Operational and Scaling Wins at Workday

From 50K to 300K Cores

OpenStack Summit
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Architecture Overview and Use Cases

Howard Abrams

Instrumentation

Monitoring, Logging and Metrics

Kyle Jorgensen

Image Challenges

Clearing the Image Distribution Bottleneck

Sergio de Carvalho

API Challenges

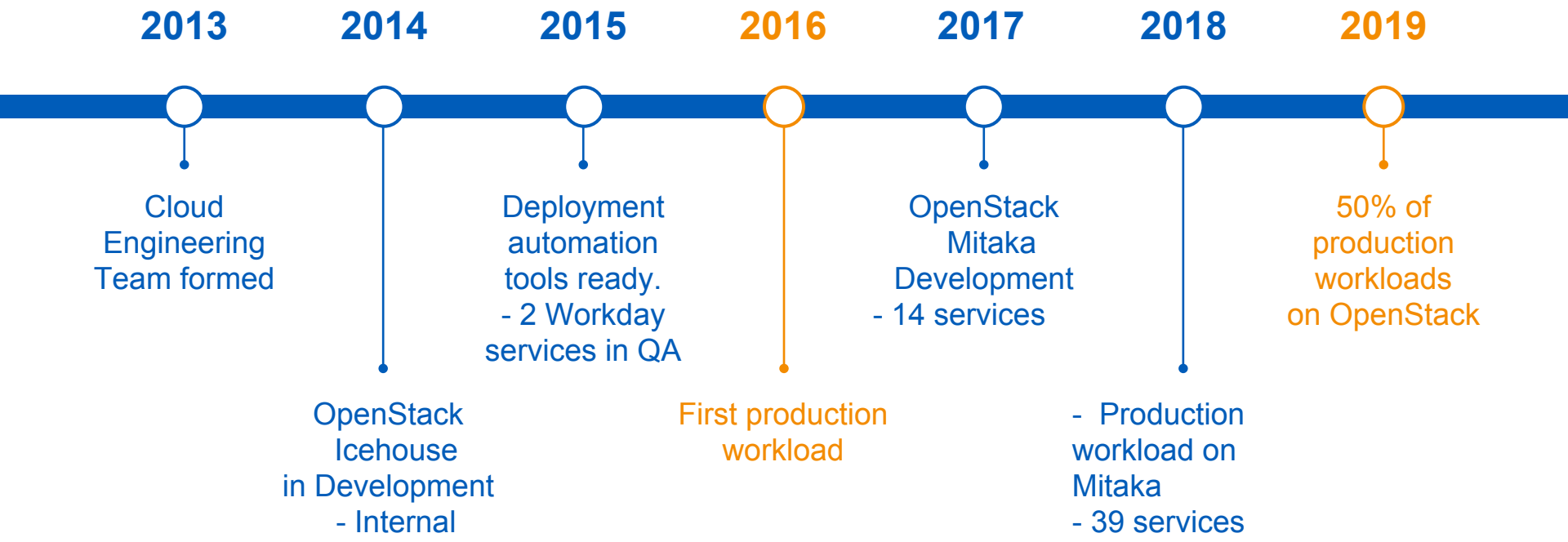
Identifying and Fighting Scaling Issues

Workday provides enterprise cloud applications for financial management, human capital management (HCM), payroll, student systems, and analytics.

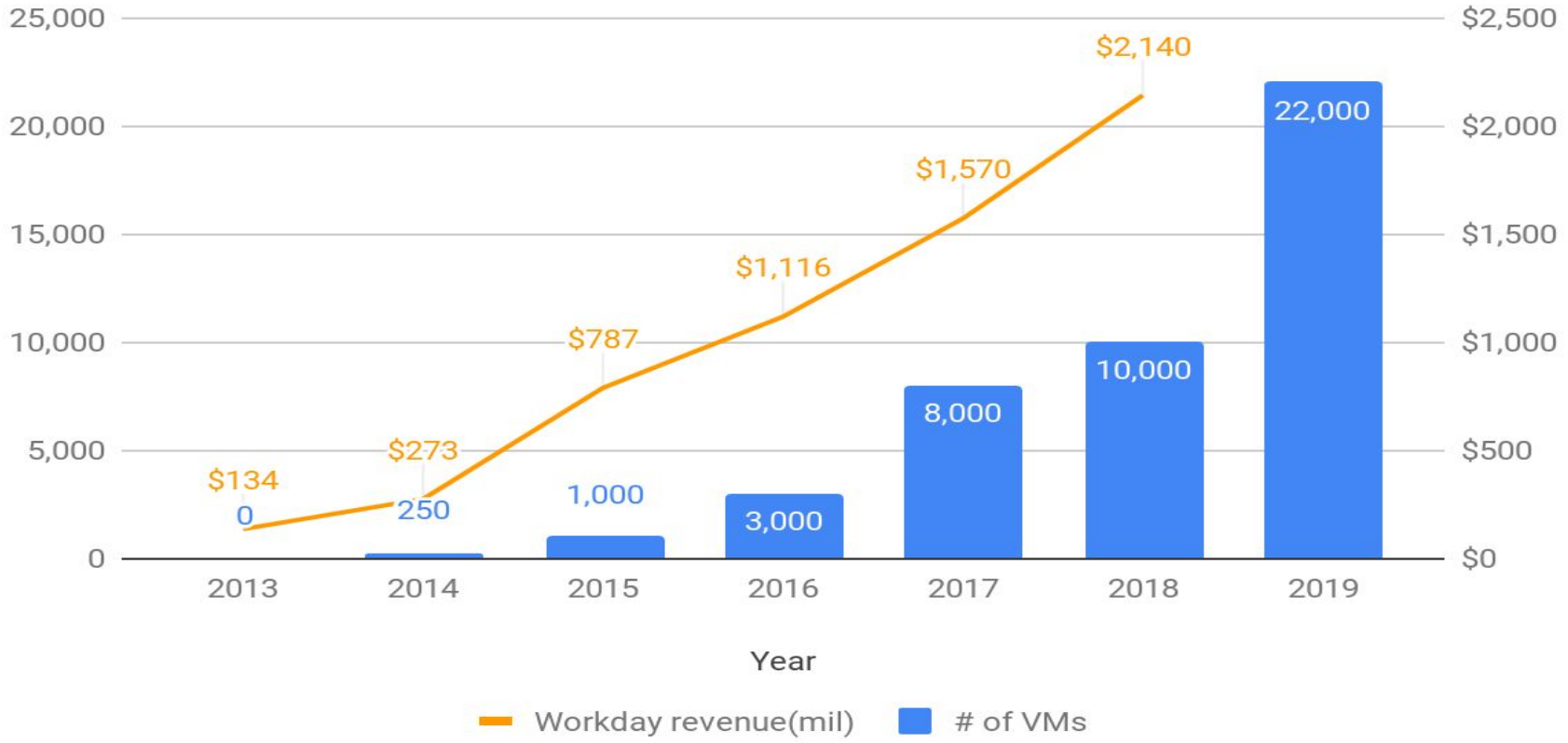
Our Story

OpenStack @ Workday

Our Journey So Far



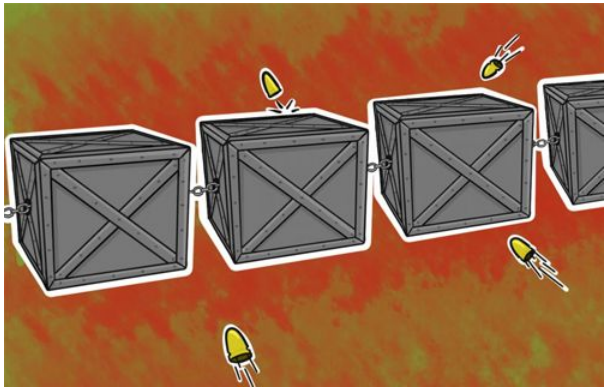
Workday Private Cloud Growth



Our Private Cloud

5 Data Centers	45 Clusters	4.6k Compute Hosts
300k Cores	22k Running VMs	4k Active VM Images

How Workday Uses the Private Cloud



Immutable Images

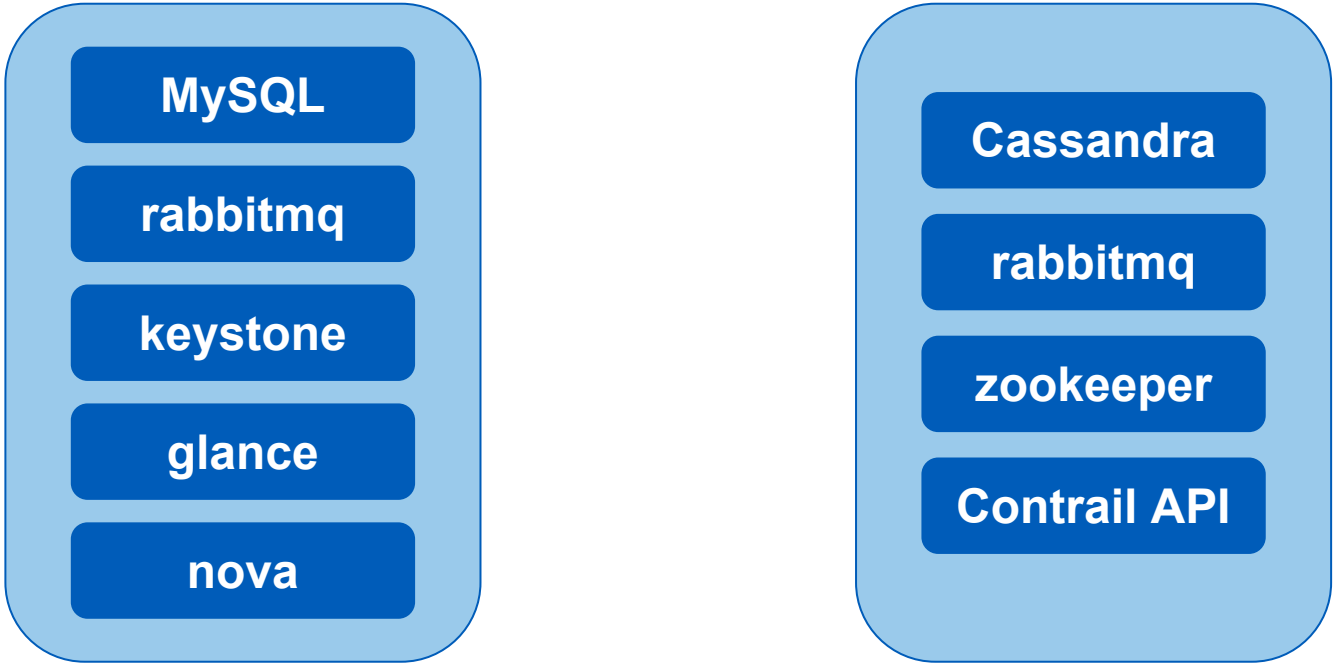
Weekly update

Narrow Update Window

https://www.blockchainsemantics.com/blog/immutable-blockchain/

Architecture Evolution

Initial Control Plane Architecture



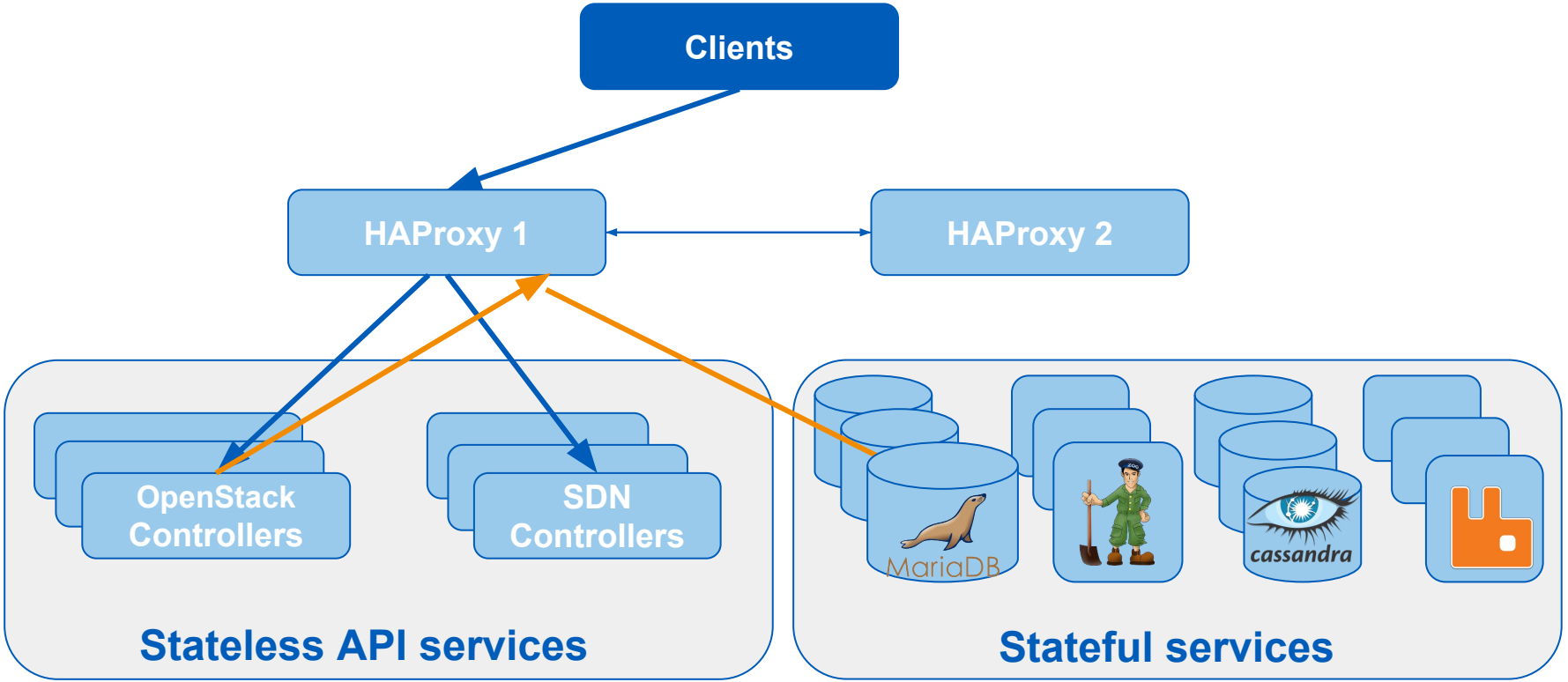
OpenStack Controller

SDN Controller

Key drivers for architectural evolution

400%	**Scalability**	Scale API services horizontally
99%	**High availability**	Make critical services highly available
0	Downtime upgrade	Provide upgrade path without affecting the workload

Control Plane



Instrumentation

Logging and Monitoring and Metrics, Oh My!

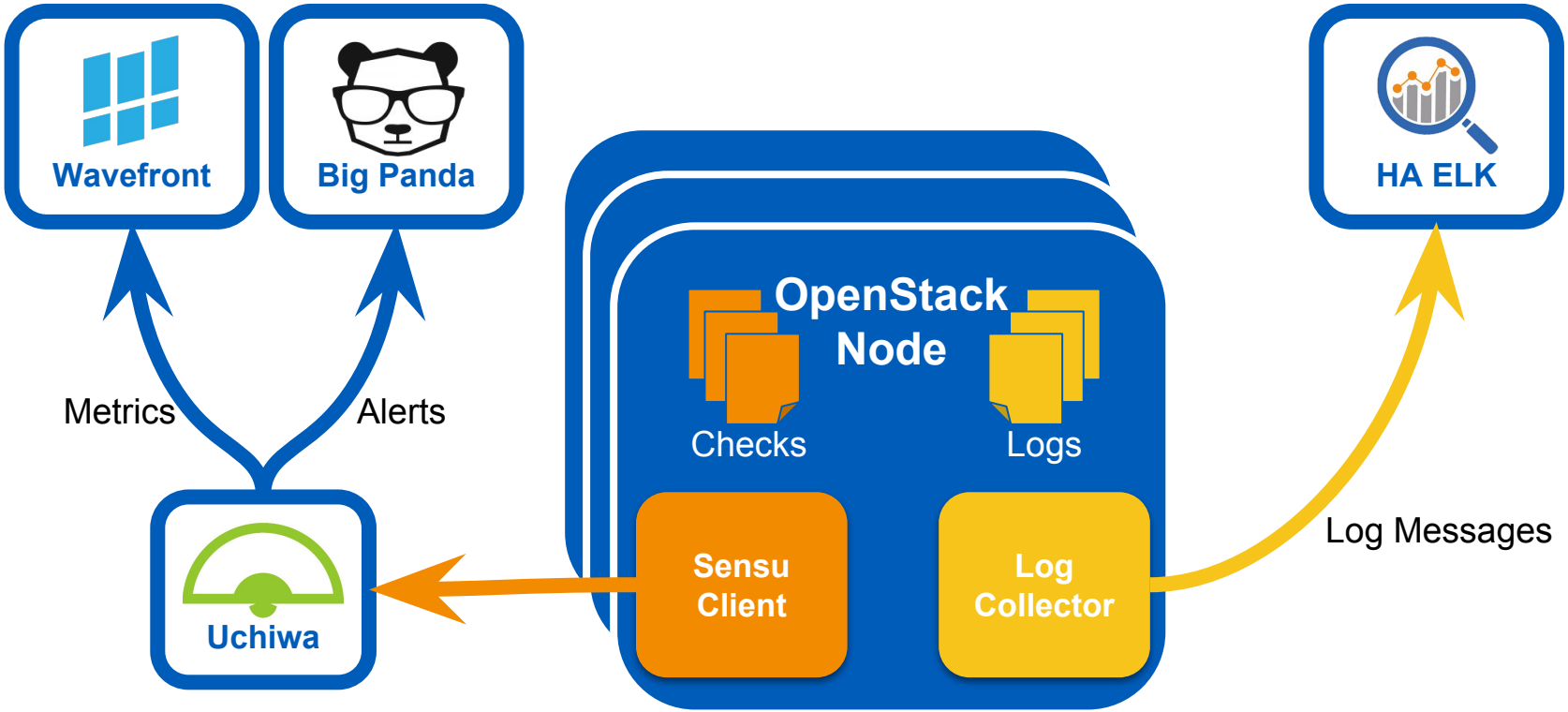
Instrumentation Challenges

- No access to production systems: *full automation*
- Dispersed logs among multiple systems
- Sporadic issues with services:

  “What do you mean RabbitMQ stopped!?”
- Vague or subjective concerns:

  “Why is the system *slow*!?”

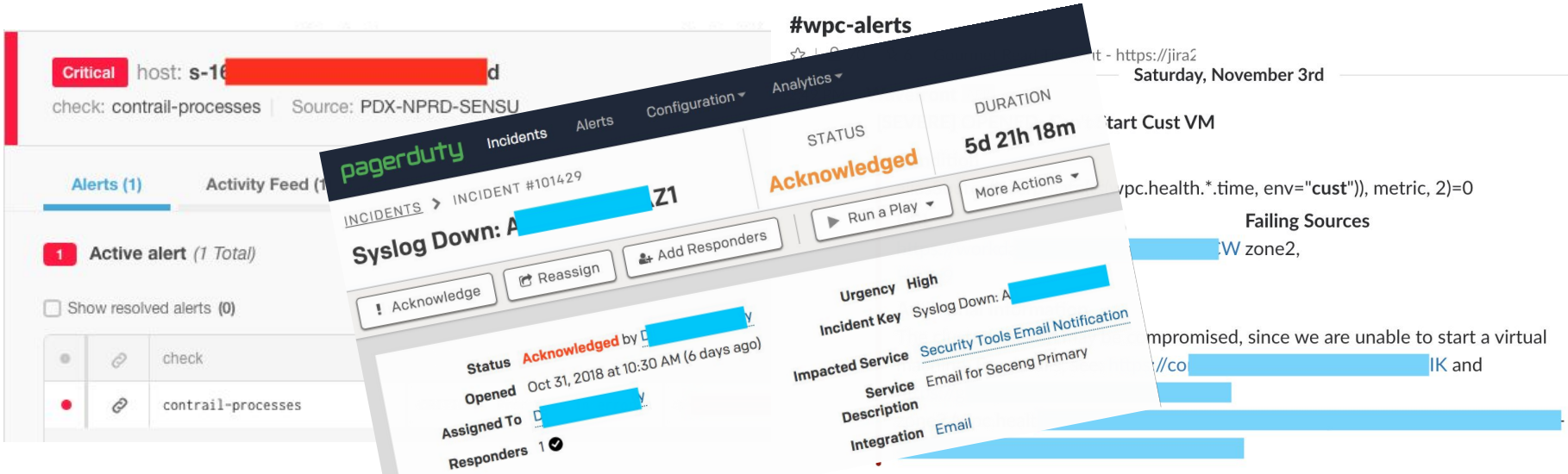
Instrumentation Architecture



Monitoring

For each issue, we:

- Fixed the issue/bug
- Wrote tests to address the issue/bug
- Wrote a check to alert if it happened again



Example: Our Health Check

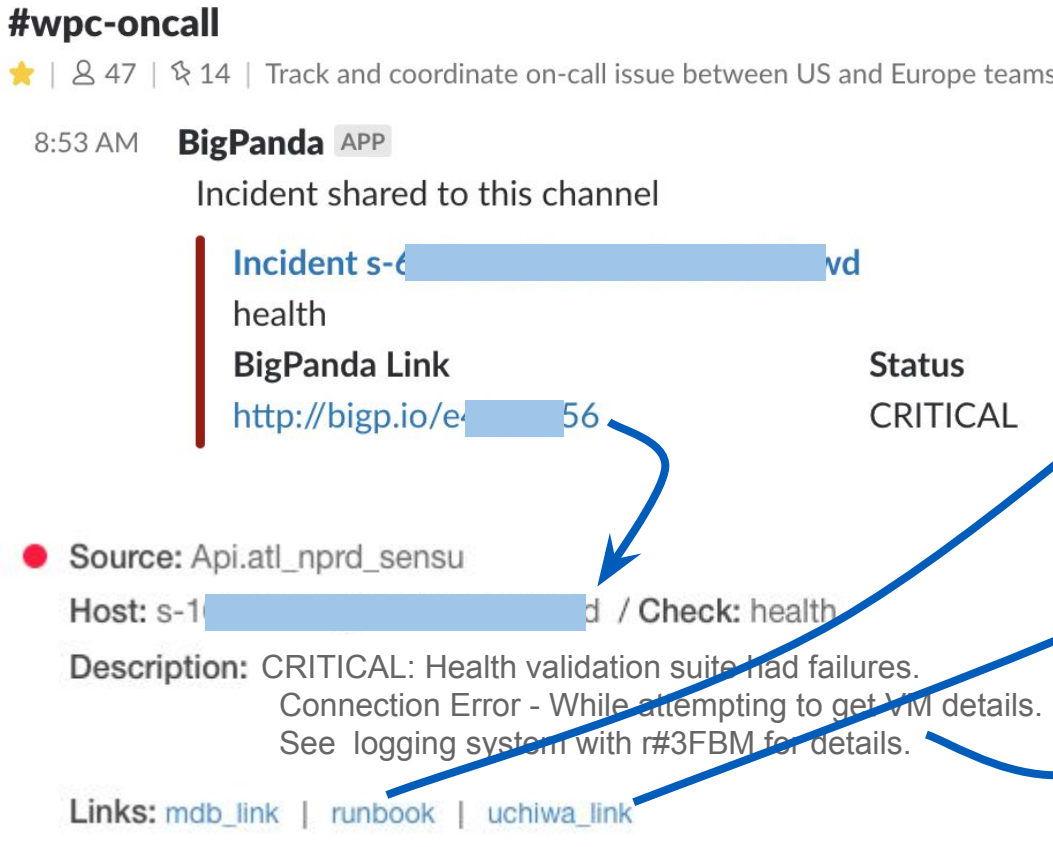
Our customers use our project (OpenStack), a particular way…

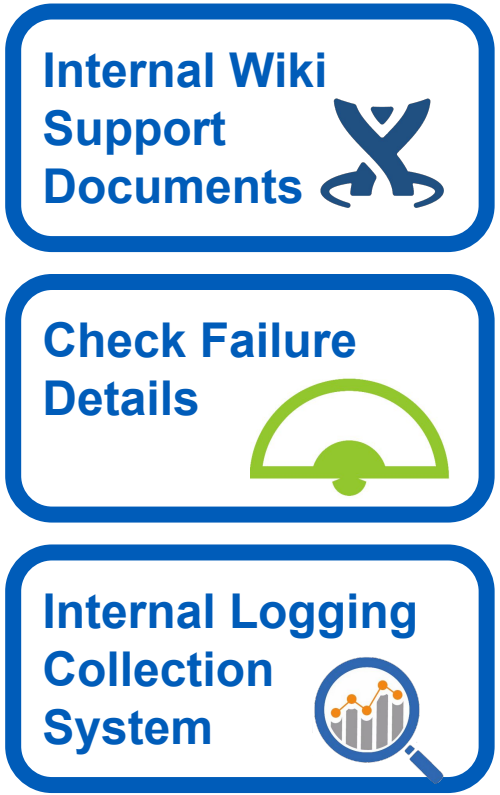
For *each node* in *each cluster*, test by:

- Start a VM with a *particular image*
- Check DNS resolves host name
- Verify SSH service
- Validate LDAP access
- Stop the VM

Rinse and Repeat

Troubleshooting Issues

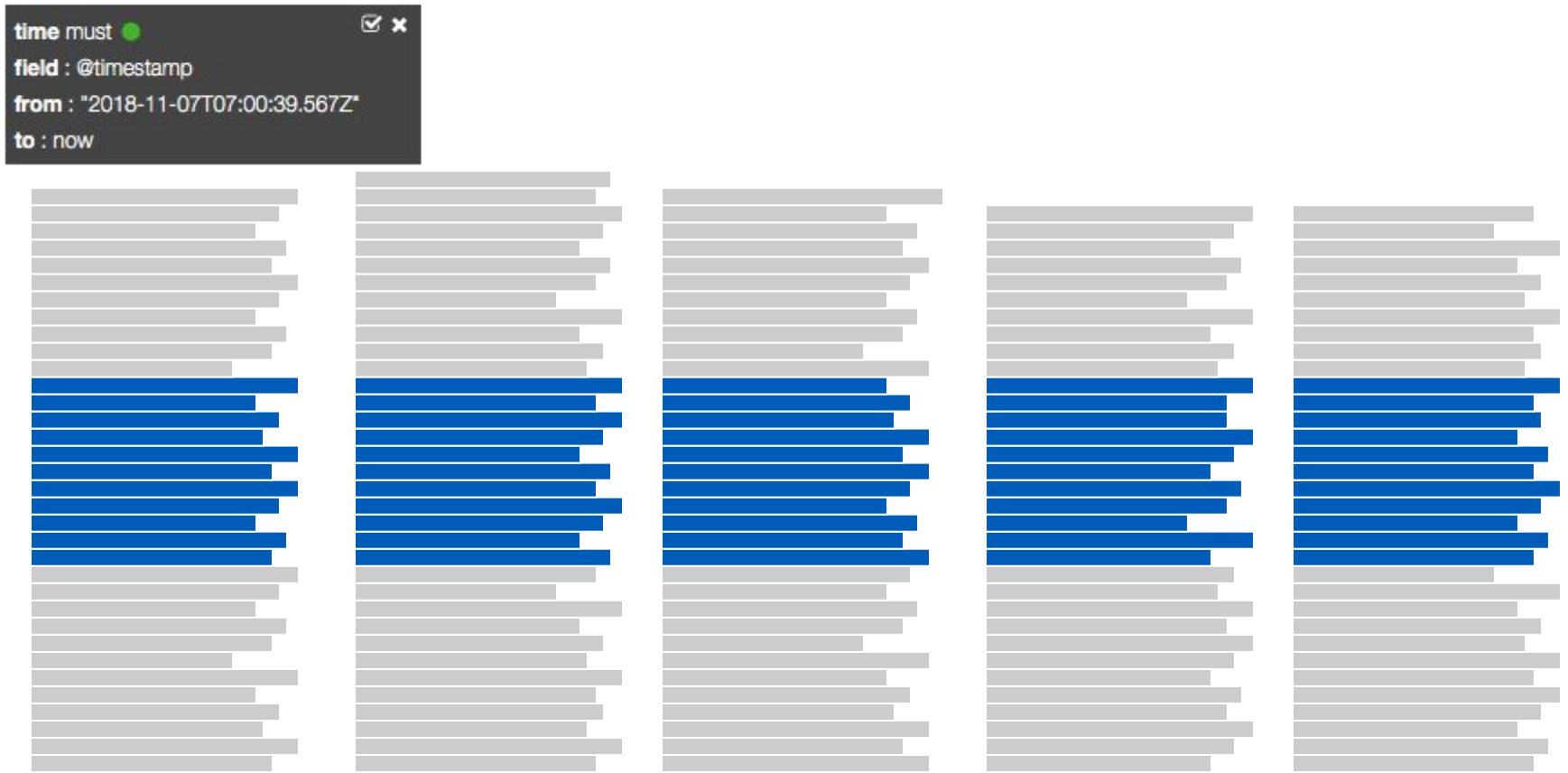




Troubleshooting with Logs

Troubleshooting with Logs

FILTERING



Troubleshooting with Logs

FILTERING

time must
field : @timestamp
from : "2018-11-07T07:00:39.567Z"
to : now

field must
field : payload
query : "<r#3FBM>"

Troubleshooting with Logs

FILTERING

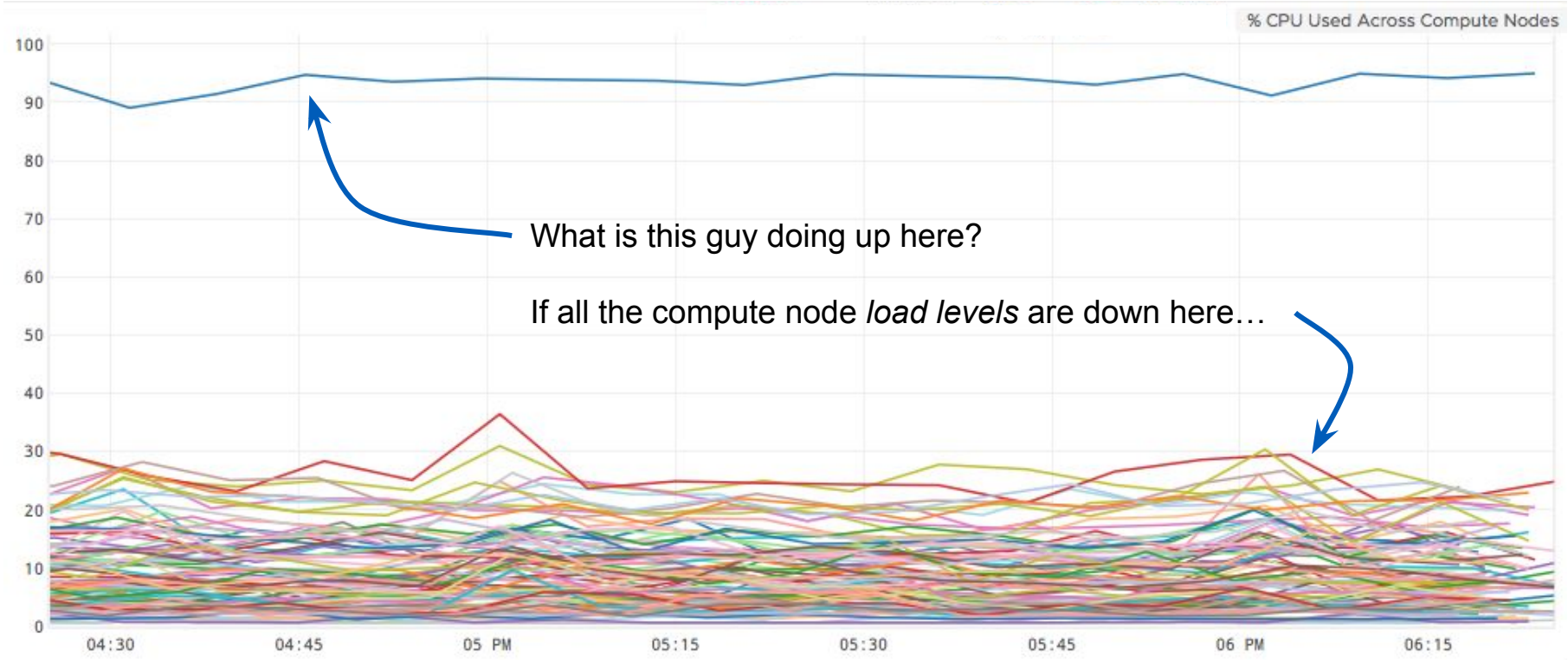
time must
field : @timestamp
from : "2018-11-07T07:00:39.567Z"
to : now

field must
field : payload
query : "<r#3FBM>"

terms must
field : log_name.raw
value : health

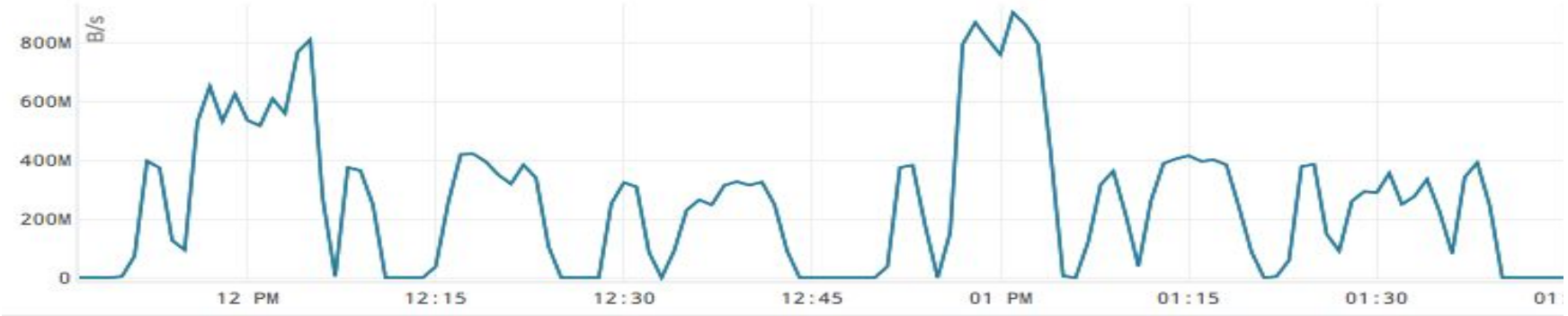
Metrics

There's death, and then there's *illness*…

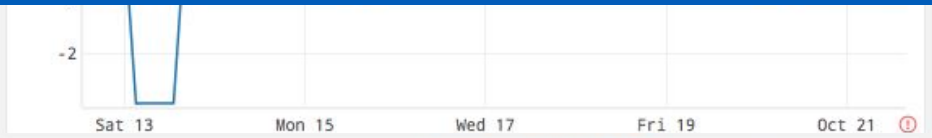


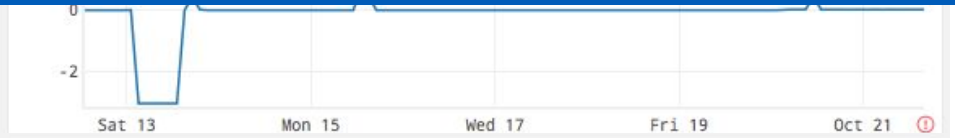
Dashboards to Track Changes

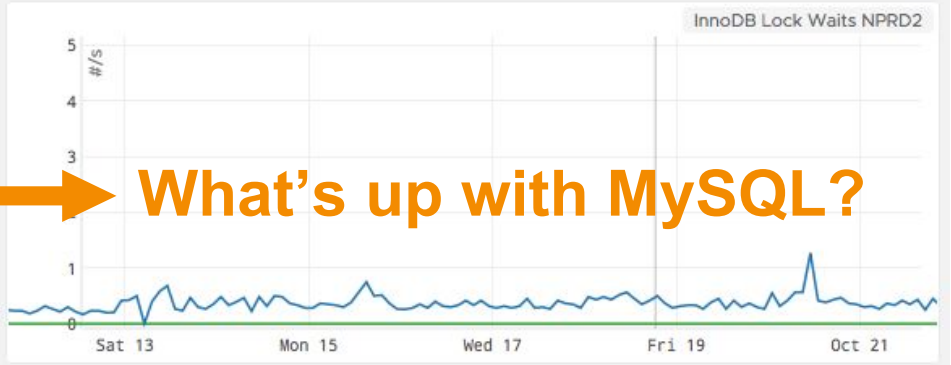
nbproc=1 –mc –set2	nbproc=1 +mc –set2	nbproc=1 +mc +set2	nbproc=2 –mc –set2	nbproc=2 +mc -set2	nbproc=2 +mc +set2



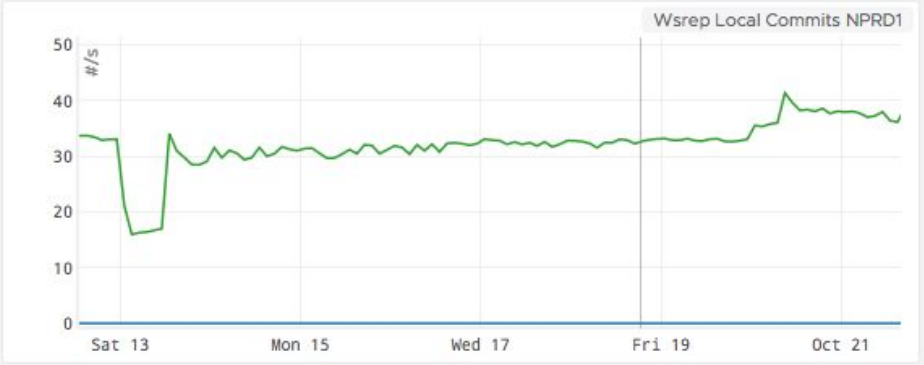
Transient Dashboards







What's up with MySQL?



Instrumentation Takeaways

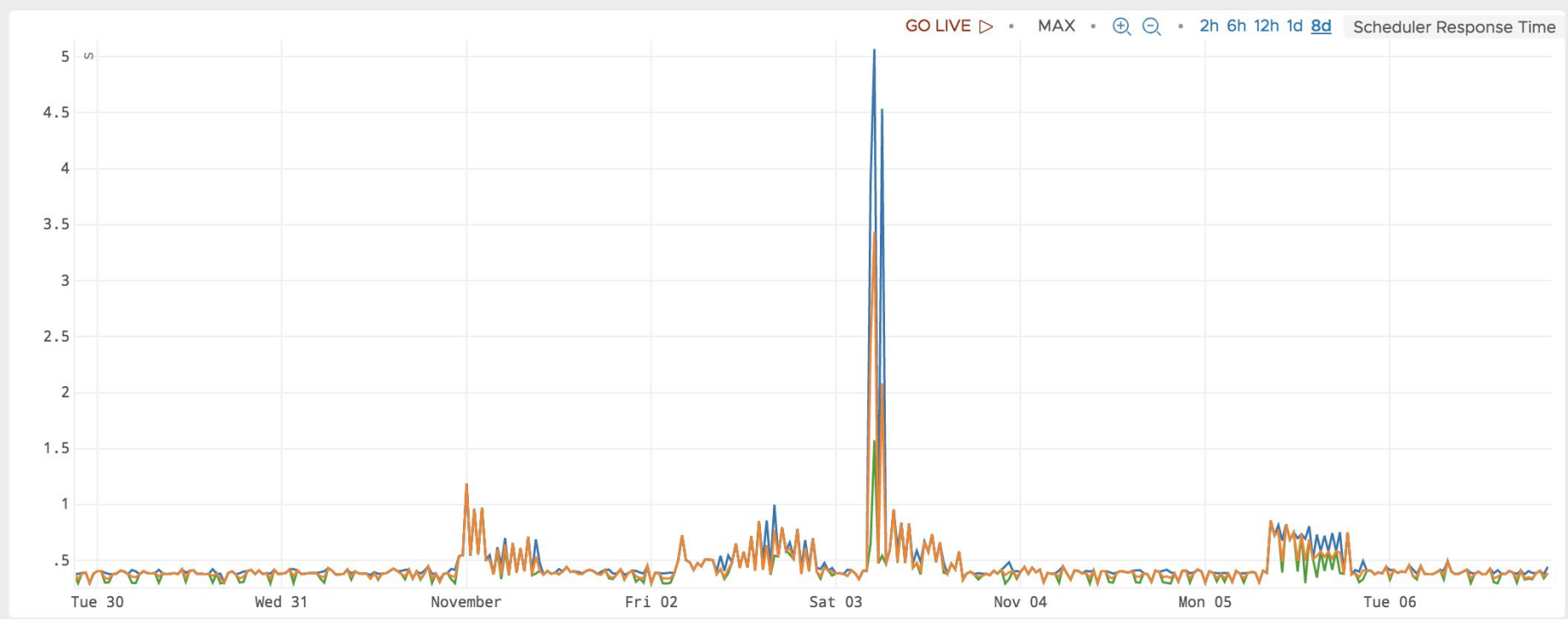
- Can’t scale if you can’t tweak. Can’t tweak if you can’t monitor.
- Collect and filter all the logs
- Create checks for everything...especially running services
- Invest in a good metric visualization tool:
  - Create focused graphs
  - Dashboards start with key metrics (correlated to your service level agreements)
  - Be able to create one-shots and special-cases
  - Learn how to accurately monitor all the OpenStack services

Image Distribution

Clearing the Image Distribution Bottleneck

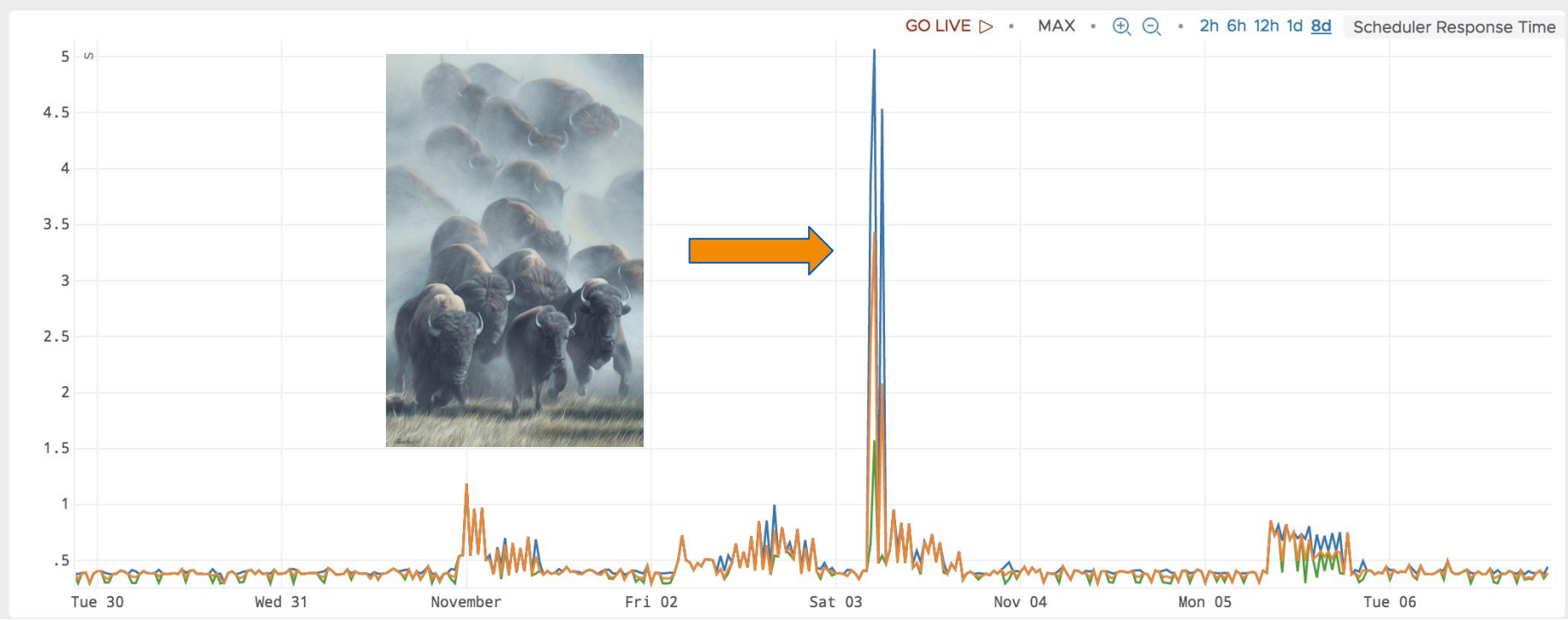
Challenge: Control Plane Usage

Example - Nova Scheduler response time



Challenge: Control Plane Usage

Example - Nova Scheduler response time



Challenge: Control Plane Usage

Example - Count of deployed VMs

Large images: worst offender

~6GB

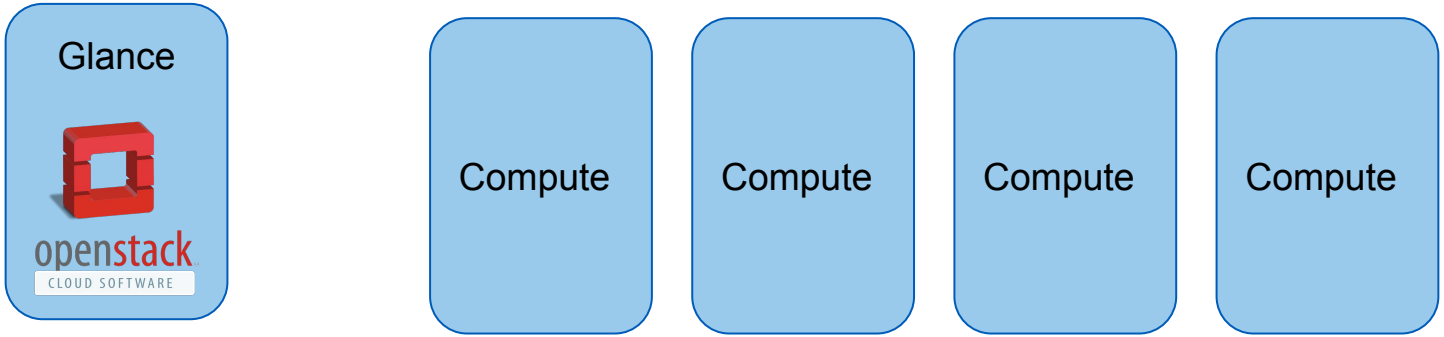
Image size

~1700

Instance count across DC’s

Problem

Many VM boots in short period of time + large images = bottleneck



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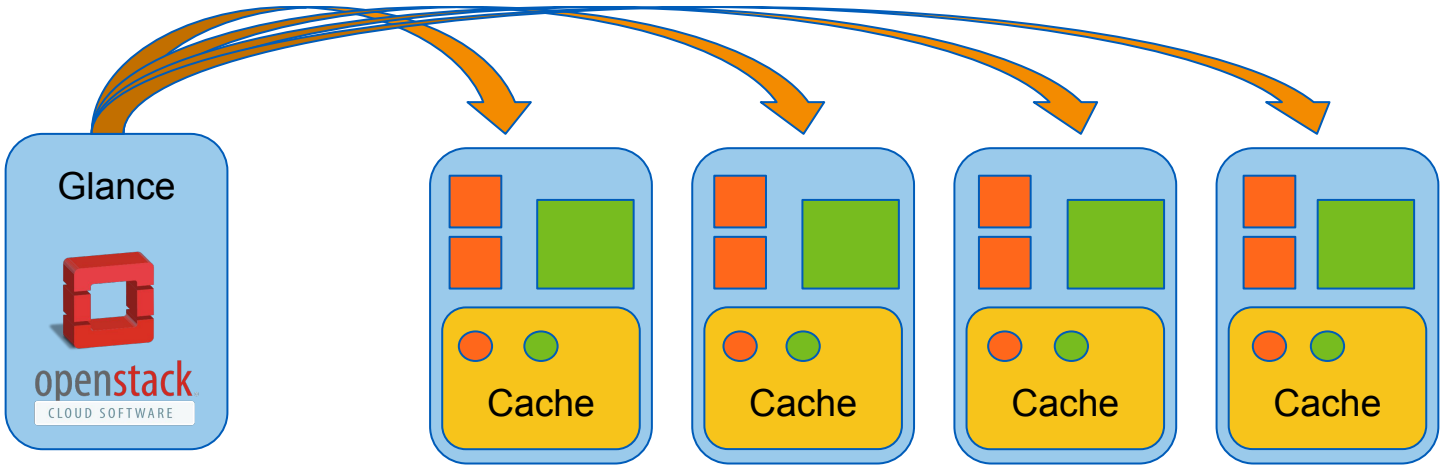

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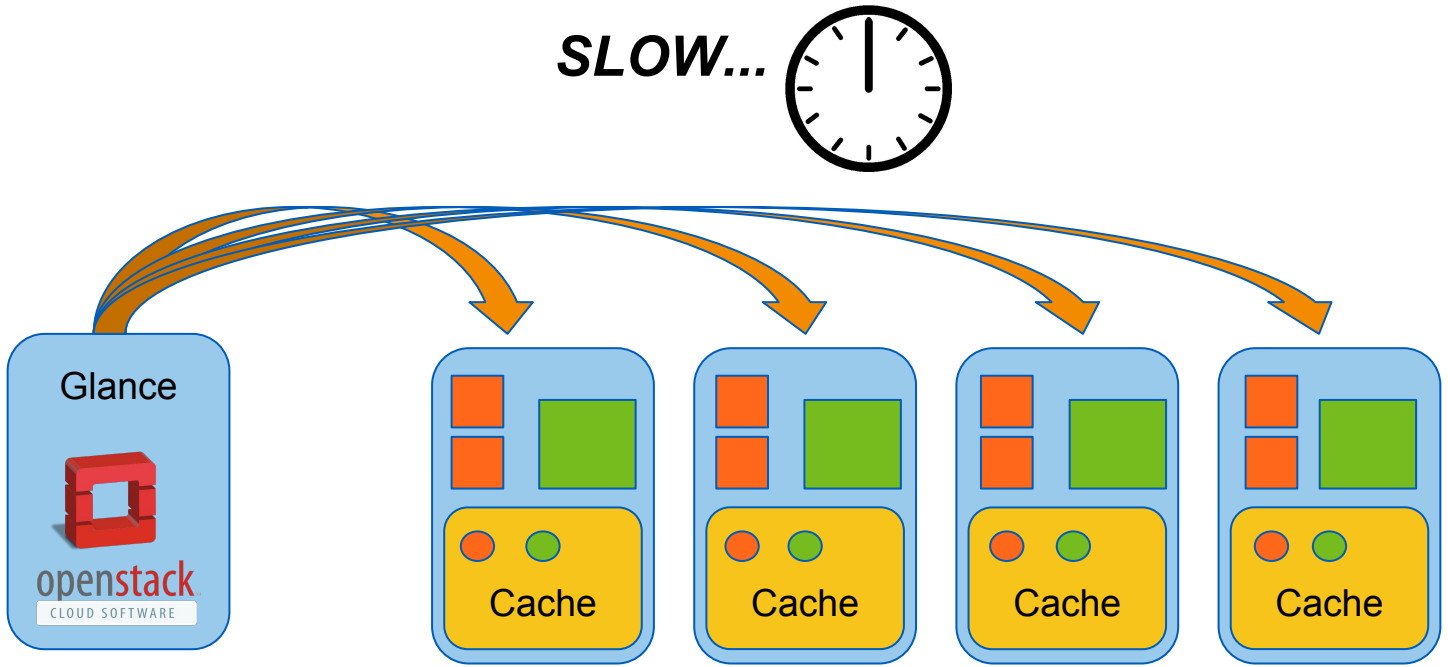
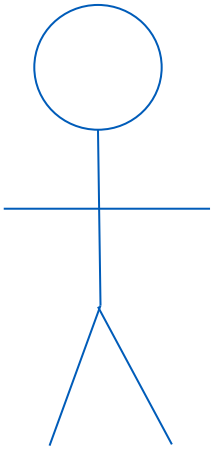


Solution: Extend Nova API



Operator

```
curl https://<host>:8774/v2.1/image_prefetch -X POST \
...
-H "X-Auth-Token: MIIOvwYJKoZIQcCoIIOsDCCDasdkoas=" \
-H "Content-Type: application/json" \
-d  '{ "image_id": "d5ac4b1a-9abe-4f88-8f5f-7896ece564b9" }'
```

Solution: Extend Nova API

```
curl https://<host>:8774/v2.1/image_prefetch -X POST \
...
-H "X-Auth-Token: MIIOvwYJKoZIQcCoIIOsDCCDasdkoas=" \
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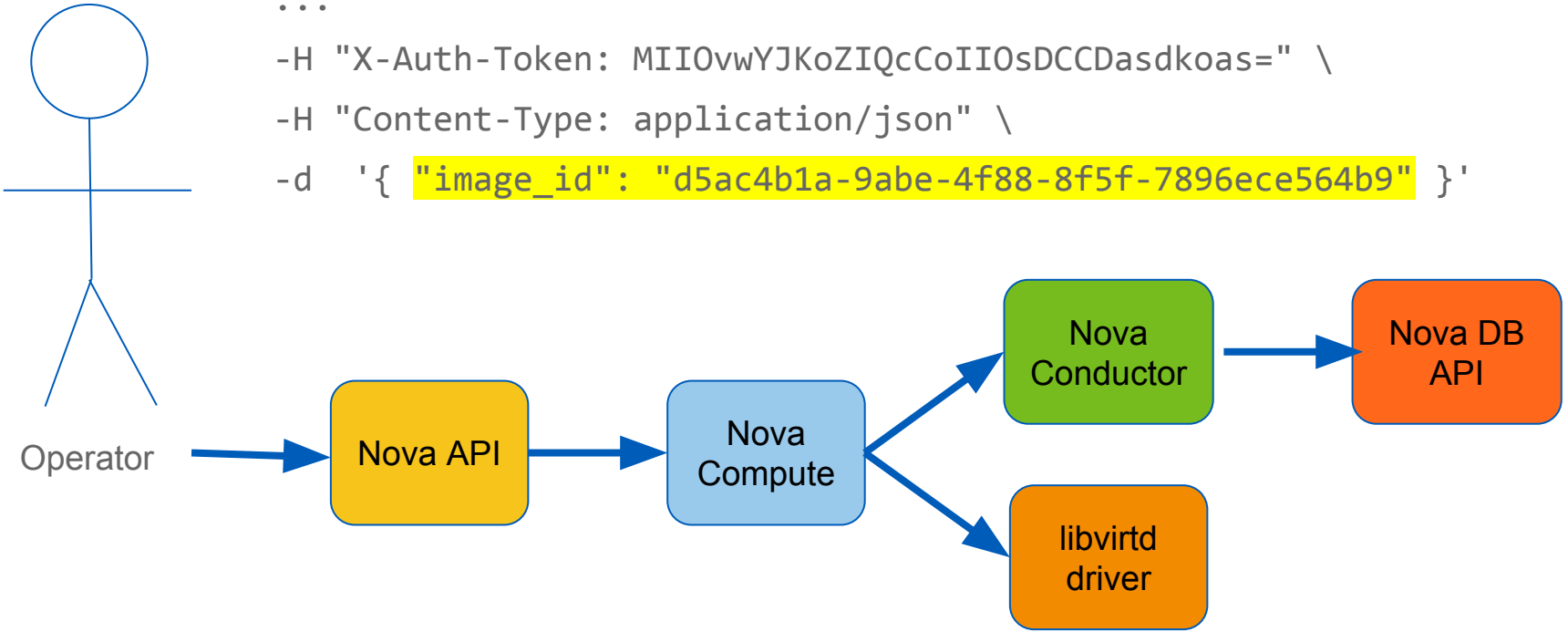
```



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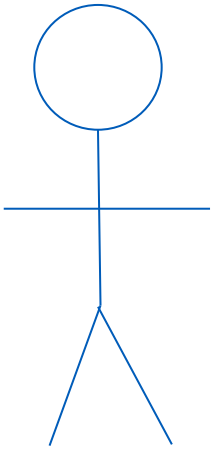
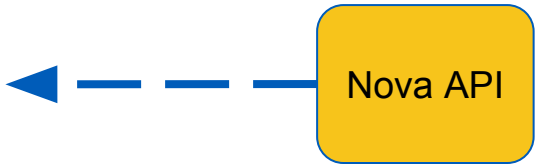


Operator

```
HTTP/1.1 202 Accepted
Content-Type: application/json
Content-Length: 50
X-Compute-Request-Id:
req-f7a3bd10-ab76-427f-b6ee-79b92fc2a978
Date: Mon, 02 Jul 2018 20:52:37 GMT
{"job_id": "f7a3bd10-ab76-427f-b6ee-79b92fc2a978"}
```



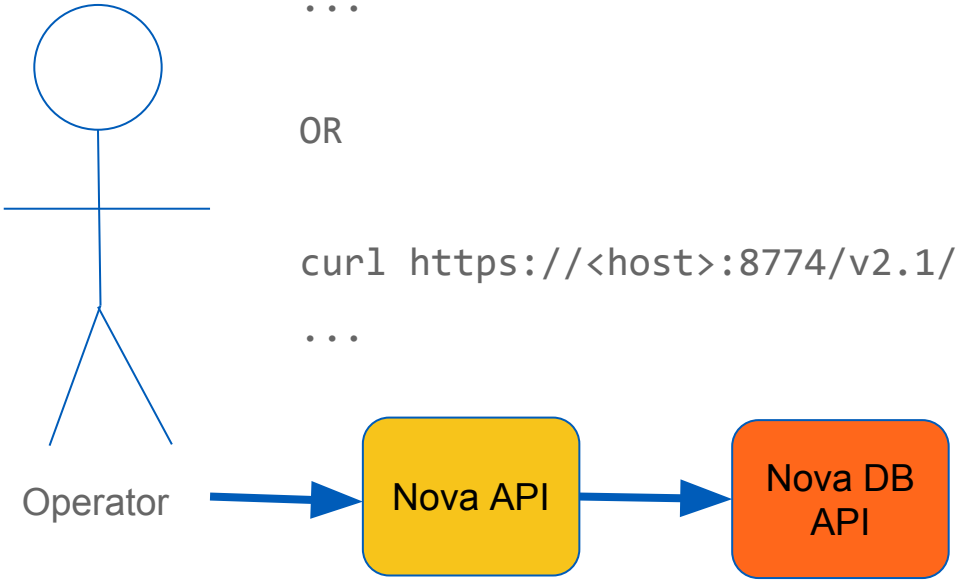
(Async job)

Solution: Extend Nova API

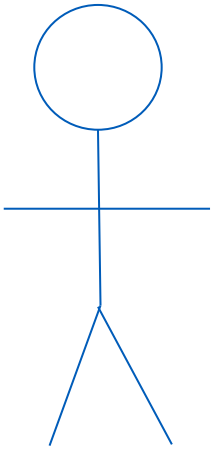
```
curl https://<host>:8774/v2.1/image_prefetch/image/<image_ID>
...

OR

curl https://<host>:8774/v2.1/image_prefetch/job/<job_ID>
...
```



Solution: Extend Nova API



Operator

```
HTTP/1.1 200 OK ...
{
    "overall_status": "5 of 10 hosts done. 0 errors.",
    "image_id": "d5ac4b1a-9abe-4f88-8f5f-7896ece564b9",
    "job_id": "f7a3bd10-ab76-427f-b6ee-79b92fc2a978",
    "total_errors": 0,
    "num_hosts_done": 5,
    "start_time": "2018-07-02T20:52:37.000000",
    "num_hosts_downloading": 2,
    "error_hosts": 0,
    "num_hosts": 10
}
```

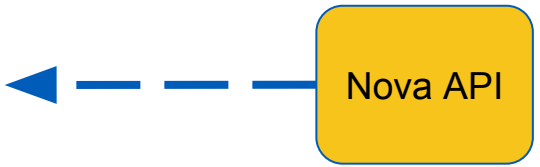
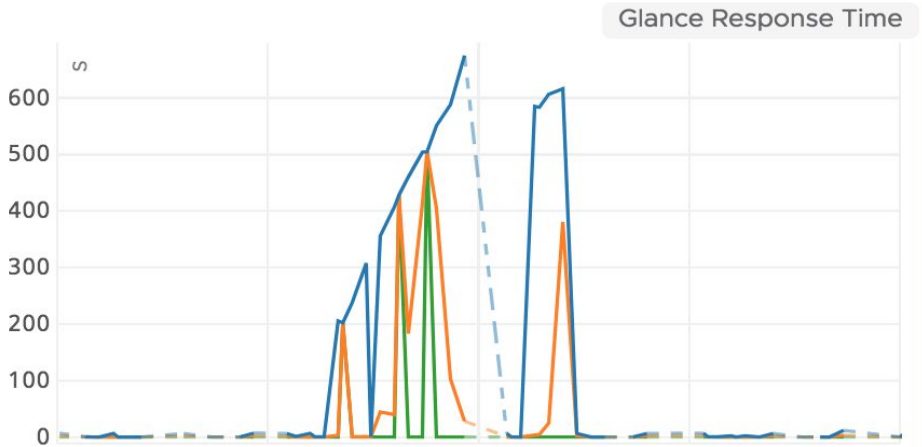


Image Prefetch API Result

Before

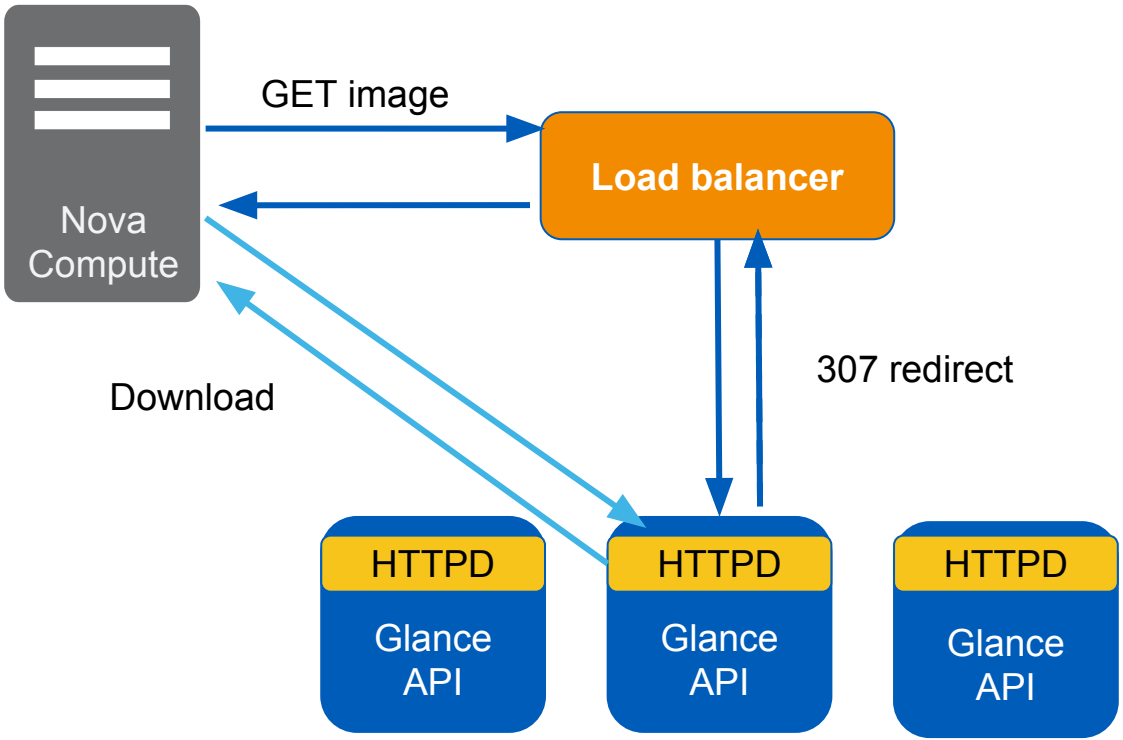


After

100% **Cache hit**

- **Avg 300 sec of VM boot time reduced**
- **VM creation failure rate decreased by 20 %**

HAProxy Bottleneck



HAProxy Bottleneck

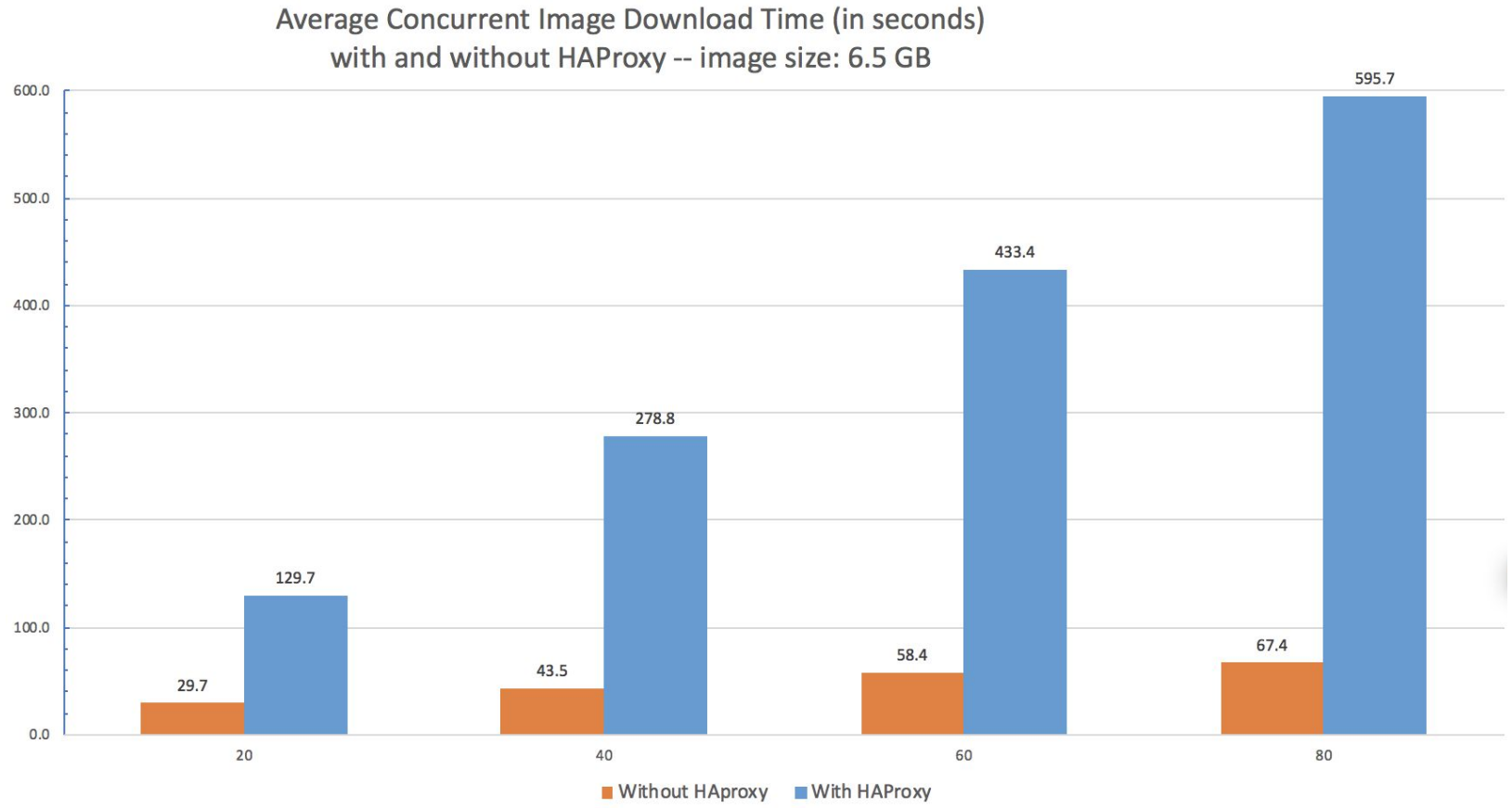
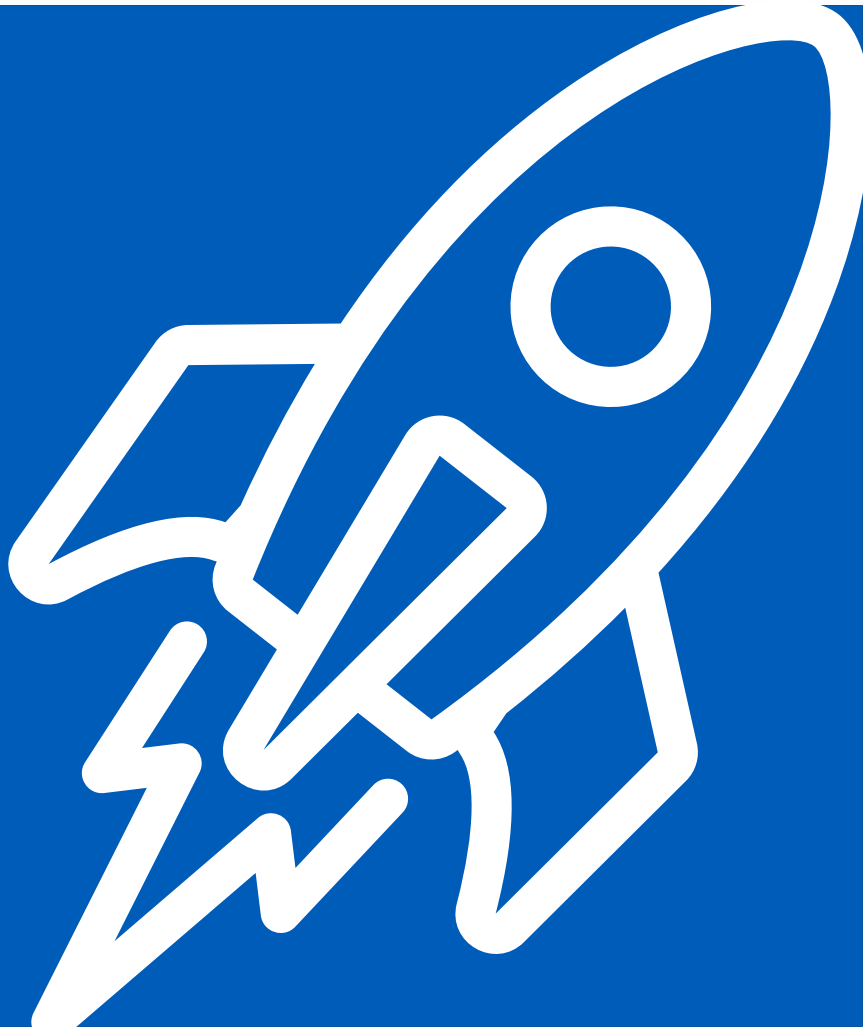


Image Distribution: Key Takeaways

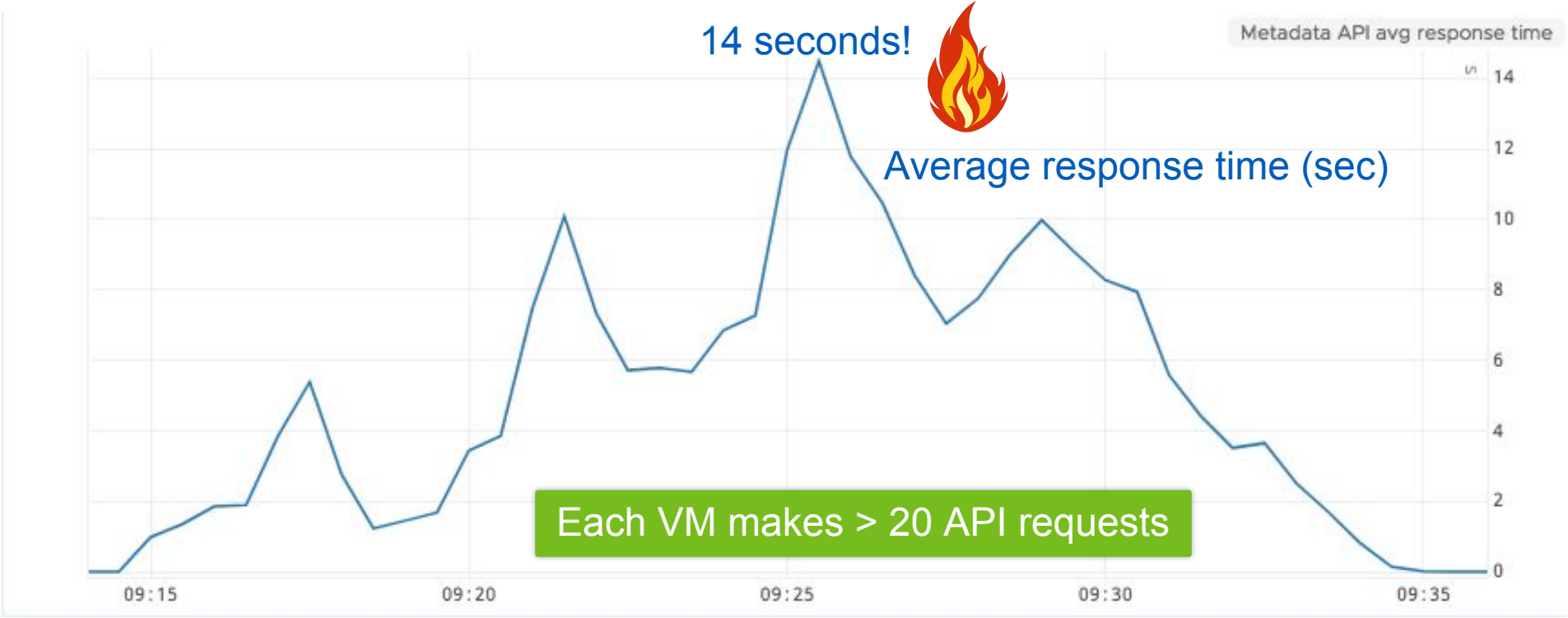
- Under heavy load, downloading images can be a bottleneck
  - Contribute image prefetch back to community
- HA Tradeoffs
- API Specific monitoring allows for unique insights

API Challenges

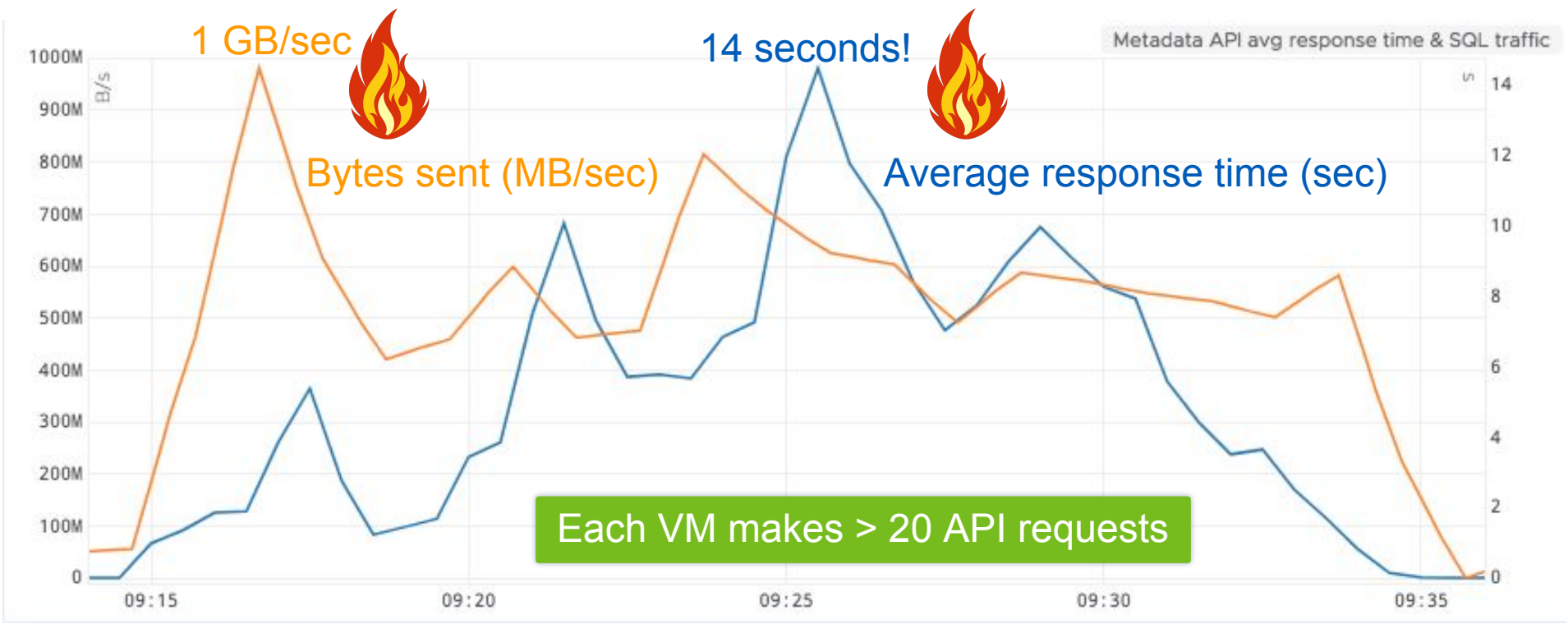
Identifying and Fighting ~~Fire~~ Scaling Issues



Nova Metadata API



Nova Metadata API & Database Transfer Rate

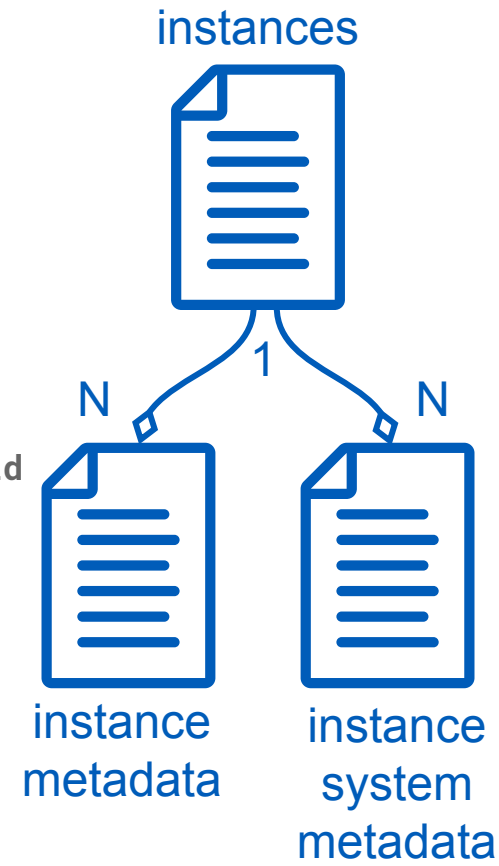


Top Query by “Rows Sent”

```
SELECT ...
  FROM (SELECT ...
          FROM instances
         WHERE instances.deleted = 0
           AND instances.uuid = ?
         LIMIT 1) AS instances
  LEFT OUTER JOIN instance_system_metadata
    ON instances.uuid = instance_system_metadata.instance_uuid
  LEFT OUTER JOIN instance_extra
    ON instance_extra.instance_uuid = instances.uuid
  LEFT OUTER JOIN instance_metadata
    ON instance_metadata.instance_uuid = instances.uuid
   AND instance_metadata.deleted = 0
    ...
```

Instance Object-Relational Mapping

```
SELECT ...
  FROM (SELECT ...
          FROM instances
         WHERE instances.deleted = 0
           AND instances.uuid = ?
         LIMIT 1) AS instances
  LEFT OUTER JOIN instance_system_metadata
    ON instances.uuid = instance_system_metadata.instance_uuid
  LEFT OUTER JOIN instance_extra
    ON instance_extra.instance_uuid = instances.uuid
  LEFT OUTER JOIN instance_metadata
    ON instance_metadata.instance_uuid = instances.uuid
   AND instance_metadata.deleted = 0
    ...
```



Instance Object-Relational Mapping

```
SELECT ...
```

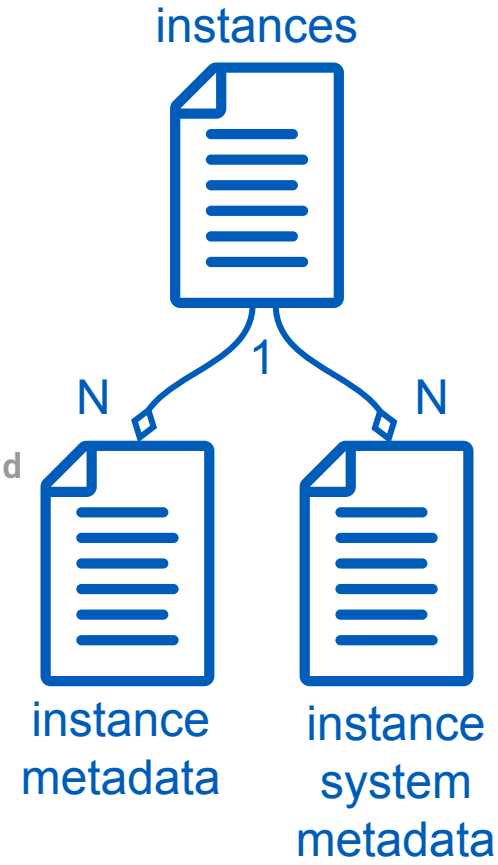
Expected result set (metadata union):

50 + 50 = 100 rows

Actual result set (metadata product):

50 x 50 = 2,500 rows!

```
                                                    _uuid
  ON instance_extra.instance_uuid = instances.uuid
LEFT OUTER JOIN instance_metadata
  ON instance_metadata.instance_uuid = instances.uuid
 AND instance_metadata.deleted = 0
  ...
```



Instance Object-Relational Mapping

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SELECT ...
```

Expected result set (metadata union):

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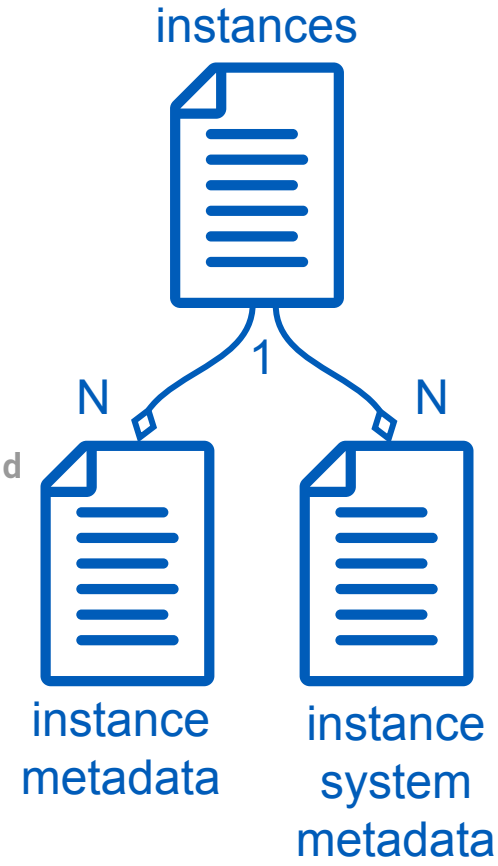
https://bugs.launchpad.net/nova/+bug/1799298

Thanks to Dan Smith & Matt Riedemann!

```
_uuid
```




```
    AND instance_metadata.deleted = 0
    ...
```

Nova Pre-loads Metadata Tables (since Mitaka)

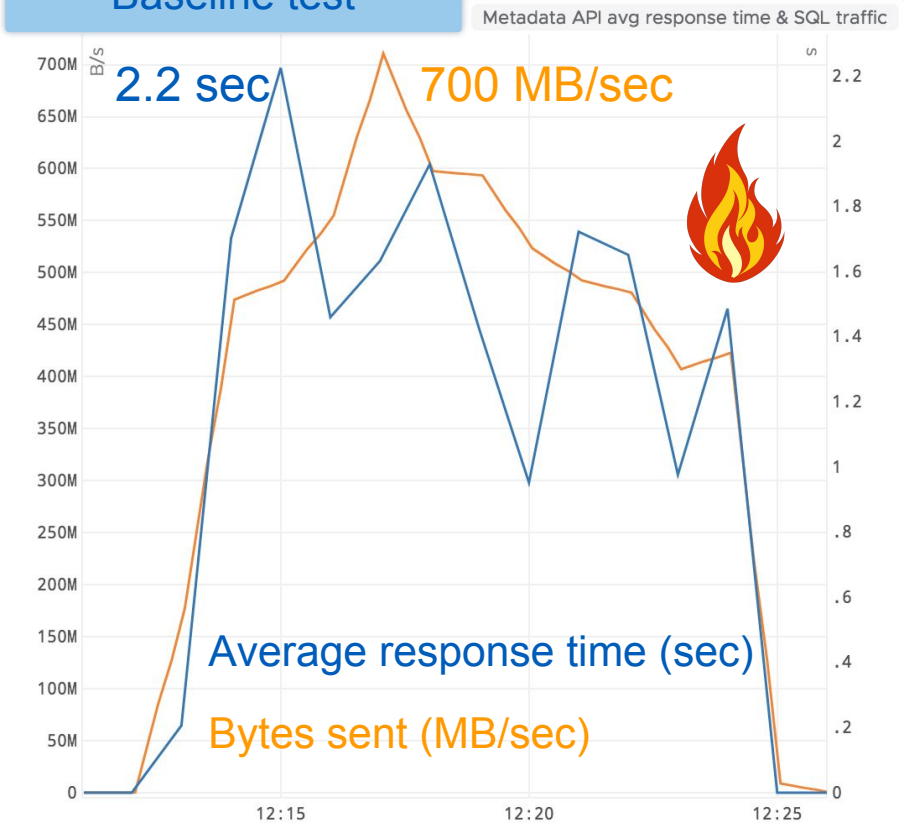
```
Commit: Avoid lazy-loads in metadata requests (Feb 5 2016)

The metadata server currently doesn't pre-query for metadata and system_metadata, which
ends up generating *two* lazy-loads on many requests. Since especially user metadata is
almost definitely one of the things an instance is going to fetch from the metadata
server, this is fairly inefficient.

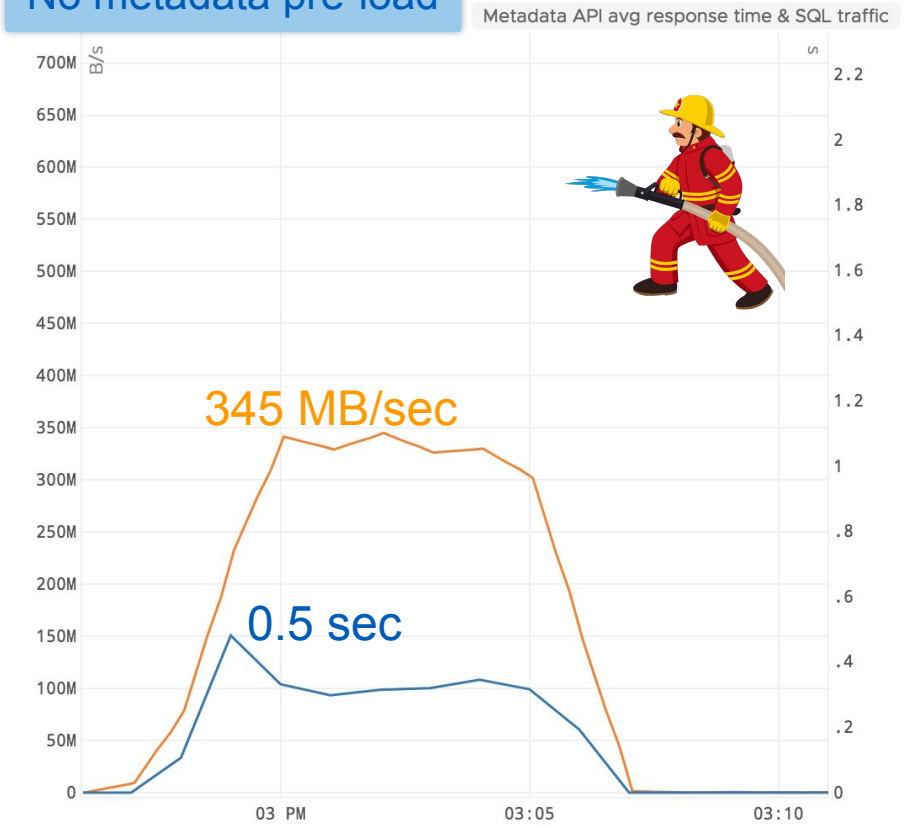

--- a/nova/api/metadata/base.py
+++ b/nova/api/metadata/base.py
 def get_metadata_by_instance_id(instance_id, address, ctxt=None):
      ctxt = ctxt or context.get_admin_context()
      instance = objects.Instance.get_by_uuid(
-         ctxt, instance_id, expected_attrs=['ec2_ids', 'flavor', 'info_cache'])
+         ctxt, instance_id, expected_attrs=['ec2_ids', 'flavor', 'info_cache',
+                                            'metadata', 'system_metadata'])
      return InstanceMetadata(instance, address)
```

Reverting Metadata Pre-load

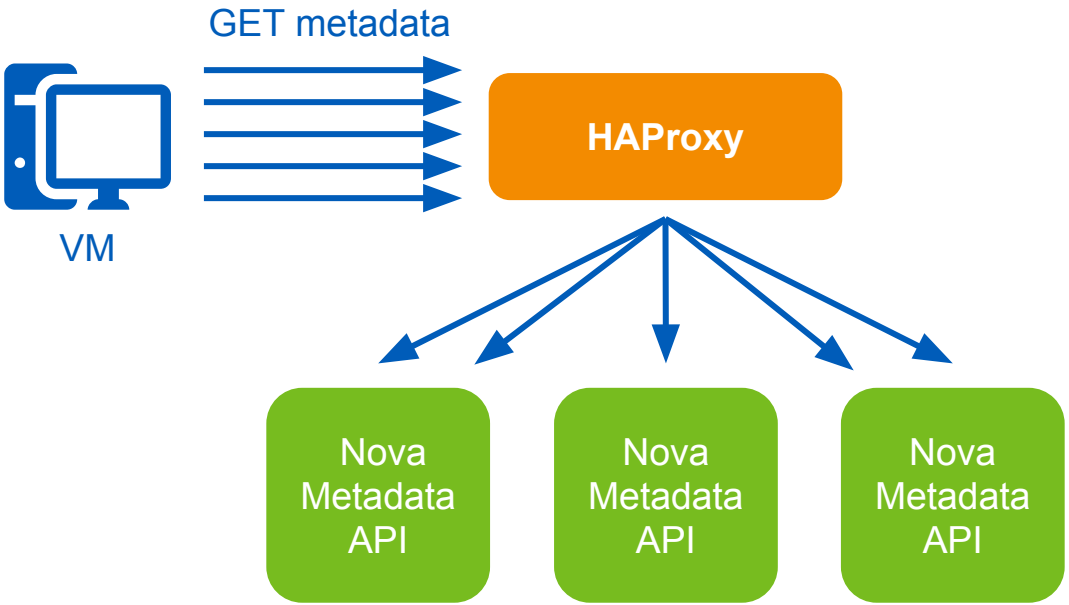
Baseline test



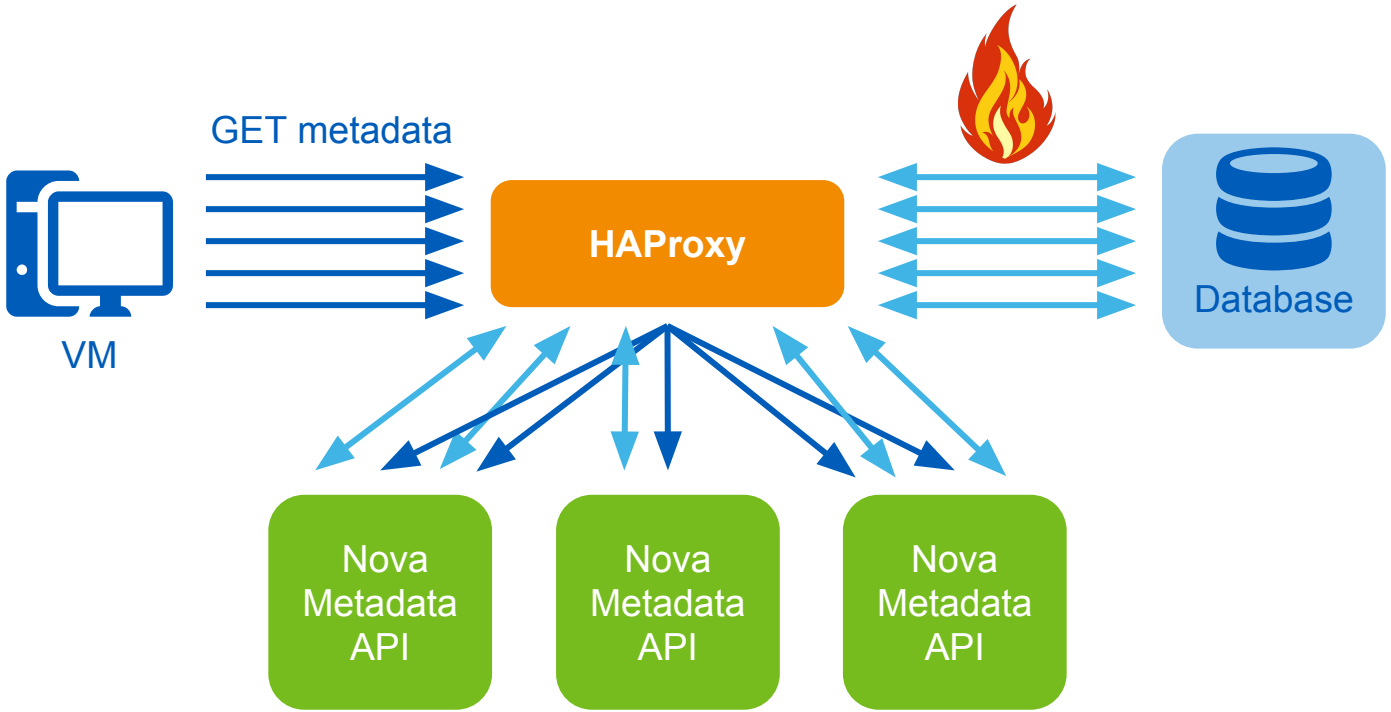
No metadata pre-load



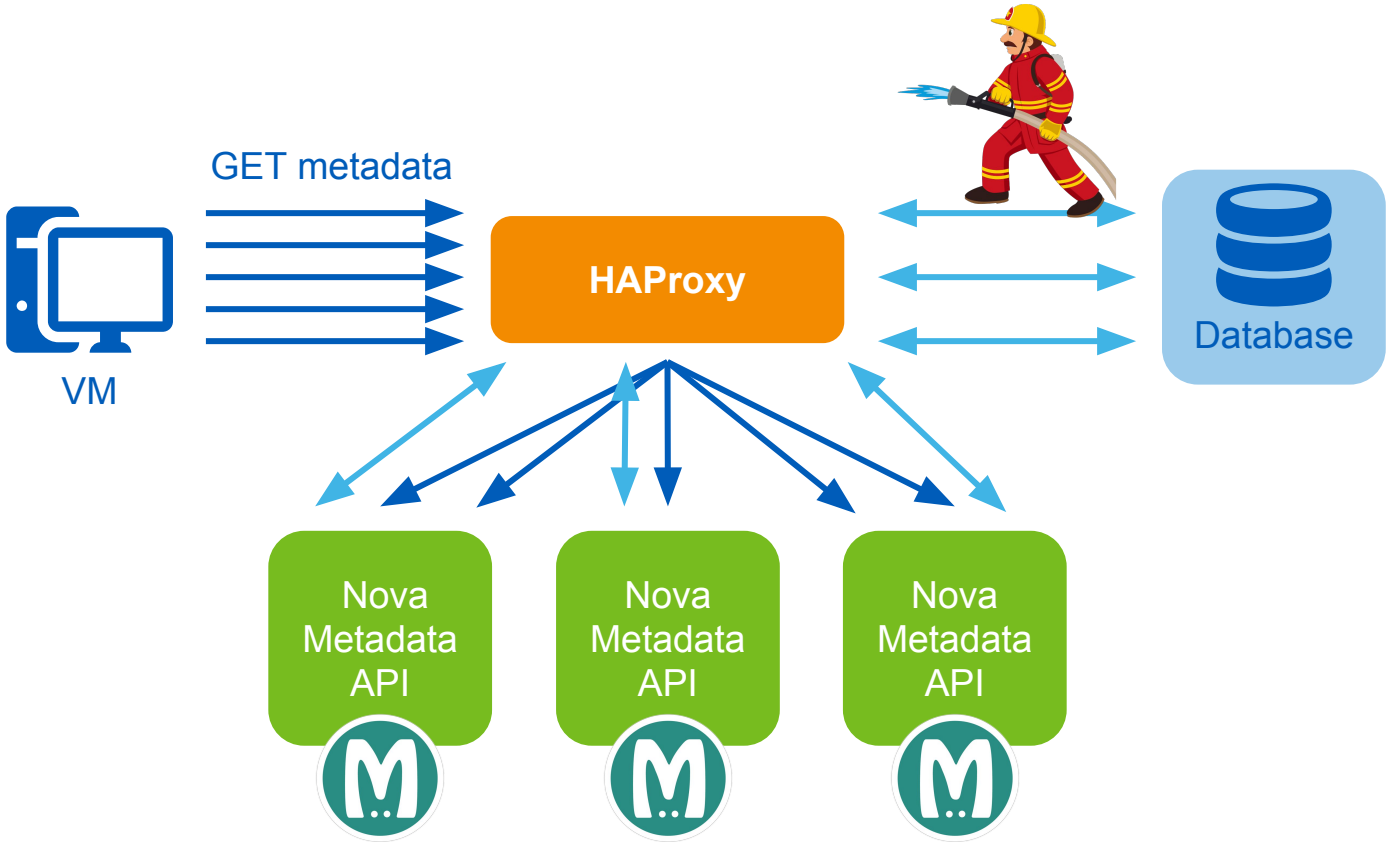
Can We Do Better?



Can We Do Better?

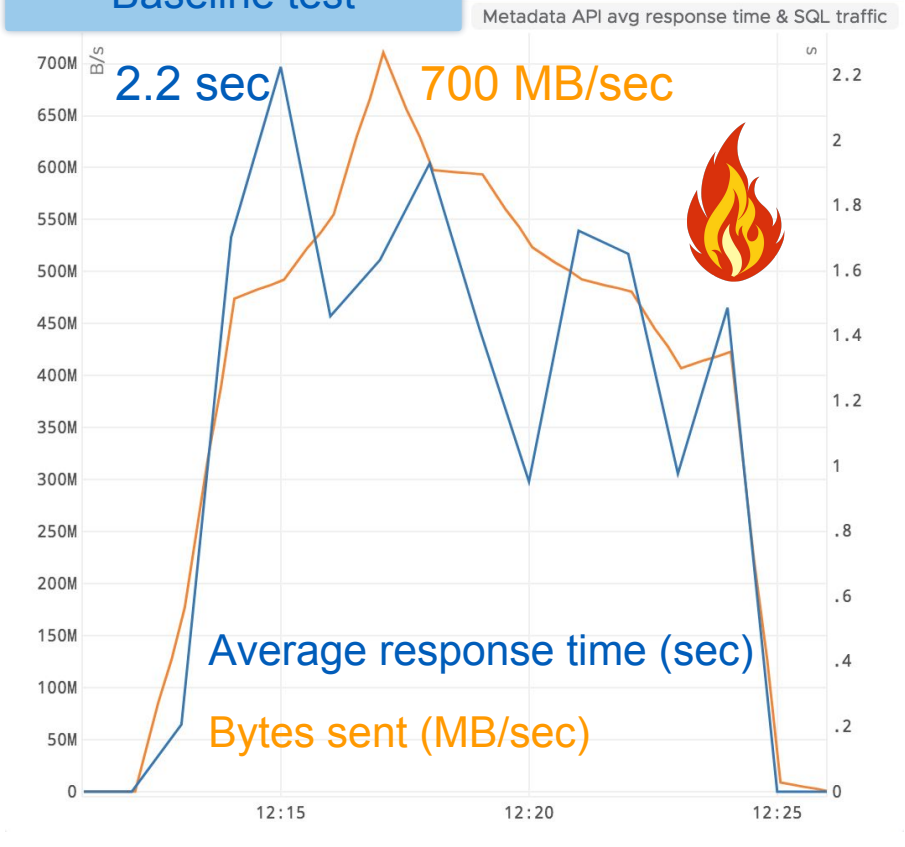


Memcached!

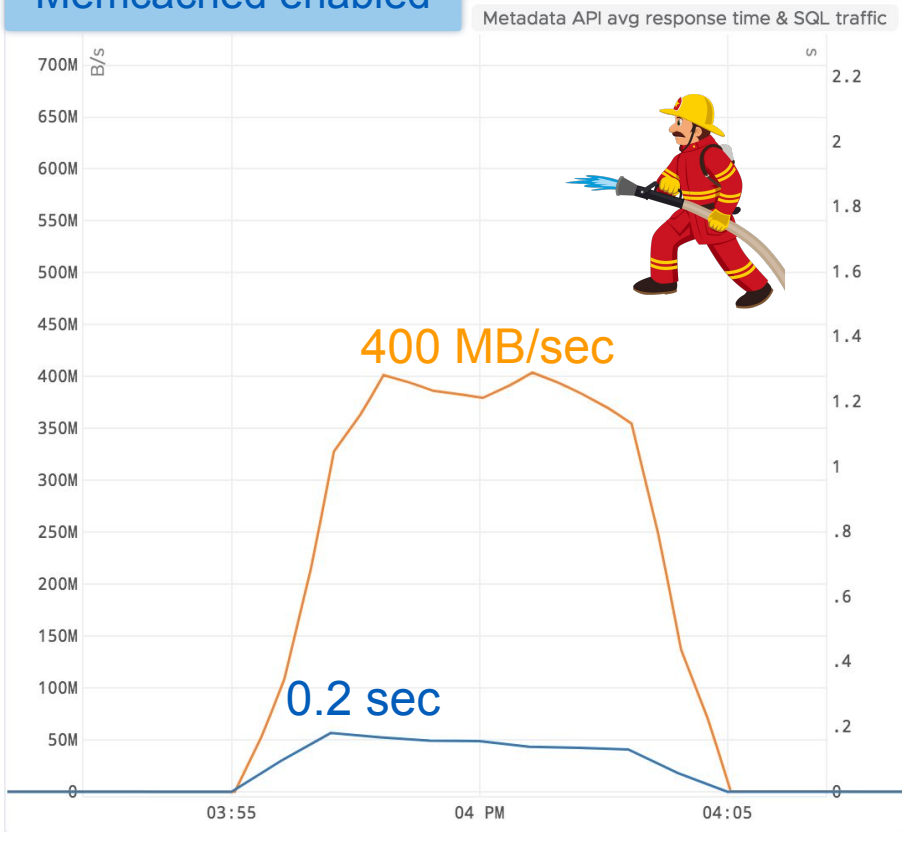

GET metadata
VM
HAProxy
Database
Nova Metadata API
Nova Metadata API
Nova Metadata API

Enabling Memcached

Baseline test

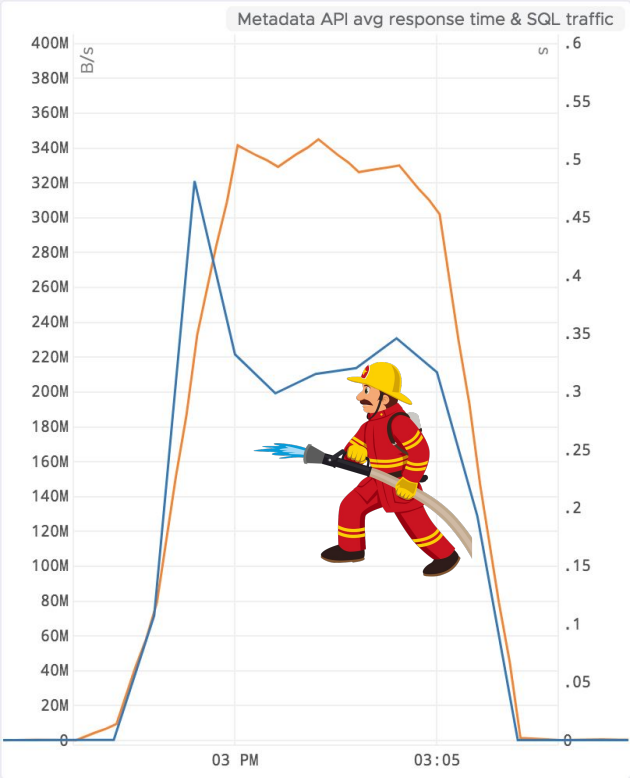


Memcached enabled

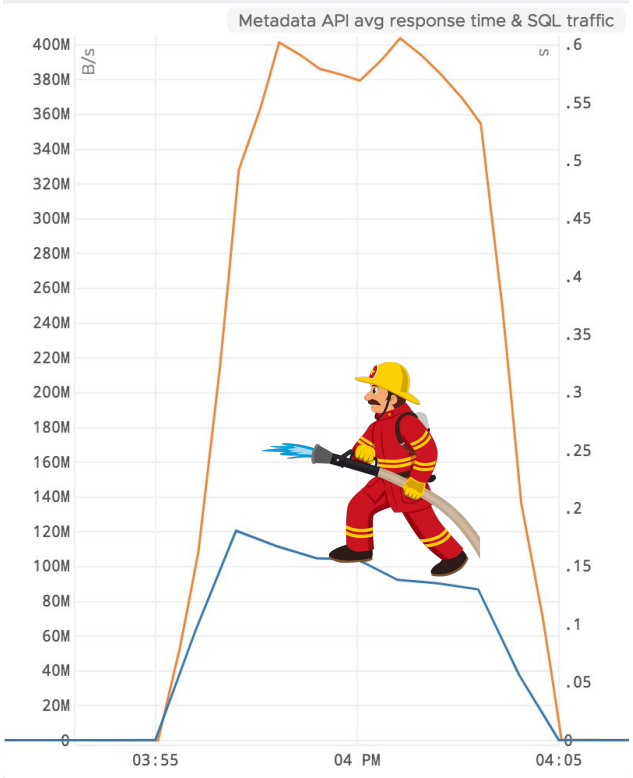


No Metadata pre-load + Memcached

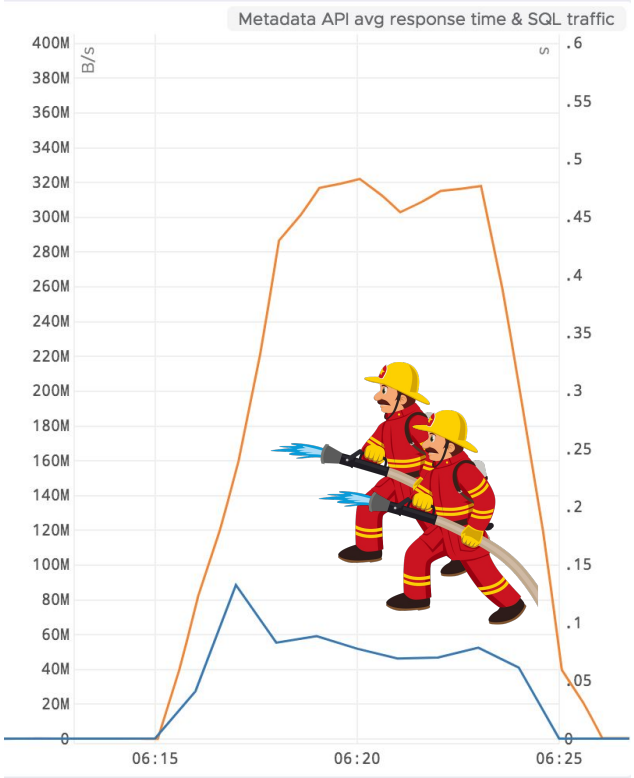
No metadata pre-load



Memcached enabled



Both



Root Causes

Heavy SQL query

Product of metadata tables

No Memcached

Repeated database fetching

HA architecture

Multiple API servers fetching data through load balancers

Lots of metadata

Booting many VMs simultaneously with *lots* of metadata

Fixes

Reduced SQL load

Rolled back pre-load of metadata tables (2-line code change)

Memcached

Enabled Memcached (3-line config change)

HA architecture

SQLProxy?
Clustered Memcached?

Lots of metadata

Reduce (ab)use of metadata?

Questions?