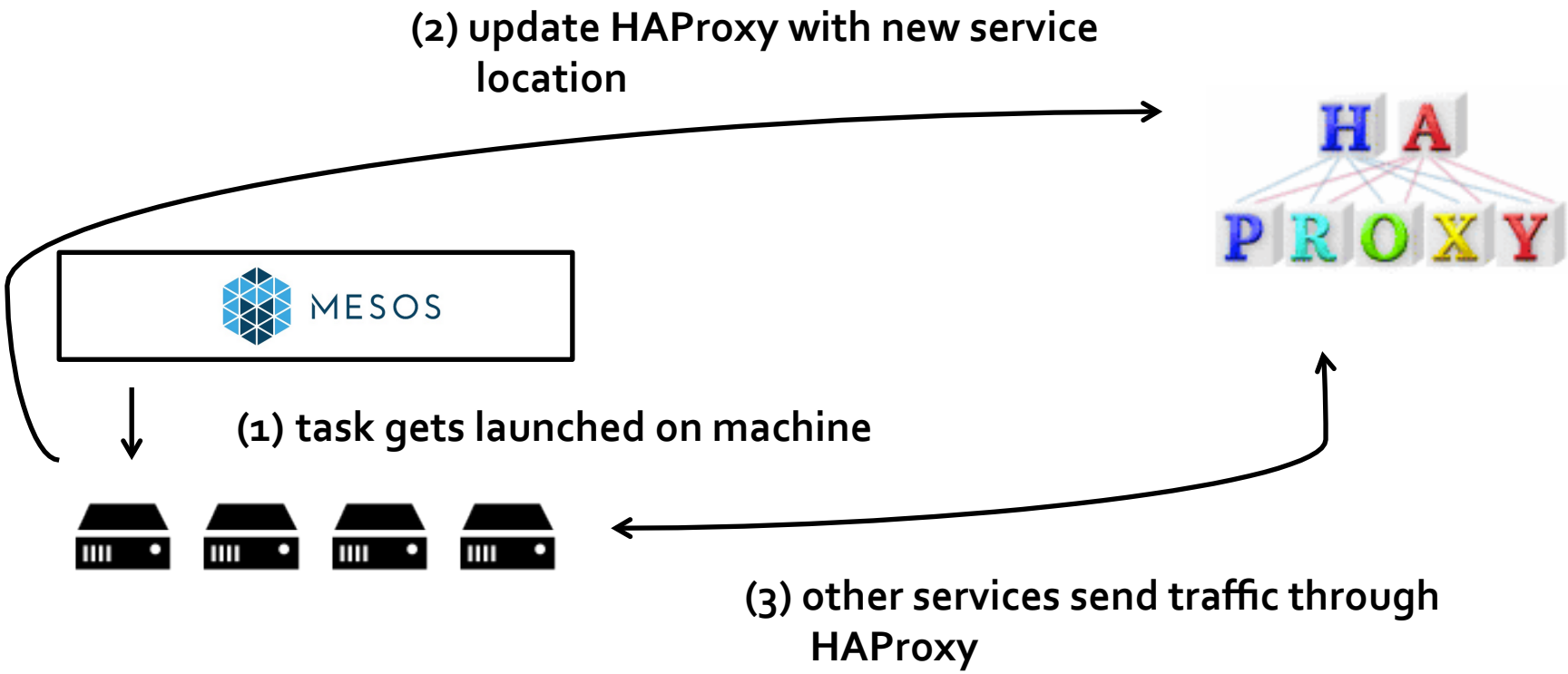
service discovery

using Apache ZooKeeper and *server sets* (github.com/twitter/commons)



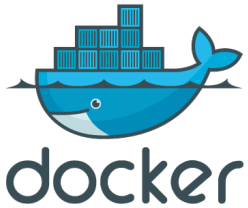
service discovery alternative

ZooKeeper/server sets requires injecting code into your clients!

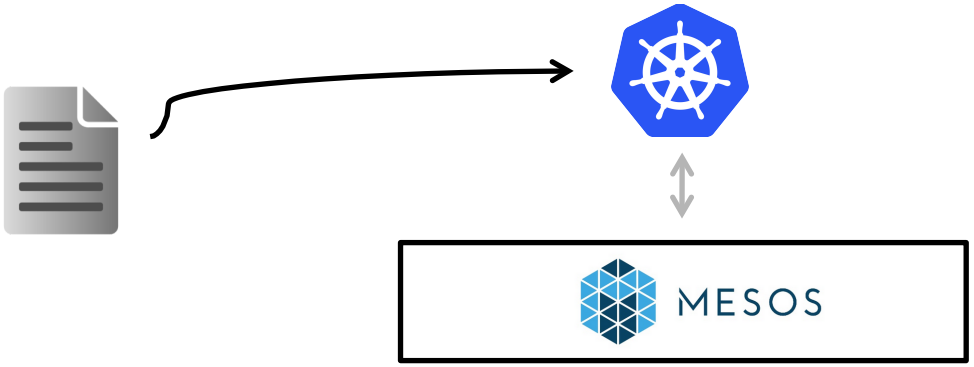


orchestration w/ Kubernetes (on Mesos)

① configuration/package management

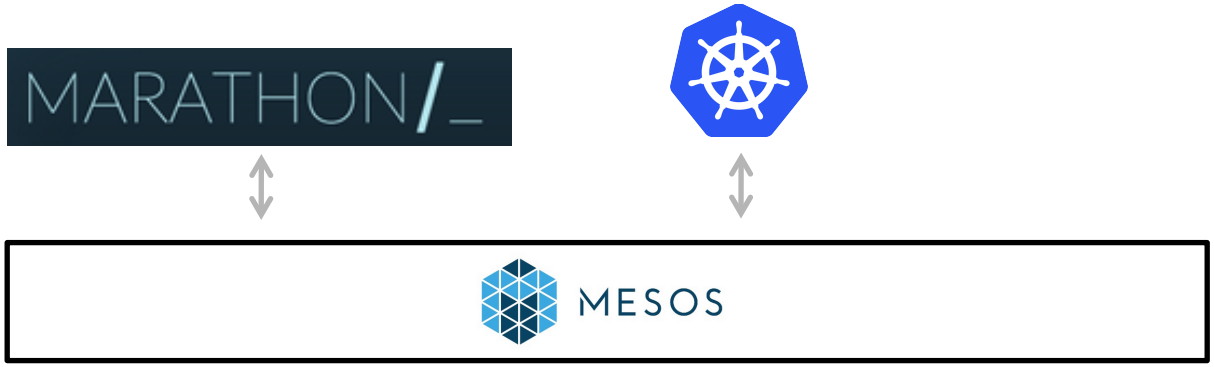


② deployment

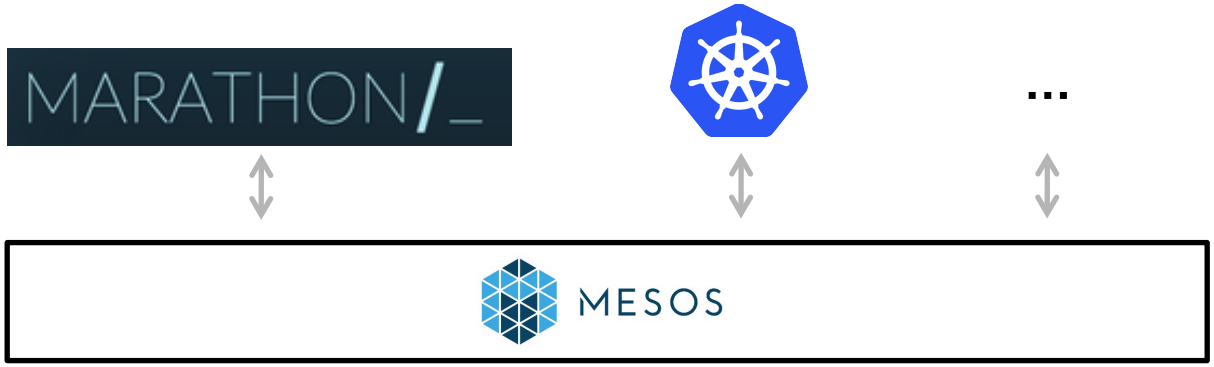


③ service discovery

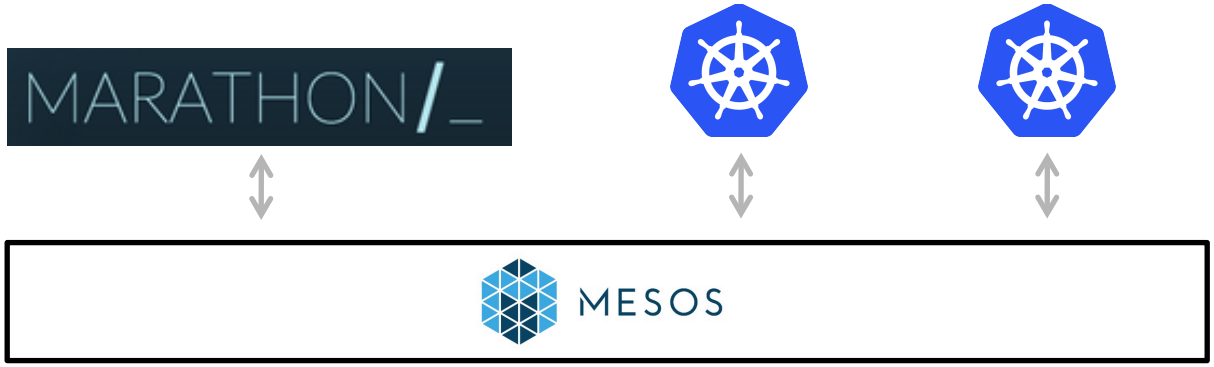
multiple schedulers!



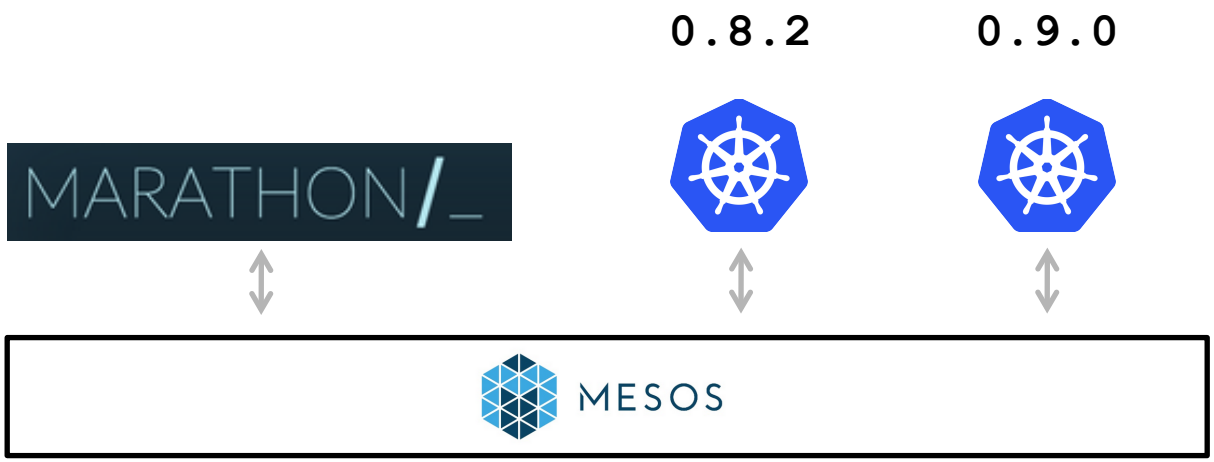
multiple schedulers!



multiple schedulers!



multiple schedulers!



agenda

① what are datacenter applications?

② how should we run datacenter applications?

③ how should we program datacenter applications?

distributed systems: dev

- leader election
- state management (working set)
- task management (launch, isolate, kill, etc)
- machine management (monitoring)
- …

distributed systems: ops

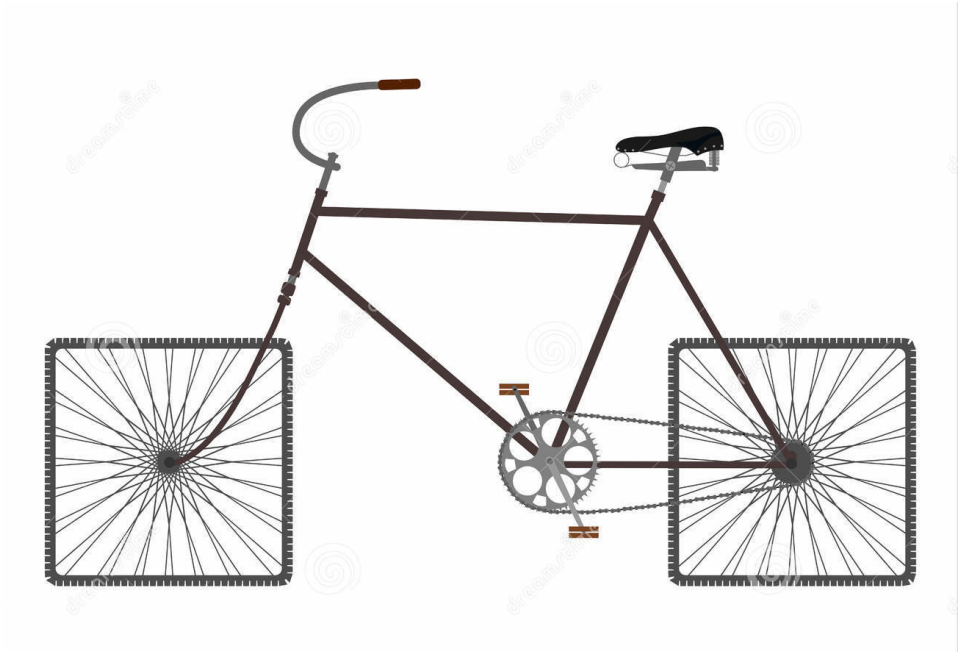
- what to do if task/machine fails?
- what happens when more resources/tasks are needed? does everything scale proportionally? should tasks take on different or more specialized functions/roles?

distributed systems: ops

- *what to do if task/machine fails?*
- what happens when more resources/tasks are needed? does everything scale proportionally? should tasks take on different or more specialized functions/roles?

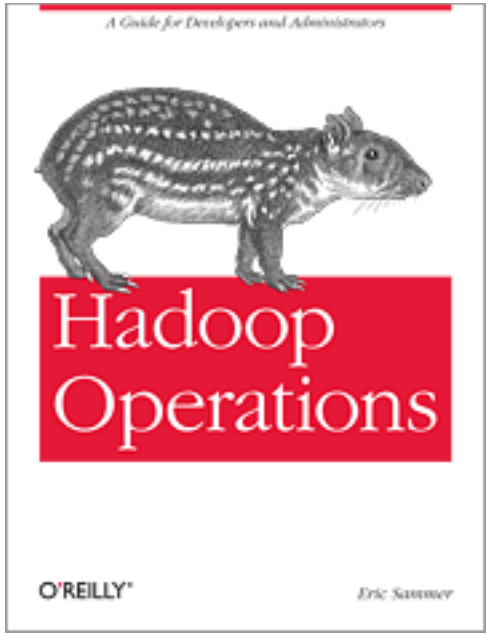
distributed systems: dev

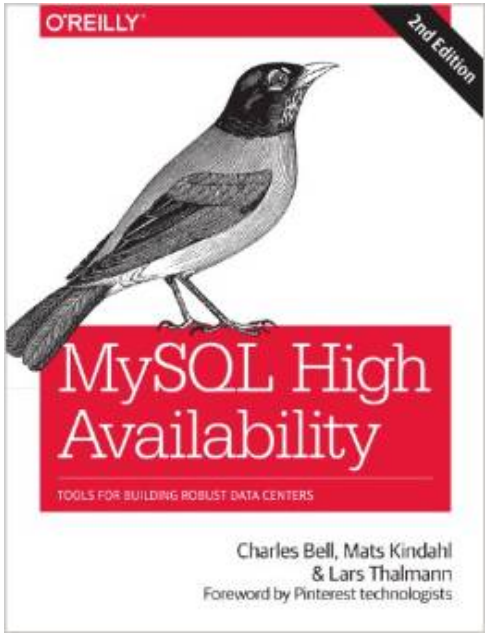
everybody keeps reinventing the wheel

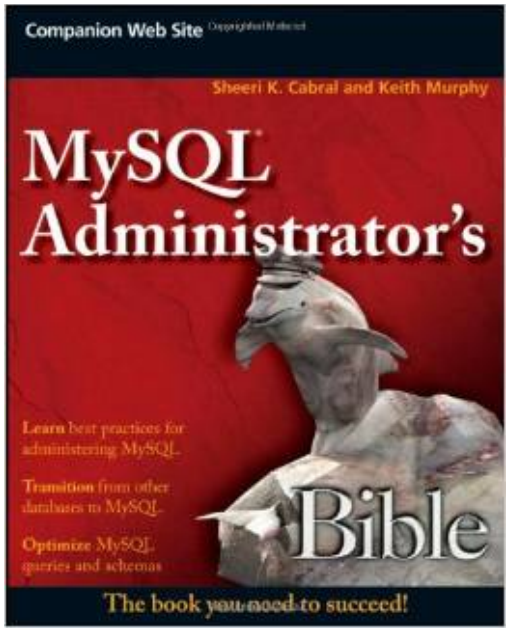


distributed systems: ops

UX of operating distributed systems is horrible







① why does each distributed system have to implement the same things?

② why can’t we build distributed systems that incorporate and automate operations?

thesis: we need a common abstraction layer upon which all distributed systems can be built and …

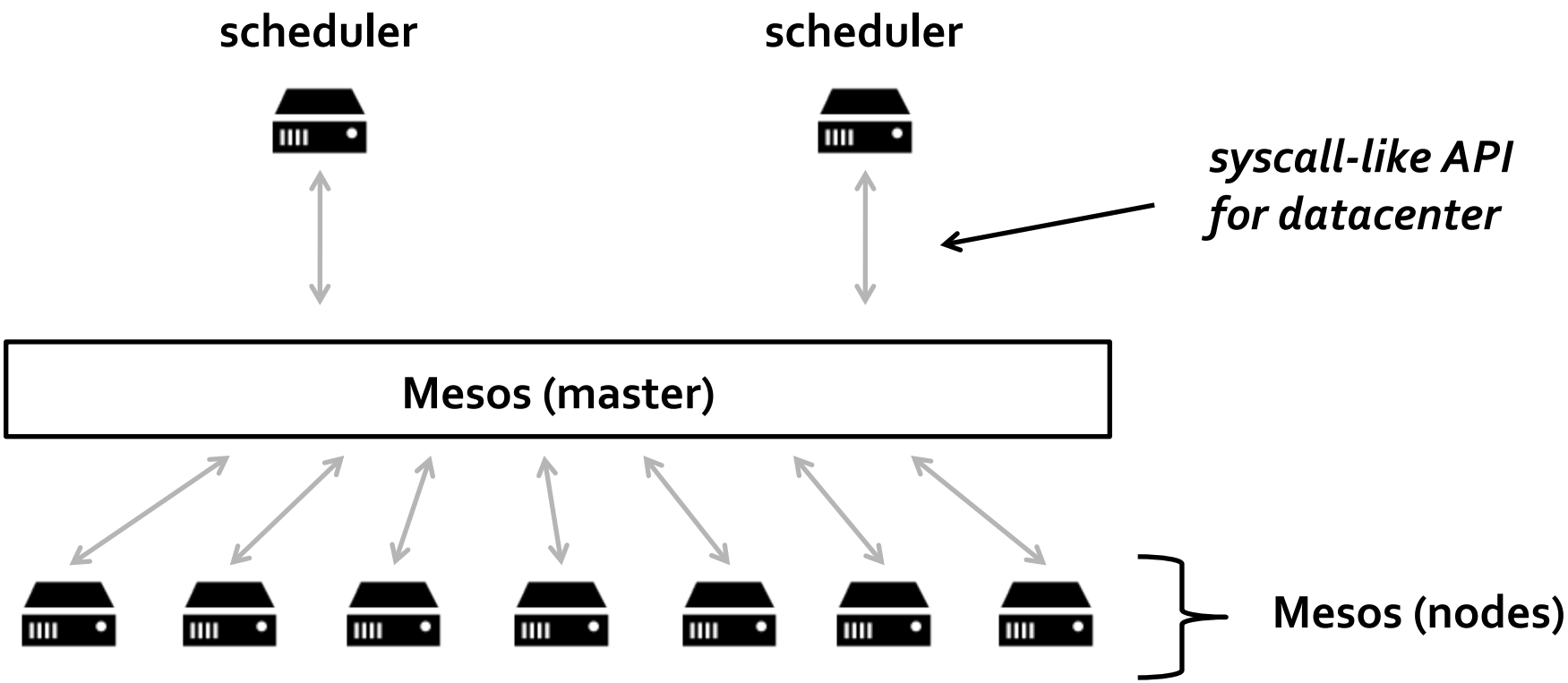
we need to build distributed systems with *schedulers* (on top of said common abstraction layer)

Apache Mesos is a
distributed system
for running and building
other distributed systems

Apache Mesos: distributed systems kernel

Apache Mesos: datacenter kernel

Mesos: datacenter kernel



Mesos: datacenter kernel

+ provide common functionality every new distributed system *re-implements*

Mesos: datacenter kernel

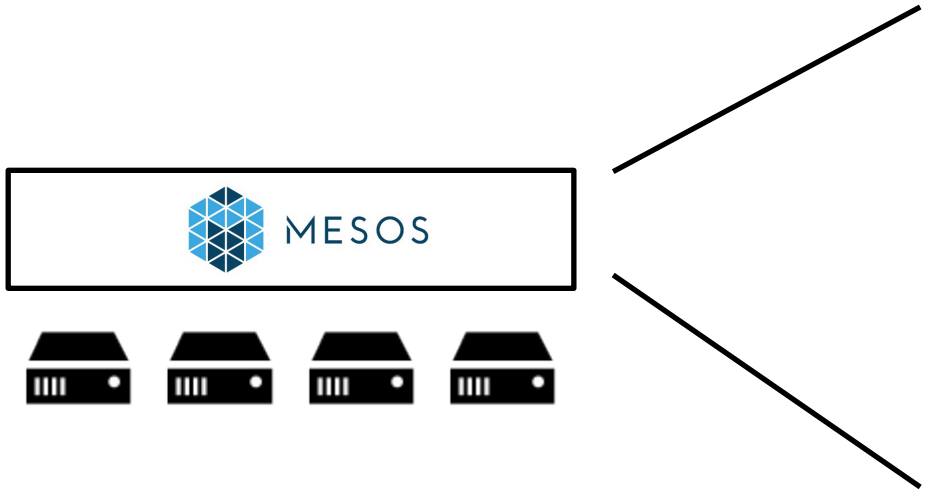
+ enable running multiple distributed systems on the same cluster of machines and dynamically share the resources more efficiently!

build against Mesos:

① abstract cloud, i.e., “hardware”

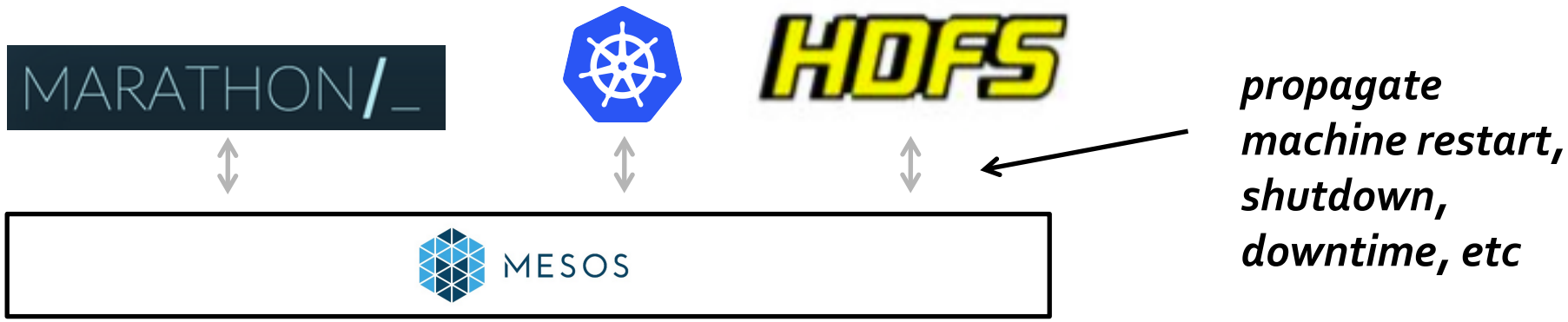
② leverage primitives to implement/automate failures, maintenance, etc.

Mesos primitives



- principals, users, roles
- advanced fair-sharing allocation algorithms
- high-availability (even during upgrades)
- resource monitoring
- preemption/revocation
- volume management
- reservations (dynamic/static)
- …

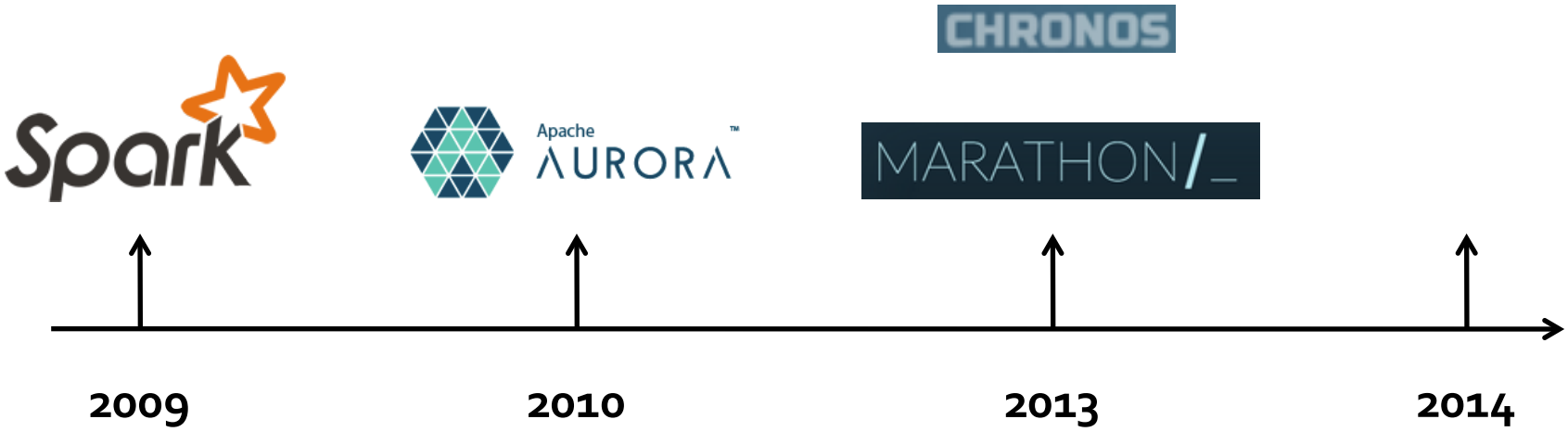
maintenance via primitives



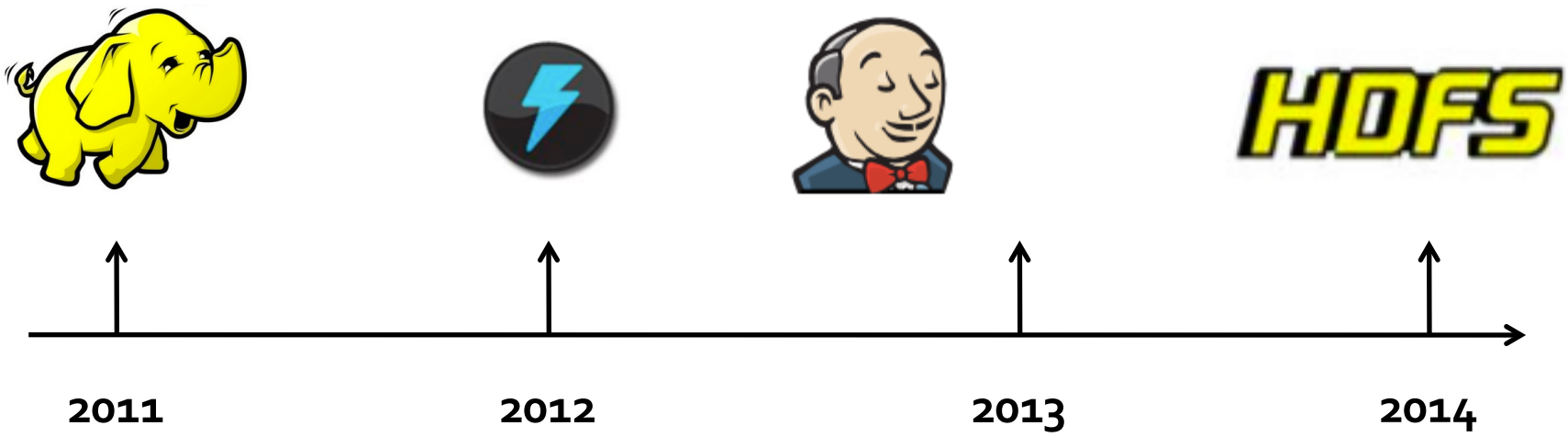
there is a lot of stuff in a kernel

there is a lot of stuff in a datacenter kernel

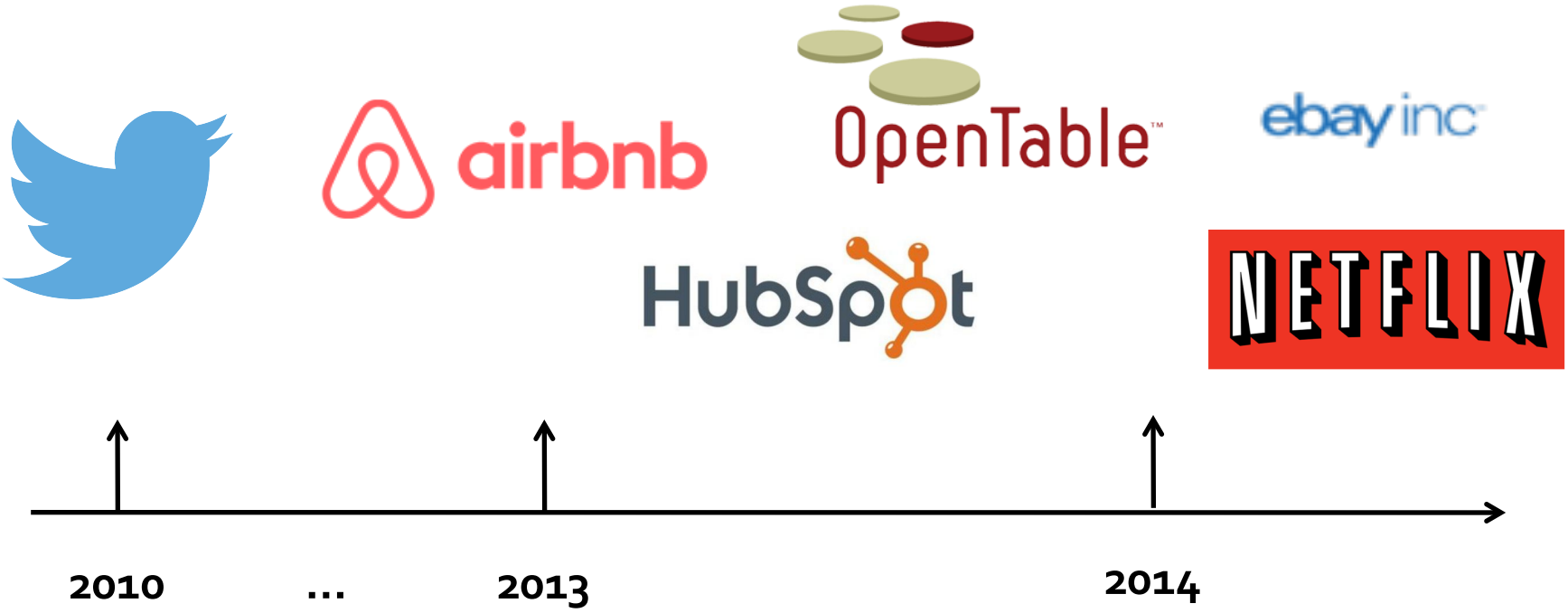
built on Mesos:



ported to Mesos:

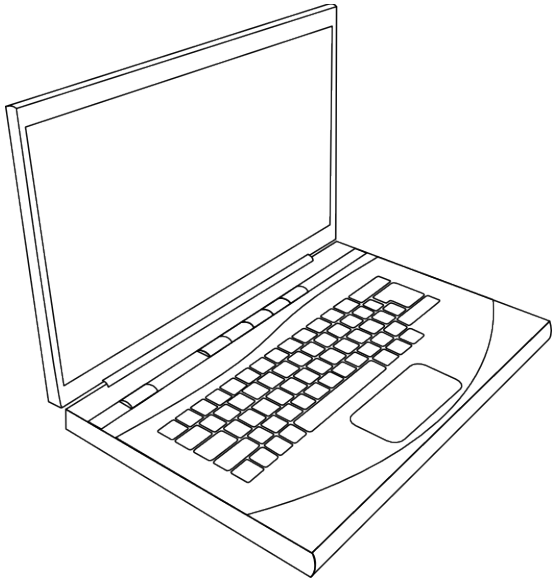


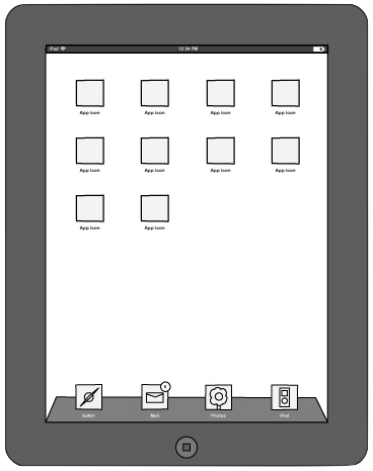
some of our adopters …

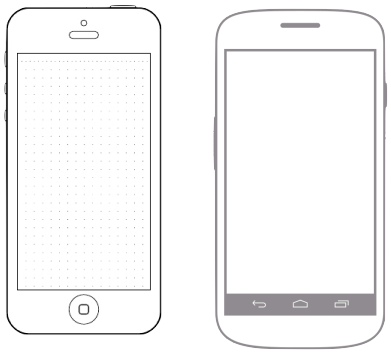


conclusion

the datacenter
is just another form factor

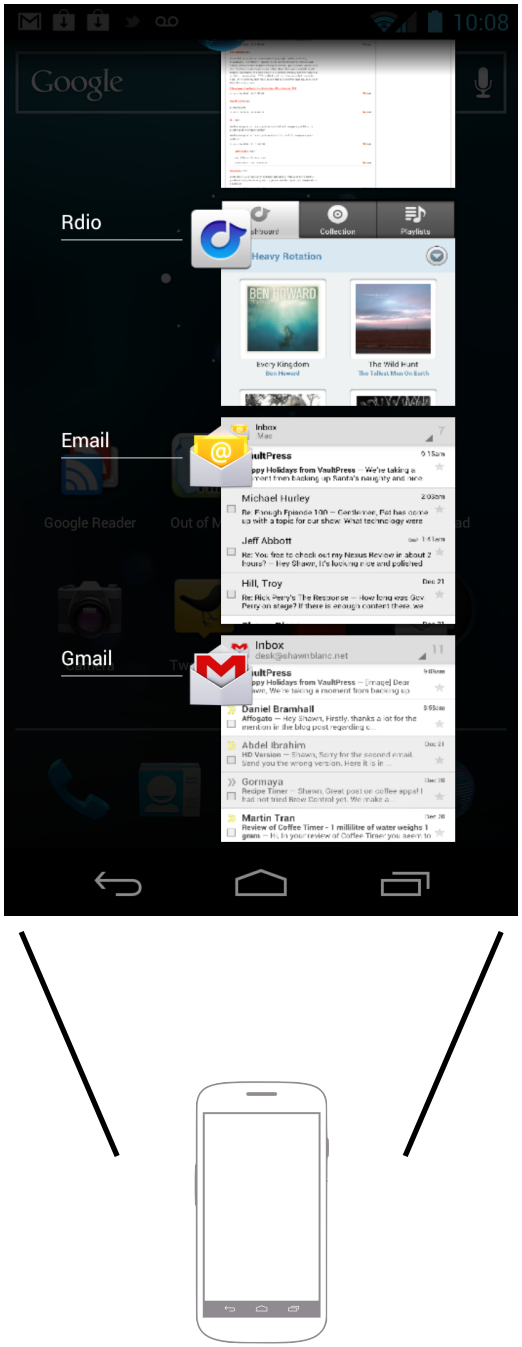




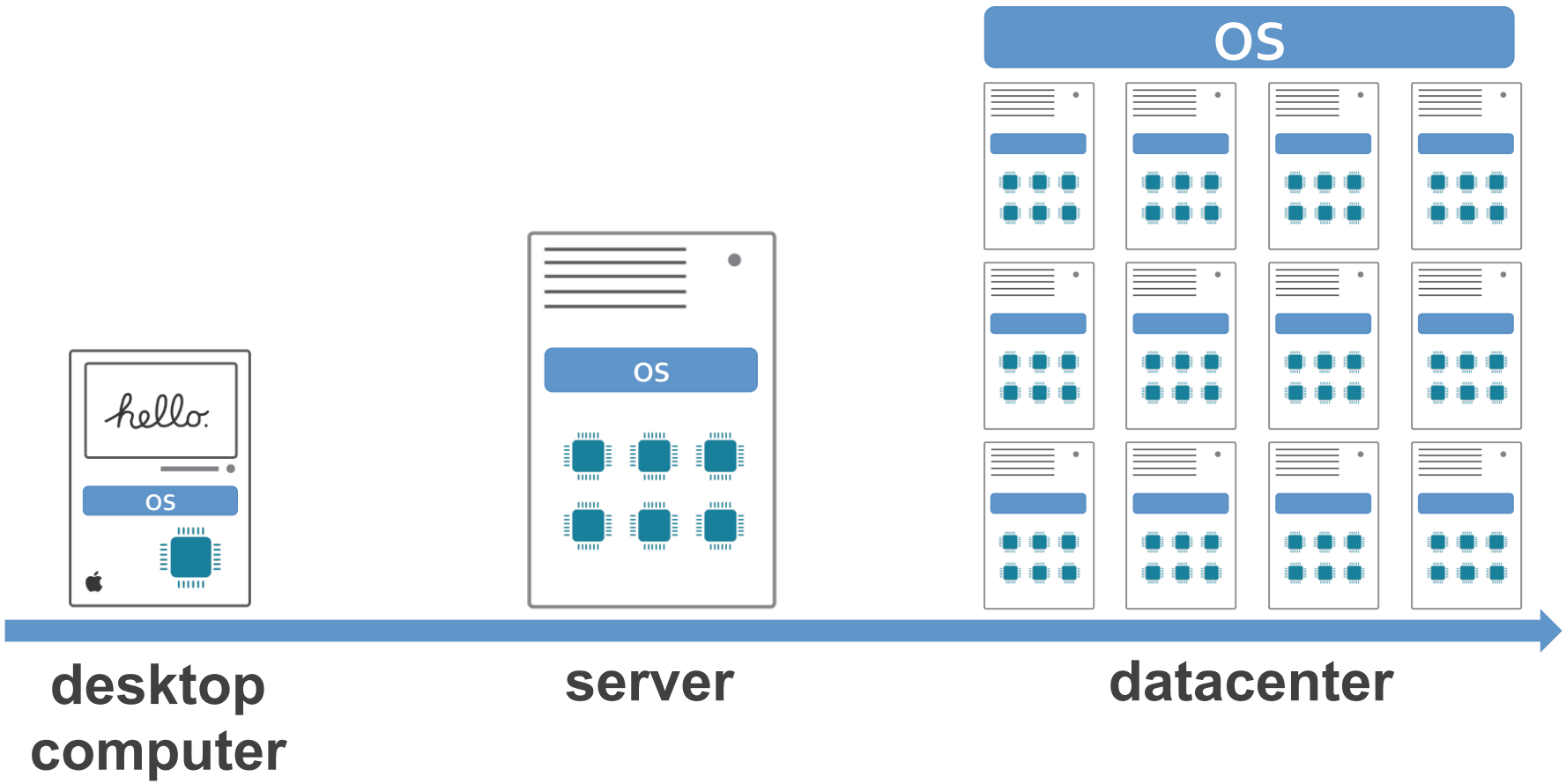


the datacenter
is just another form factor

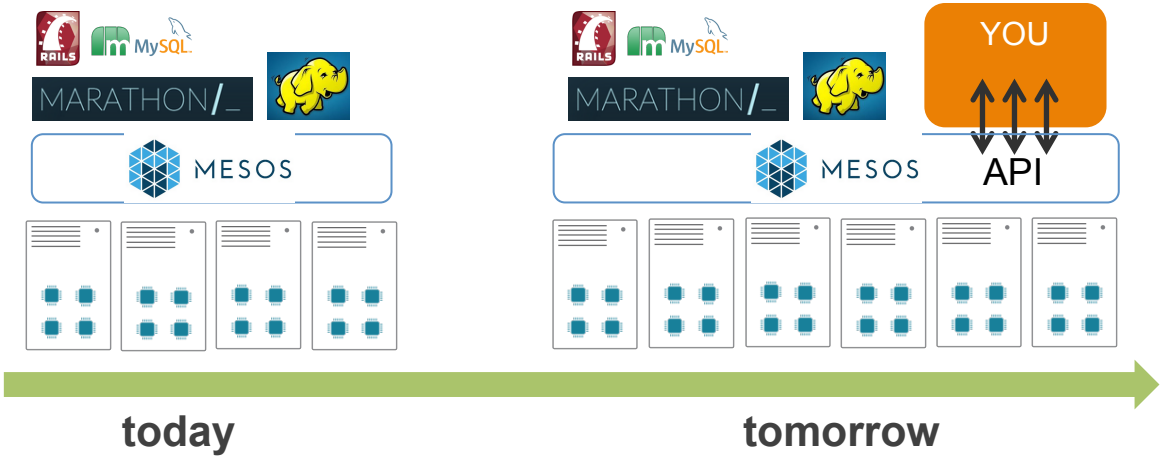
why can’t we run applications on our datacenters just like we run applications on our mobile phones?


10:08
Google
Rdio
Collection
Playlists
Heavy Rotation
Email
Inbox
Michael Hurley
Jeff Abbott
Hill, Troy
Gmail
Inbox
Daniel Bramhall
Abdel Ibrahim
Gormaya
Martin Tran

the datacenter computer needs an operating system



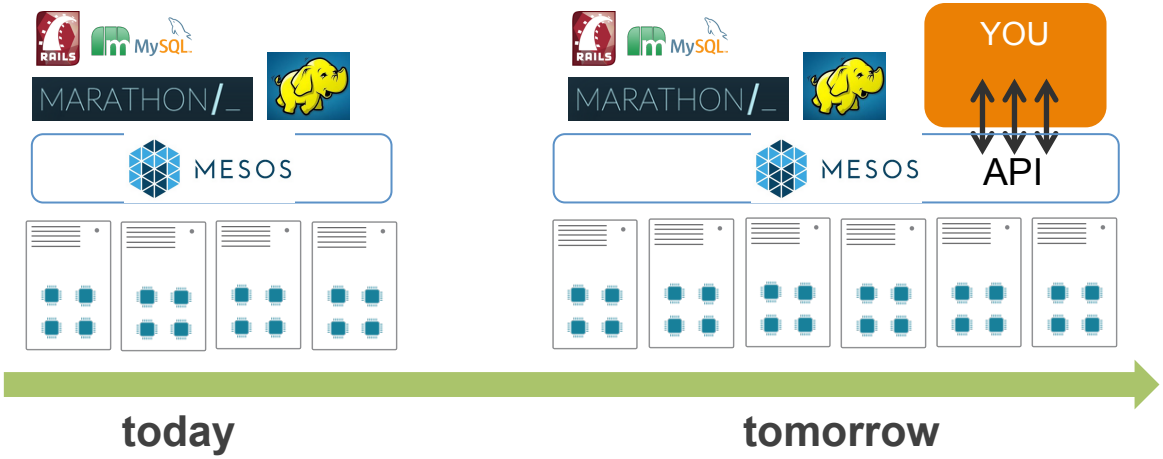
Mesos: datacenter kernel



provides common functionality every new distributed system *re-implements*:

- failure detection
- package distribution
- task starting
- resource isolation
- resource monitoring
- task killing, cleanup
- …

Mesos: datacenter kernel



provides common functionality every new distributed system *re-implements*:

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- …

don't reinvent the wheel!

Mesosphere DCOS

Frameworks
Marathon
Chronos
...

DCOS CLI

DCOS GUI

Repository

Kernel
Mesos

Modules
mesos-dns

Airbnb's Chronos

Chronos, a scheduler for running
cron jobs with dependencies

Airbnb's Chronos

Chronos, a scheduler for running
cron jobs with dependencies

cron *for the datacenter operating system*

Mesosphere's Marathon

Marathon, a scheduler for running *stateless services* written in any language

Mesosphere's Marathon

Marathon, a scheduler for running *stateless services* written in any language

init *for the datacenter operating system*

Q&A

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