
# Globally Distributed Cloud Native Applications at Netflix

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Cloud Native

Global Architecture

NetflixOSS Components

# Cloud Native

# We are Engineers

We solve hard problems

We build amazing and complex things

We fix things when they break

# We strive for perfection

Perfect code

Perfect hardware

Perfectly operated


# But perfection takes too long…

So we compromise

Time to market vs. Quality

Utopia remains out of reach

# Where time to market wins big

Making a land-grab

Disrupting competitors (OODA)

Anything delivered as web services

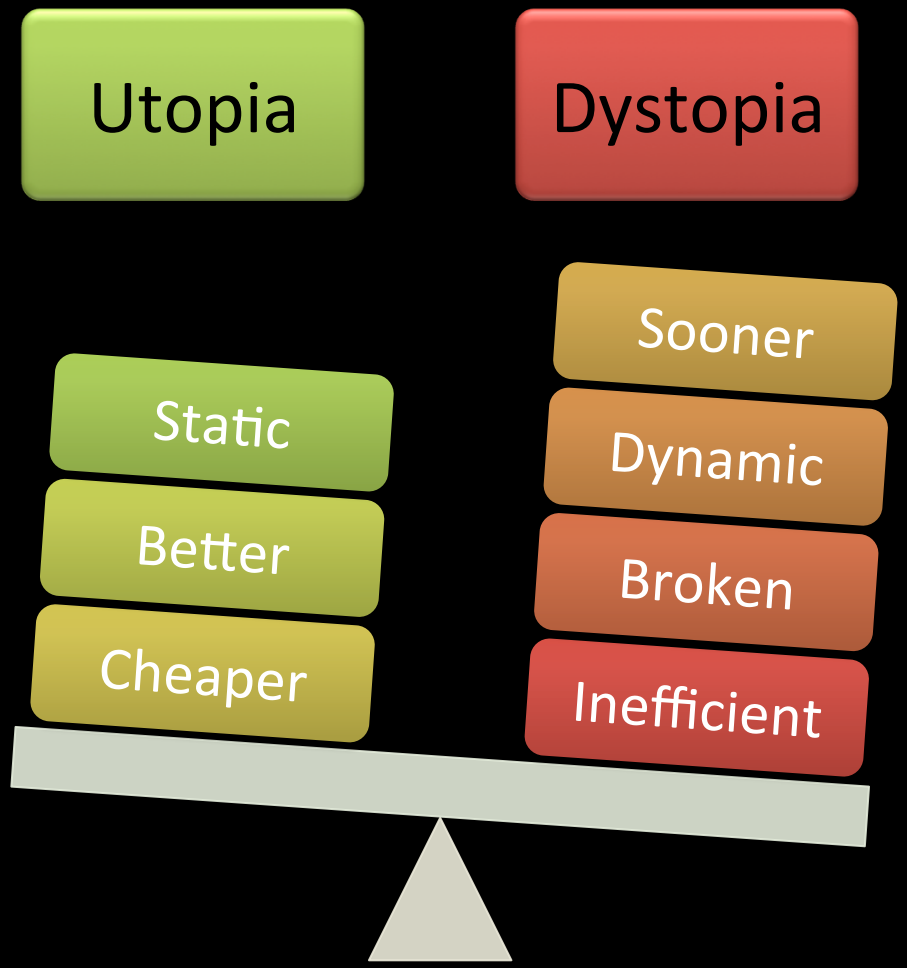
# How Soon?

Code features in days instead of months

Get hardware in minutes instead of weeks

Incident response in seconds instead of hours

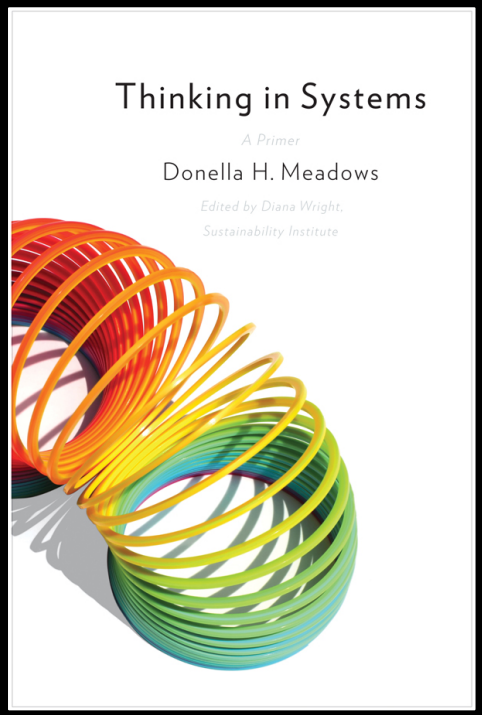
# Tipping the Balance

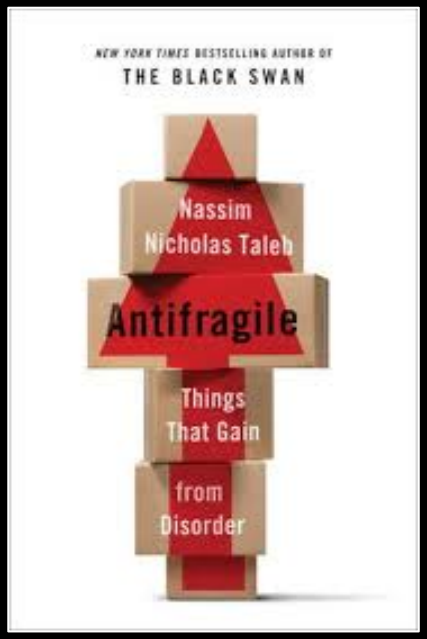


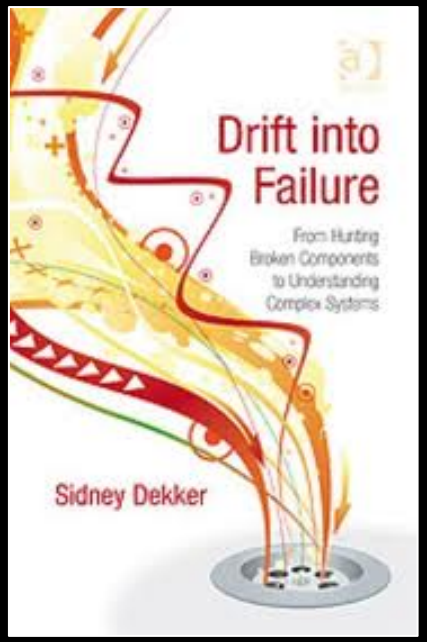
# A new engineering challenge

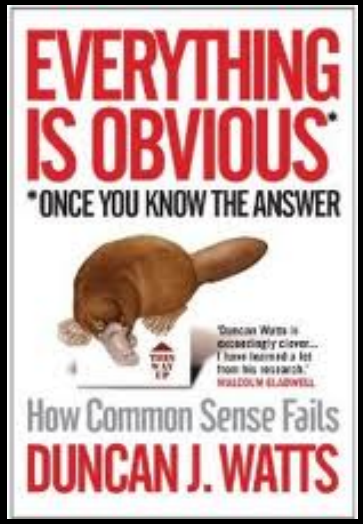
Construct a highly agile and highly available service from ephemeral and often broken components

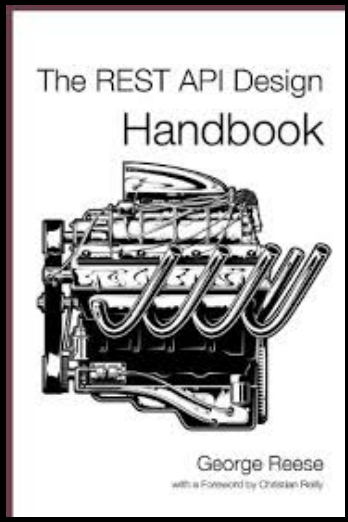
# Inspiration

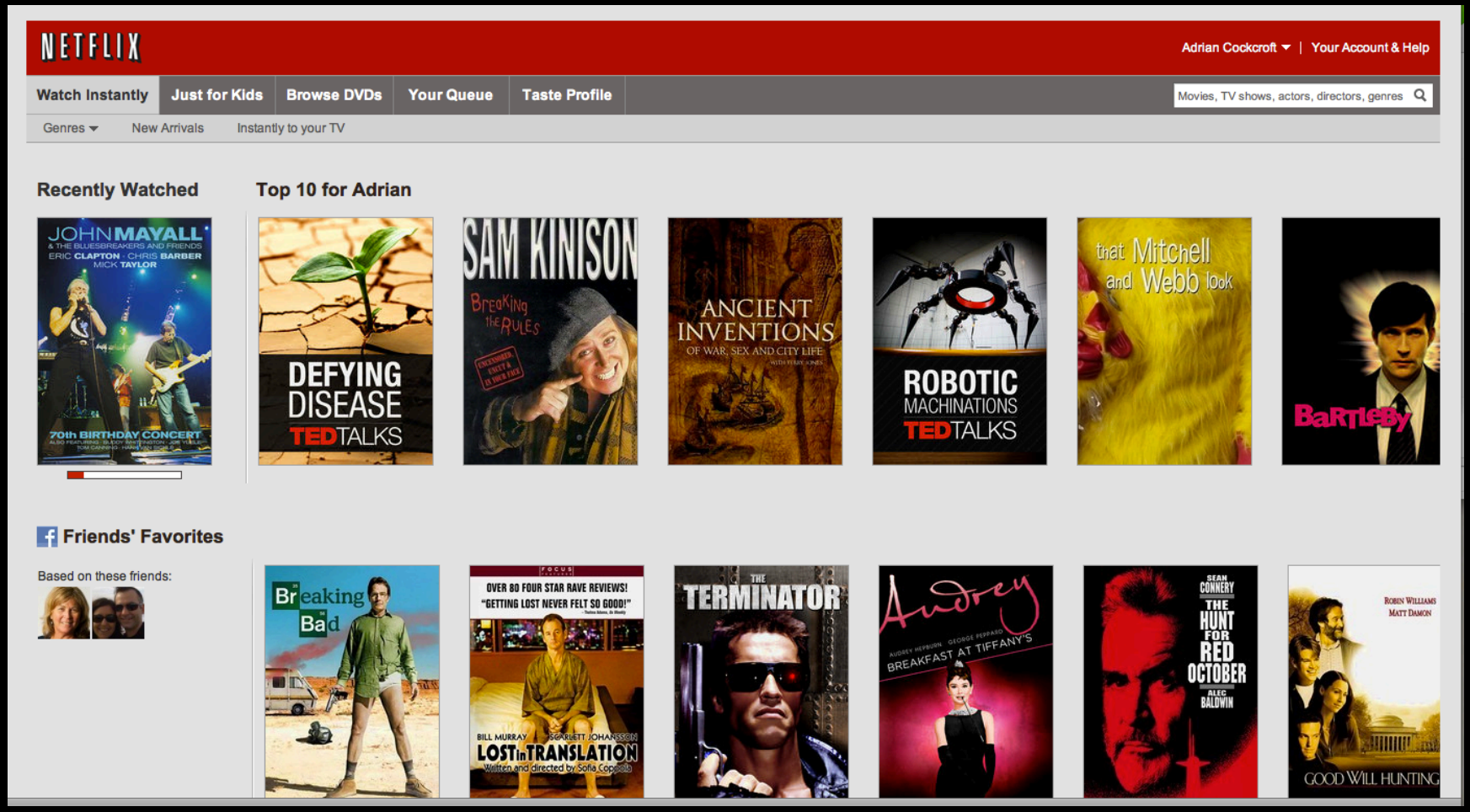



# Netflix Streaming

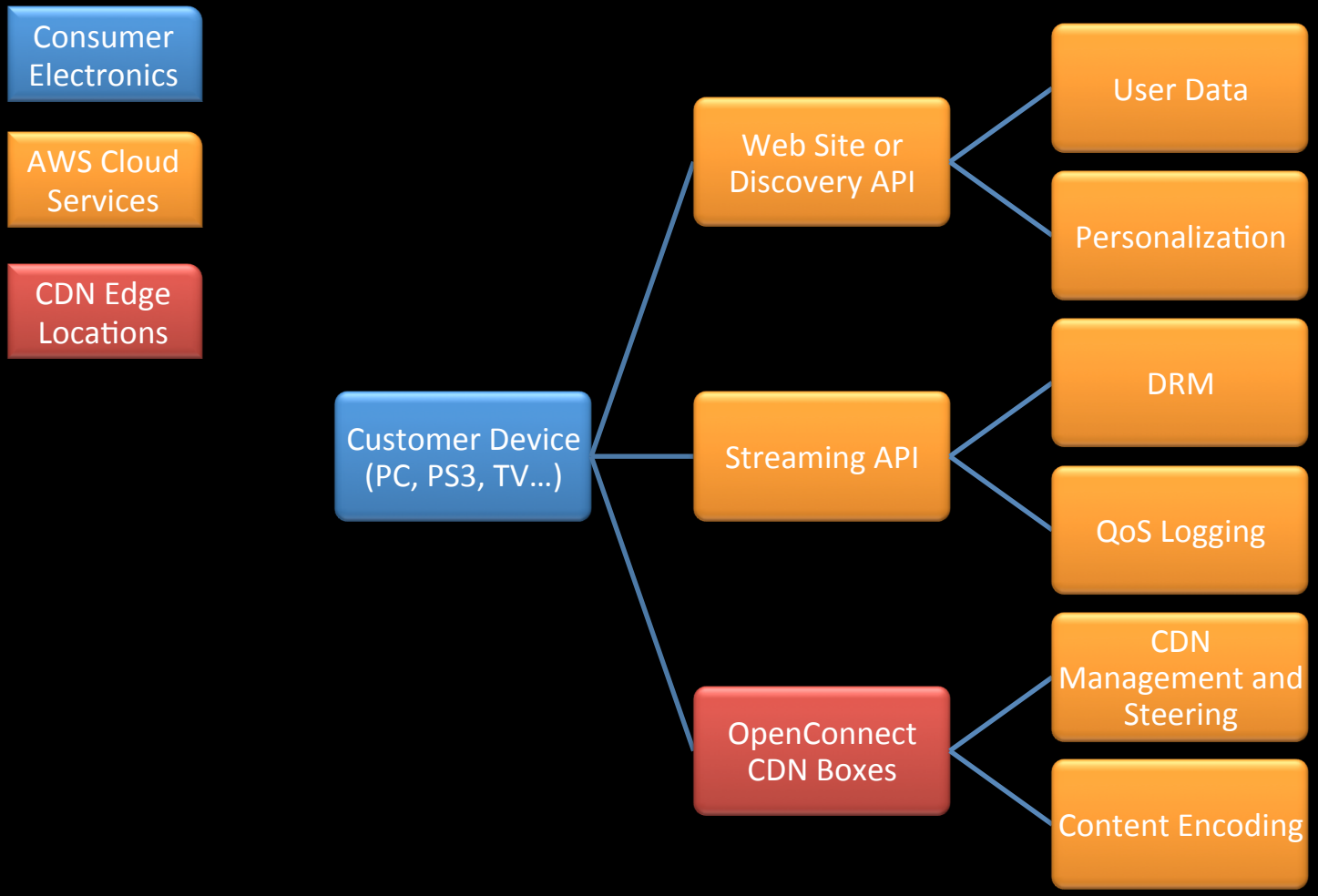
A Cloud Native Application based on
an open source platform

# Netflix Member Web Site Home Page

## Personalization Driven – How Does It Work?



# How Netflix Streaming Works



Nov 2012 Streaming Bandwidth

18x Prime

| | Upstream | | Downstream | | Aggregate | |
|---|---|---|---|---|---|---|
| Rank | Application | Share | Application | Share | Application | Share |
| 1 | BitTorrent | 36.8% | Netflix | 33.0% | Netflix | 28.8% |
| 2 | HTTP | 9.83% | YouTube | 14.8% | YouTube | 13.1% |
| 3 | Skype | 4.76% | HTTP | 12.0% | HTTP | 11.7% |
| 4 | Netflix | 4.51% | BitTorrent | 5.89% | BitTorrent | 10.3% |
| 5 | SSL | 3.73% | iTunes | 3.92% | iTunes | 3.43% |
| 6 | YouTube | 2.70% | MPEG | 2.22% | SSL | 2.23% |
| 7 | PPStream | 1.65% | Flash Video | 2.21% | MPEG | 2.05% |
| 8 | Facebook | 1.62% | SSL | 1.97% | Flash Video | 2.01% |
| 9 | Apple PhotoStream | 1.46% | Amazon Video | 1.75% | Facebook | 1.50% |
| 10 | Dropbox | 1.17% | Facebook | 1.48% | RTMP | 1.41% |
| | Top 10 | 68.24% | Top 10 | 79.01% | Top 10 | 76.54% |

sandvine

Table 3 - Top 10 Peak Period Applications (North America, Fixed Access)

March 2013

Mean Bandwidth +39% 6mo

25x Prime

| | Upstream | | Downstream | | Aggregate | |
|---|---|---|---|---|---|---|
| Rank | Application | Share | Application | Share | Application | Share |
| 1 | BitTorrent | 34.81% | Netflix | 32.25% | Netflix | 28.88% |
| 2 | HTTP | | YouTube | 17.11% | YouTube | 15.43% |
| 3 | SSL | | HTTP | 11.11% | HTTP | 10.66% |
| 4 | Netflix | | BitTorrent | 5.57% | BitTorrent | 9.23% |
| 5 | Skype | | MPEG | 2.58% | SSL | 2.39% |
| 6 | YouTube | | Hulu | 2.41% | MPEG | 2.30% |
| 7 | Faceboo | | iTunes | 1.90% | Hulu | 2.16% |
| 8 | Apple Pl | | SSL | 1.89% | iTunes | 1.71% |
| 9 | Dropbox | | Flash Video | 1.72% | Flash Video | 1.53% |
| 10 | Carboni | | Facebook | 1.48% | Facebook | 1.52% |
| Top 10 | | 67.38% | | 78.03% | | 75.82% |

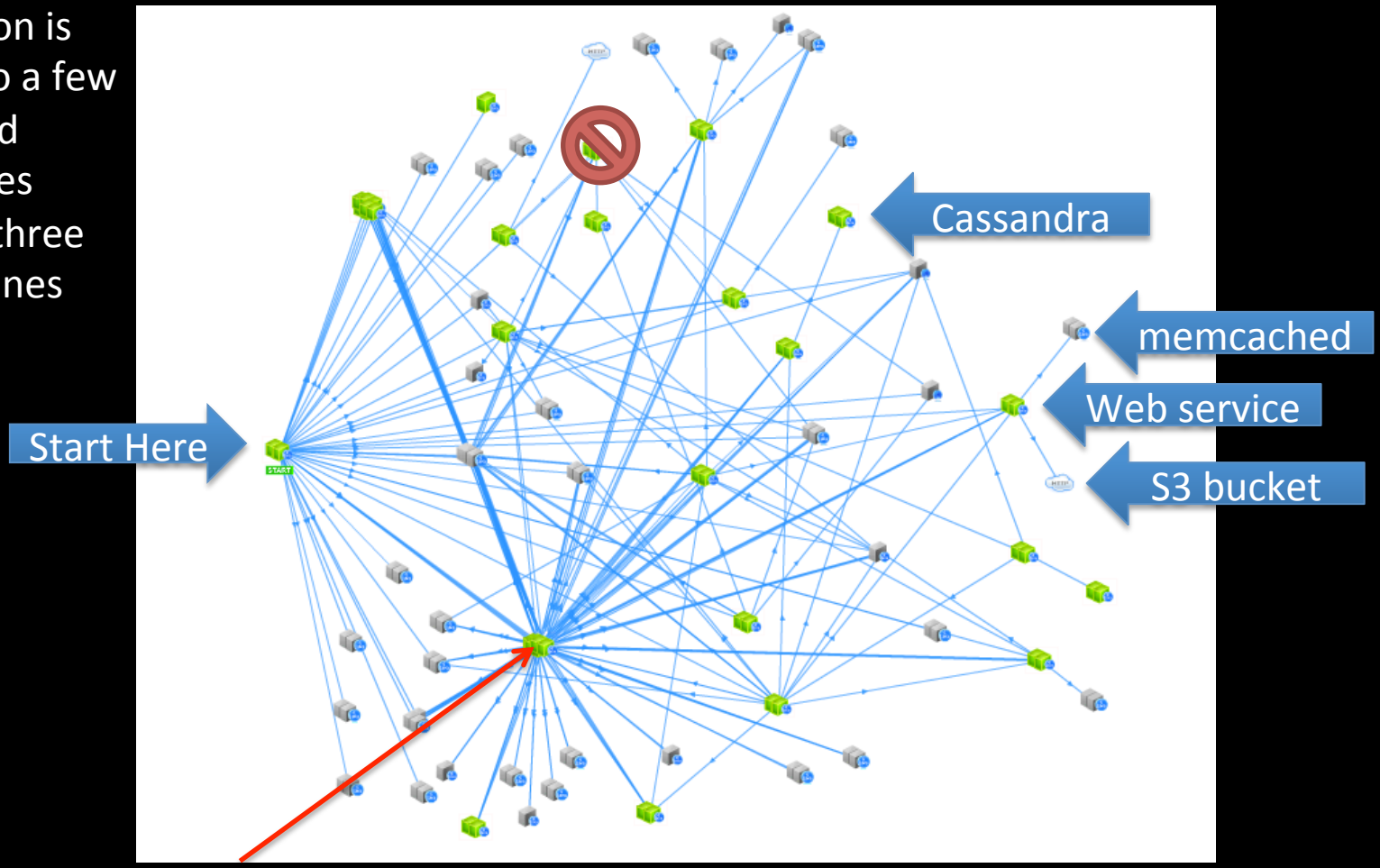

Amazon Video 1.31%

sandvine

# Real Web Server Dependencies Flow

(Netflix Home page business transaction as seen by AppDynamics)

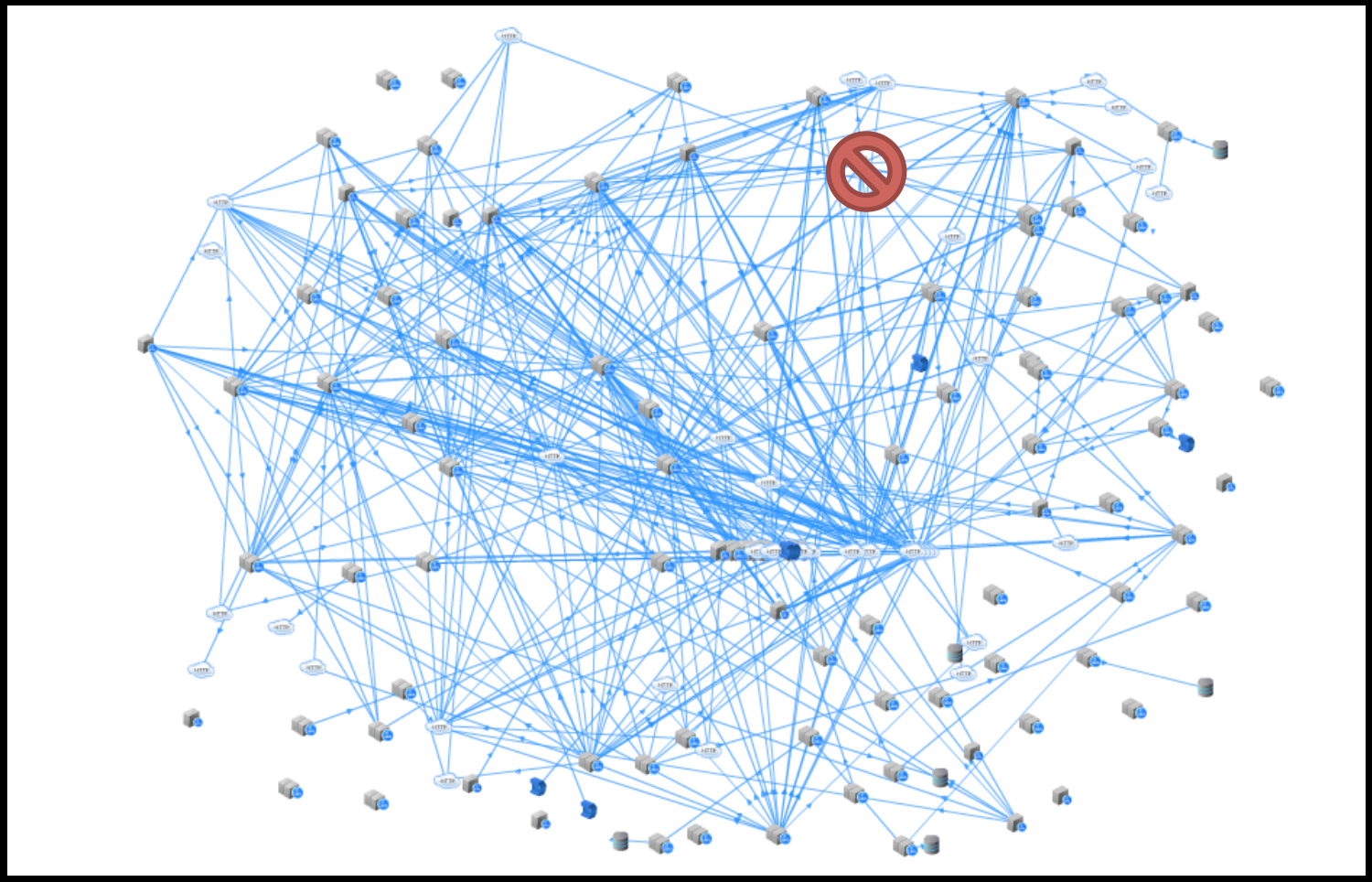
Each icon is three to a few hundred instances across three AWS zones




Personalization movie group choosers
(for US, Canada and Latam)

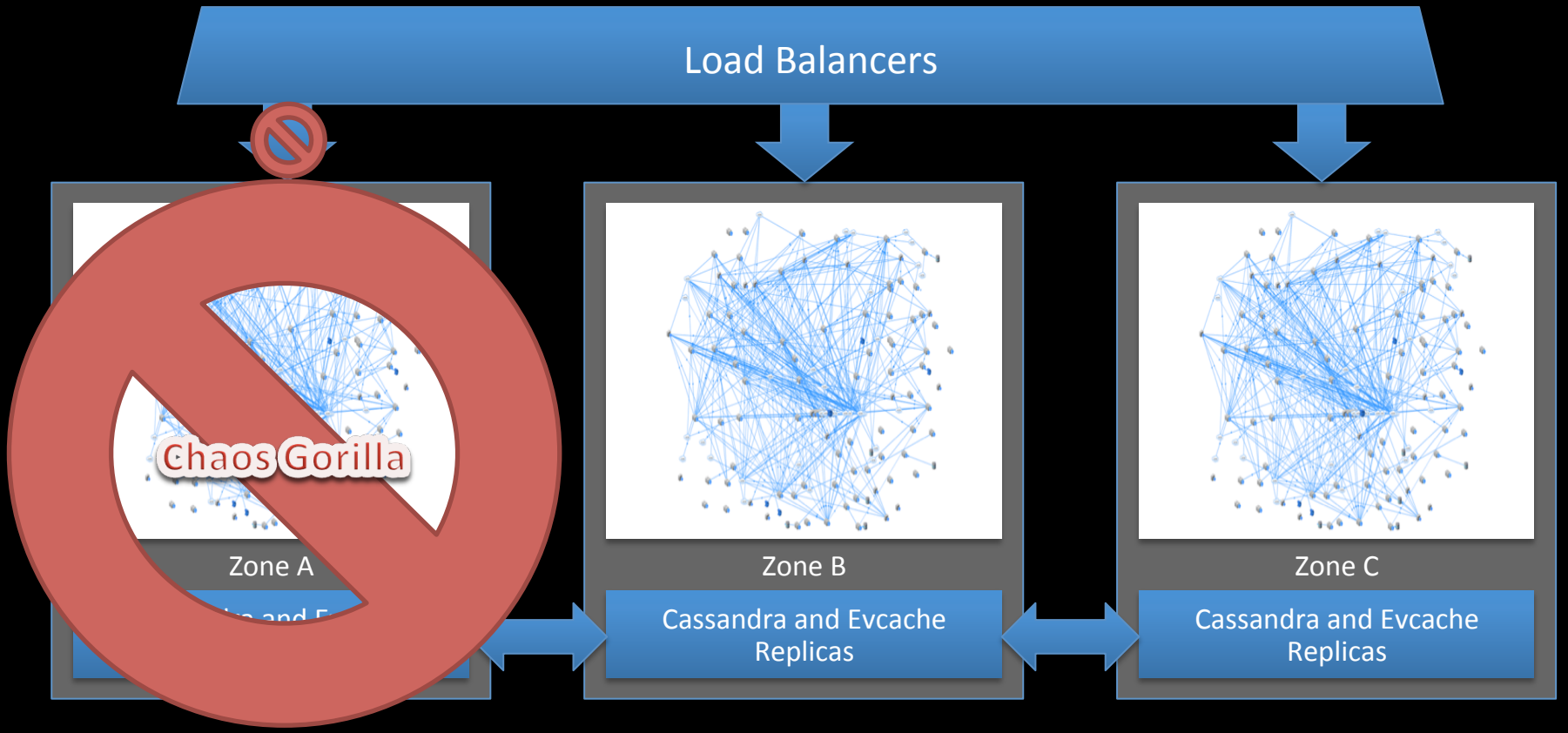
# Component Micro-Services

Test With Chaos Monkey, Latency Monkey



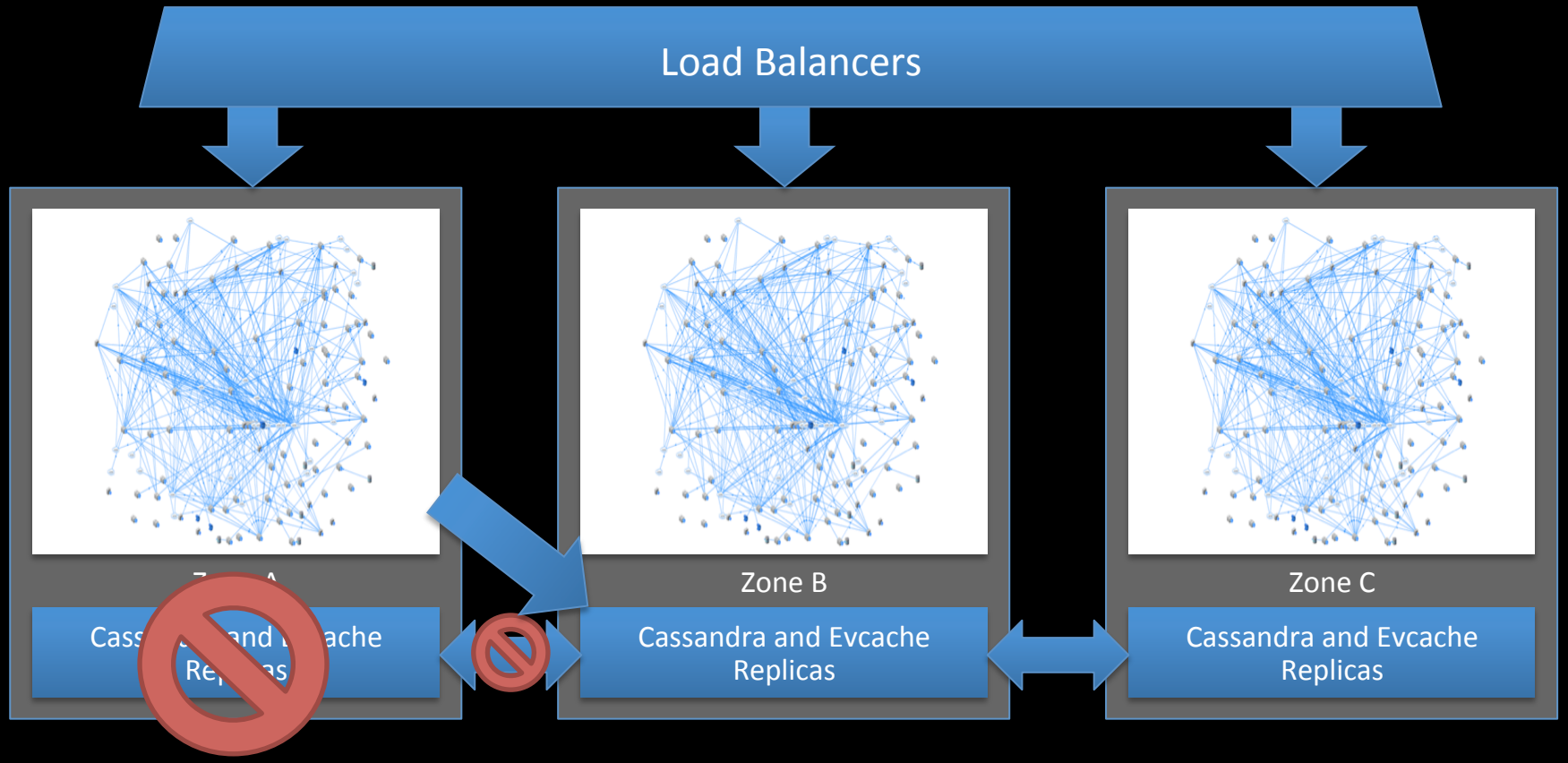
# Three Balanced Availability Zones

Test with Chaos Gorilla

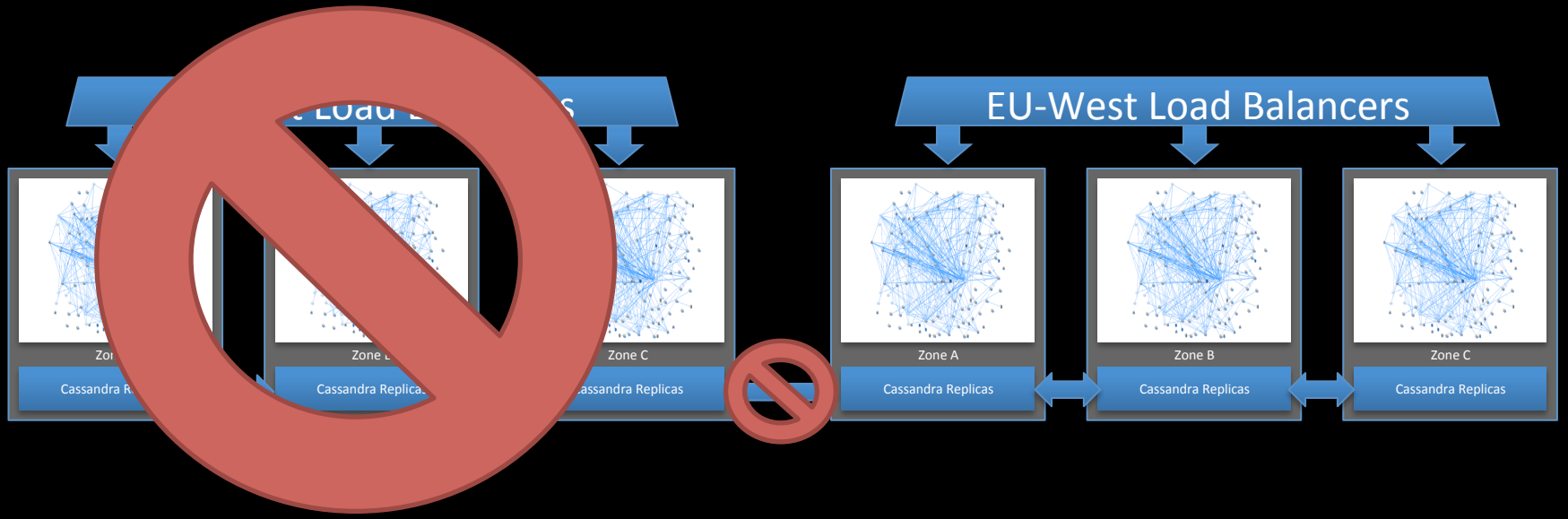


# Triple Replicated Persistence

## Cassandra maintenance affects individual replicas



# Isolated Regions



# Failure Modes and Effects

| Failure Mode | Probability | Current Mitigation Plan |
|---|---|---|
| Application Failure | High | Automatic degraded response |
| AWS Region Failure | Low | Switch traffic between regions |
| AWS Zone Failure | Medium | Continue to run on 2 out of 3 zones |
| Datacenter Failure | Medium | Migrate more functions to cloud |
| Data store failure | Low | Restore from S3 backups |
| S3 failure | Low | Restore from remote archive |

Until we got really good at mitigating high and medium probability failures, the ROI for mitigating regional failures didn't make sense. Working on it now.

# Antifragile Testing

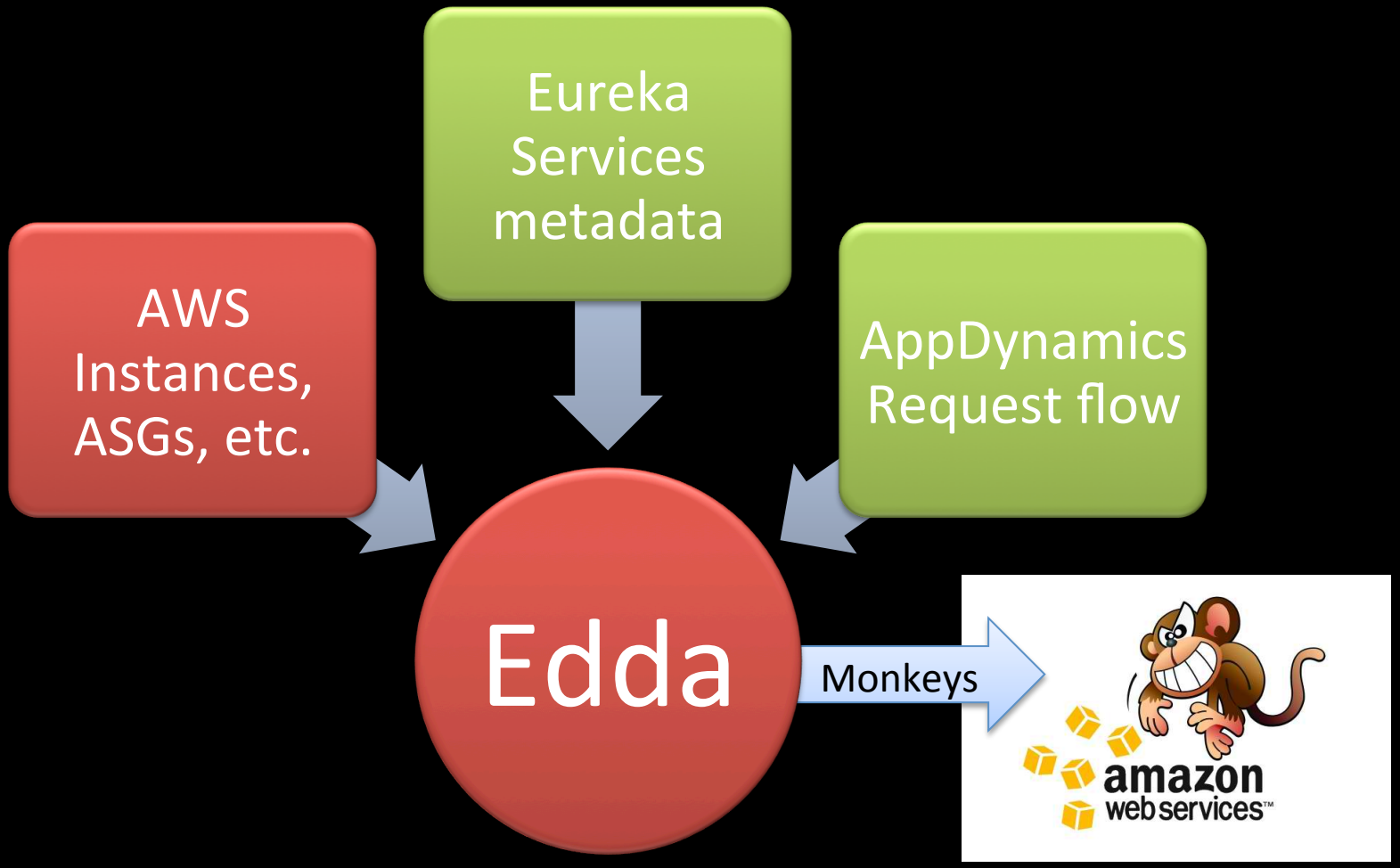
http://techblog.netflix.com/2012/07/chaos-monkey-released-into-wild.html

- Chaos Monkey makes sure systems are resilient
  - Kill individual instances without customer impact
- Chaos Gorilla shuts down entire zone
  - Run in production once every 3 months


- Latency Monkey
  - Injects extra latency and error return codes

# Edda – Configuration History

http://techblog.netflix.com/2012/11/edda-learn-stories-of-your-cloud.html



# Edda Query Examples

Find any instances that have ever had a specific public IP address

```
$ curl "http://edda/api/v2/view/instances;publicIpAddress=1.2.3.4;_since=0"
 ["i-0123456789","i-012345678a","i-012345678b”]
```

Show the most recent change to a security group

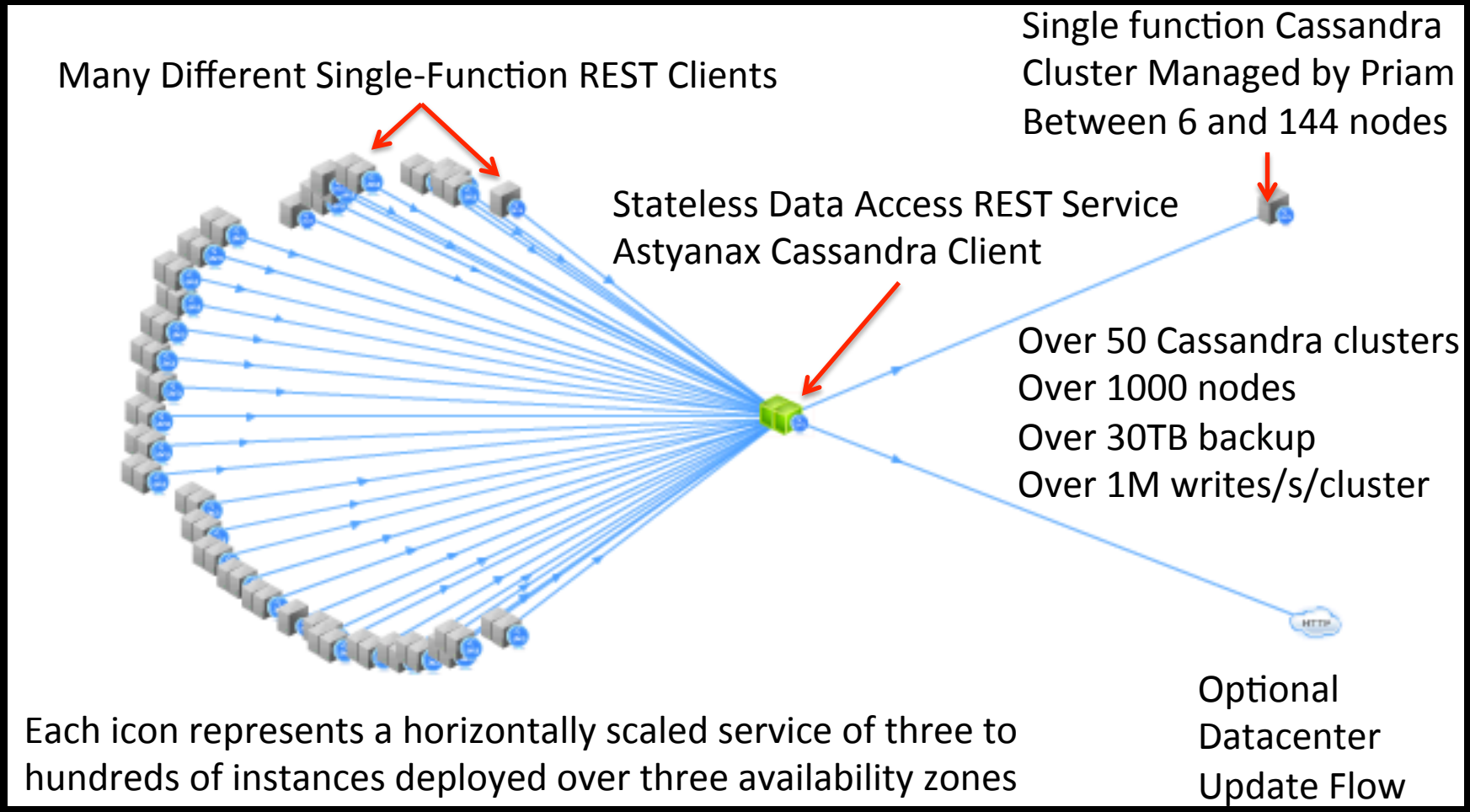
```
$ curl "http://edda/api/v2/aws/securityGroups/sg-0123456789;_diff;_all;_limit=2"
--- /api/v2/aws.securityGroups/sg-0123456789;_pp;_at=1351040779810
+++ /api/v2/aws.securityGroups/sg-0123456789;_pp;_at=1351044093504
@@ -1,33 +1,33 @@
 {
…
       "ipRanges" : [
         "10.10.1.1/32",
         "10.10.1.2/32",
+        "10.10.1.3/32",
-        "10.10.1.4/32"
…
 }
```

# Highly Available Storage

A highly scalable, available and durable deployment pattern based on Apache Cassandra

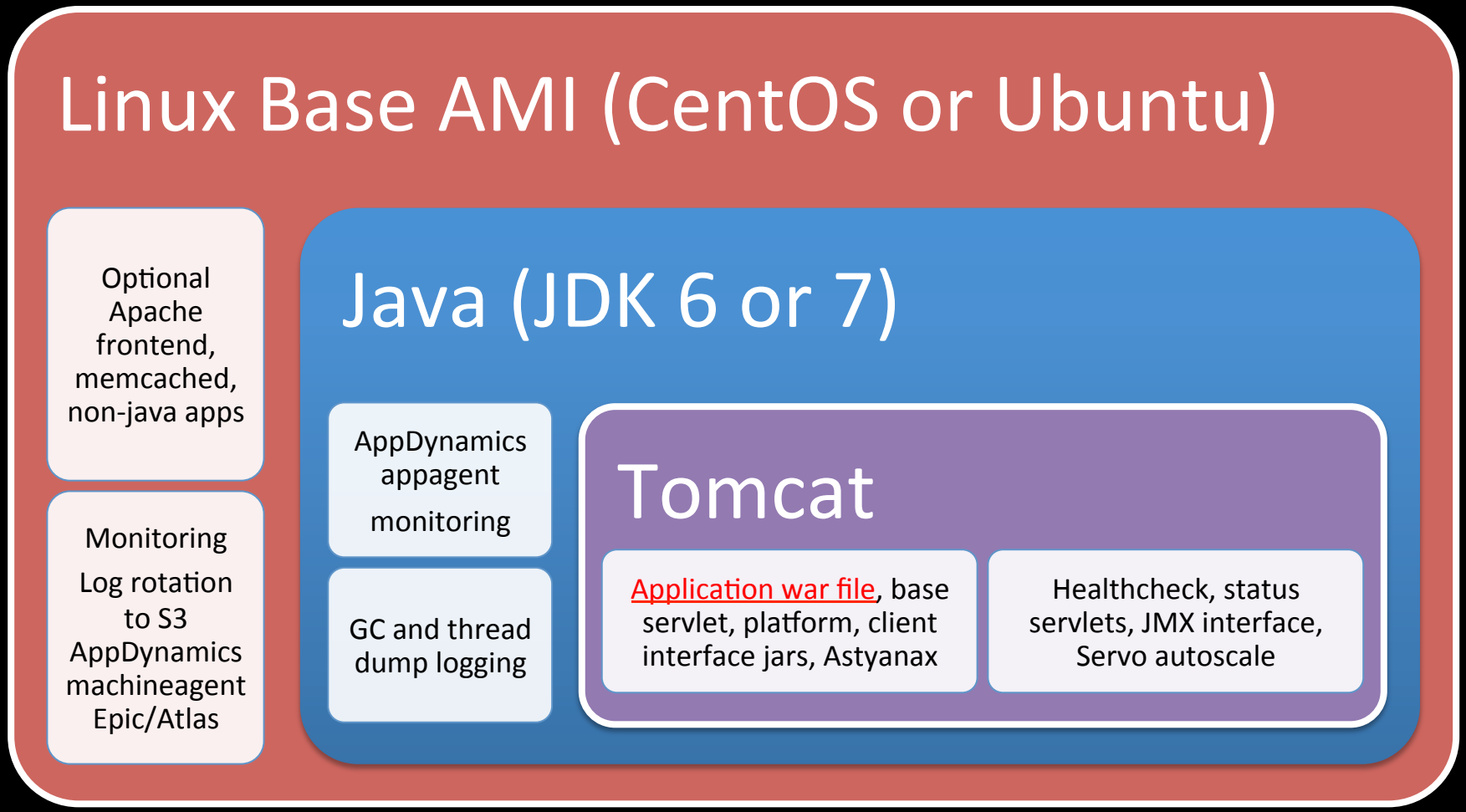
# Single Function Micro-Service Pattern

## One keyspace, replaces a single table or materialized view

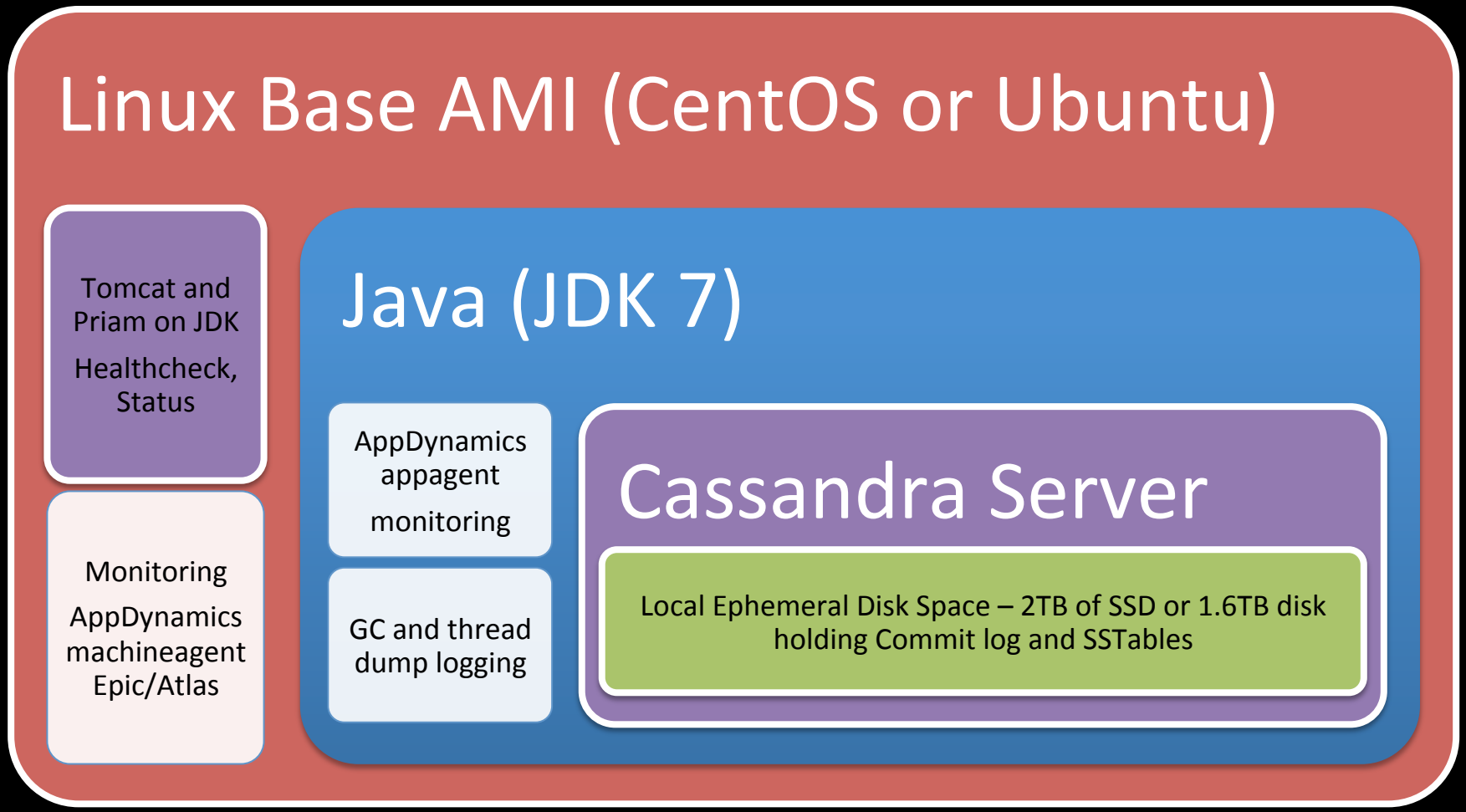



Appdynamics Service Flow Visualization

# Stateless Micro-Service Architecture



# Cassandra Instance Architecture



# Priam – Cassandra Automation

Available at http://github.com/netflix

- Netflix Platform Tomcat Code
- Zero touch auto-configuration
- State management for Cassandra JVM
- Token allocation and assignment
- Broken node auto-replacement
- Full and incremental backup to S3
- Restore sequencing from S3
- Grow/Shrink Cassandra “ring”

# ETL for Cassandra

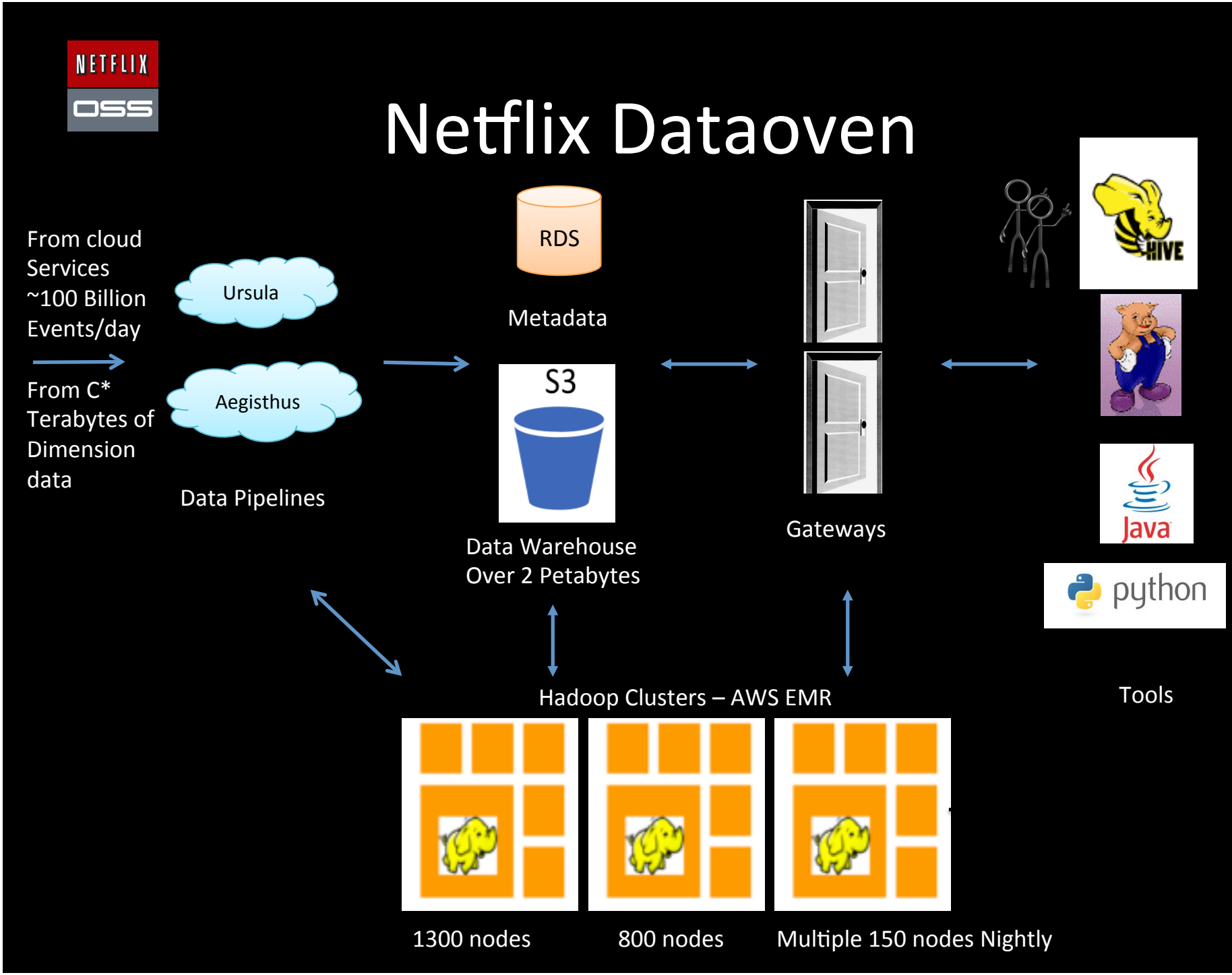
- Data is de-normalized over many clusters!
- Too many to restore from backups for ETL
- Solution – read backup files using Hadoop
- Aegisthus
  - http://techblog.netflix.com/2012/02/aegisthus-bulk-data-pipeline-out-of.html
  - High throughput raw SSTable processing
  - Re-normalizes many clusters to a consistent view
  - Extract, Transform, then Load into Teradata

# Cloud Native Big Data

Size the cluster to the data

Size the cluster to the questions

Never wait for space or answers


NETFLIX
OSS
Netflix Dataoven
From cloud Services ~100 Billion Events/day
From C* Terabytes of Dimension data
Ursula
Aegisthus
Data Pipelines
RDS
Metadata
S3
Data Warehouse Over 2 Petabytes
Gateways
HIVE
Java
python
Tools
Hadoop Clusters – AWS EMR
1300 nodes
800 nodes
Multiple 150 nodes Nightly

# Global Architecture

Local Client Traffic to Cassandra

Synchronous Replication Across Zones

Asynchronous Replication Across Regions

# Astyanax Cassandra Client for Java

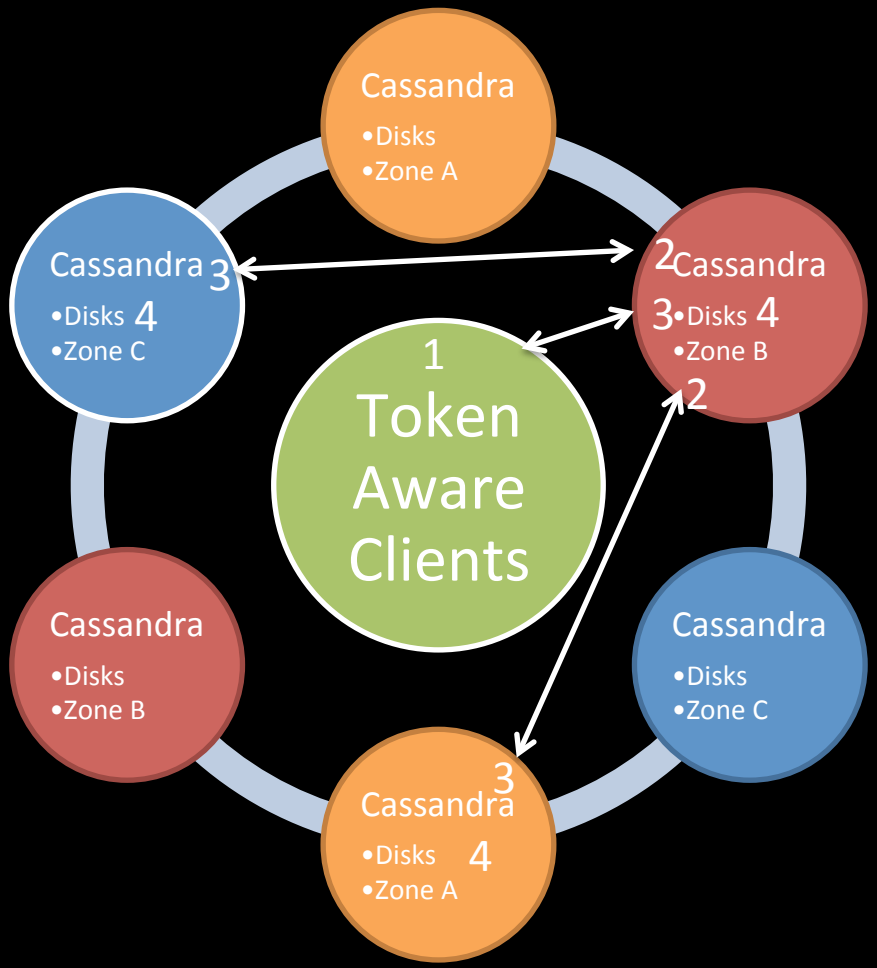
Available at http://github.com/netflix

- Features
  - Complete abstraction of connection pool from RPC protocol
  - Fluent Style API
  - Operation retry with backoff
  - Token aware
- Recipes
  - Distributed row lock (without zookeeper)
  - Multi-region row lock
  - Uniqueness constraint
  - Multi-row uniqueness constraint
  - Chunked and multi-threaded large file storage
  - Reverse index search
  - All rows query
  - Durable message queue

# Astyanax - Cassandra Write Data Flows

## Single Region, Multiple Availability Zone, Token Aware

1. Client Writes to local coordinator
2. Coodinator writes to other zones
3. Nodes return ack
4. Data written to internal commit log disks (no more than 10 seconds later)




If a node goes offline, hinted handoff completes the write when the node comes back up.

Requests can choose to wait for one node, a quorum, or all nodes to ack the write

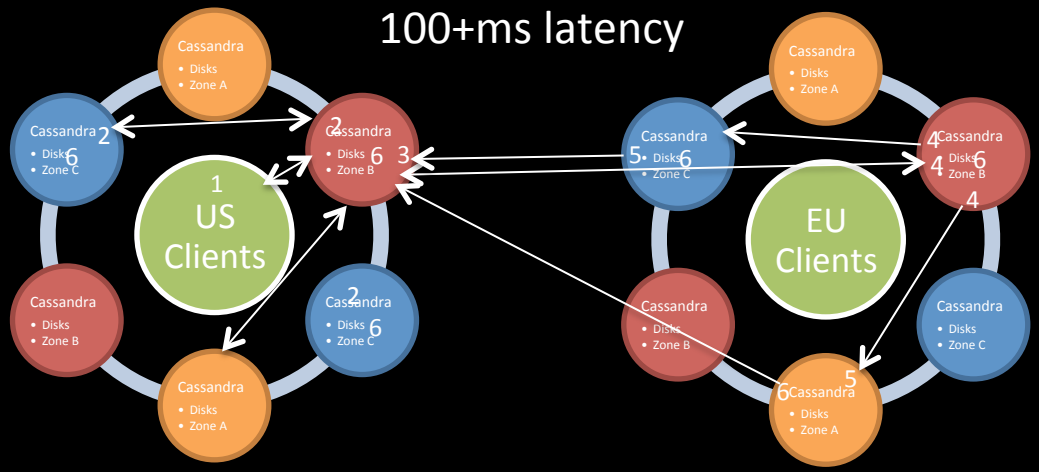
SSTable disk writes and compactions occur asynchronously

# Data Flows for Multi-Region Writes

## Token Aware, Consistency Level = Local Quorum

1. Client writes to local replicas
2. Local write acks returned to Client which continues when 2 of 3 local nodes are committed
3. Local coordinator writes to remote coordinator.
4. When data arrives, remote coordinator node acks and copies to other remote zones
5. Remote nodes ack to local coordinator
6. Data flushed to internal commit log disks (no more than 10 seconds later)

If a node or region goes offline, hinted handoff completes the write when the node comes back up. Nightly global compare and repair jobs ensure everything stays consistent.



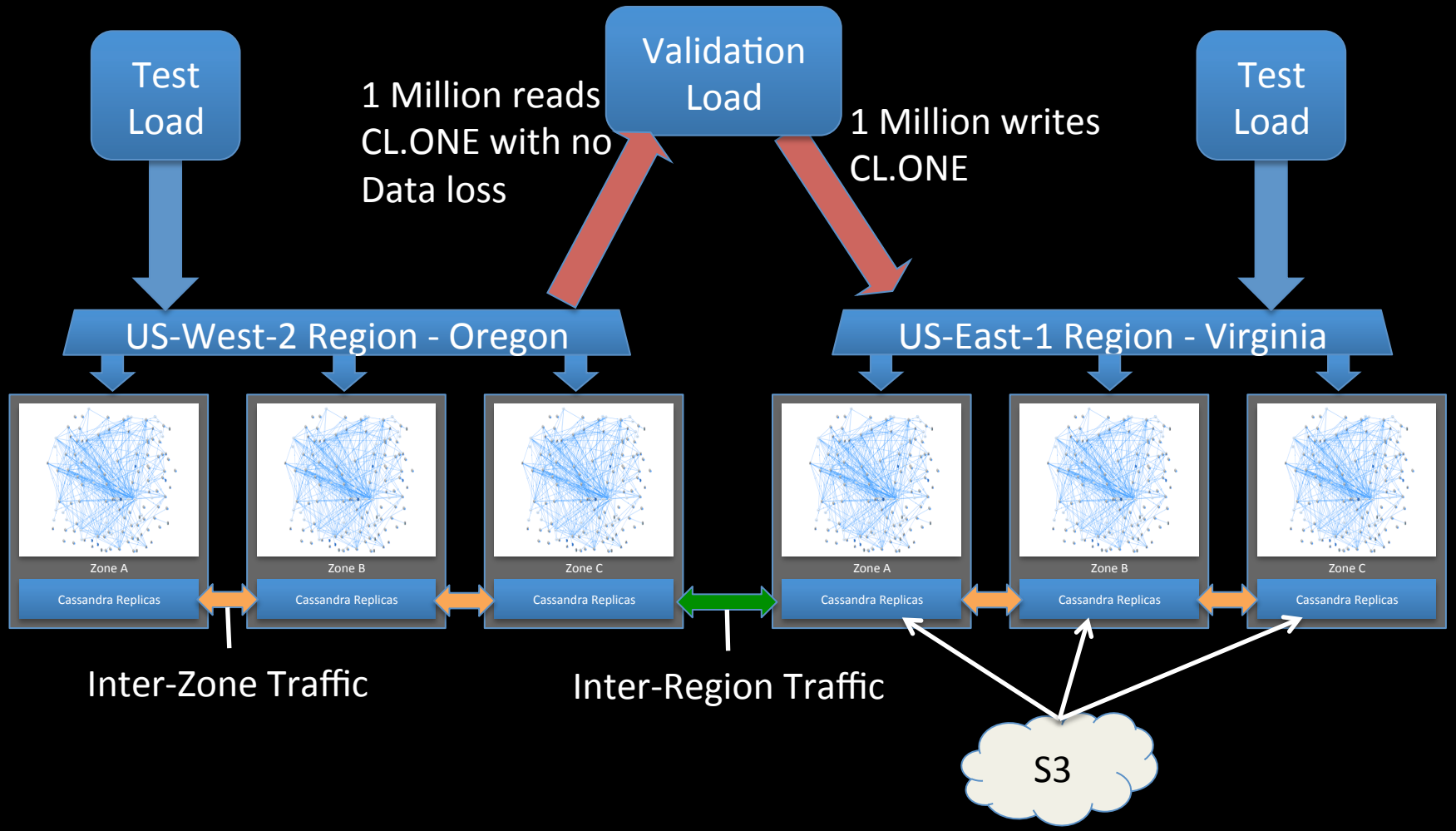
# Cross Region Use Cases

- Geographic Isolation
  - US to Europe replication of subscriber data
  - Read intensive, low update rate
  - Production use since late 2011
- Redundancy for regional failover
  - US East to US West replication of everything
  - Includes write intensive data, high update rate
  - Testing now

# Benchmarking Global Cassandra

## Write intensive test of cross region capacity

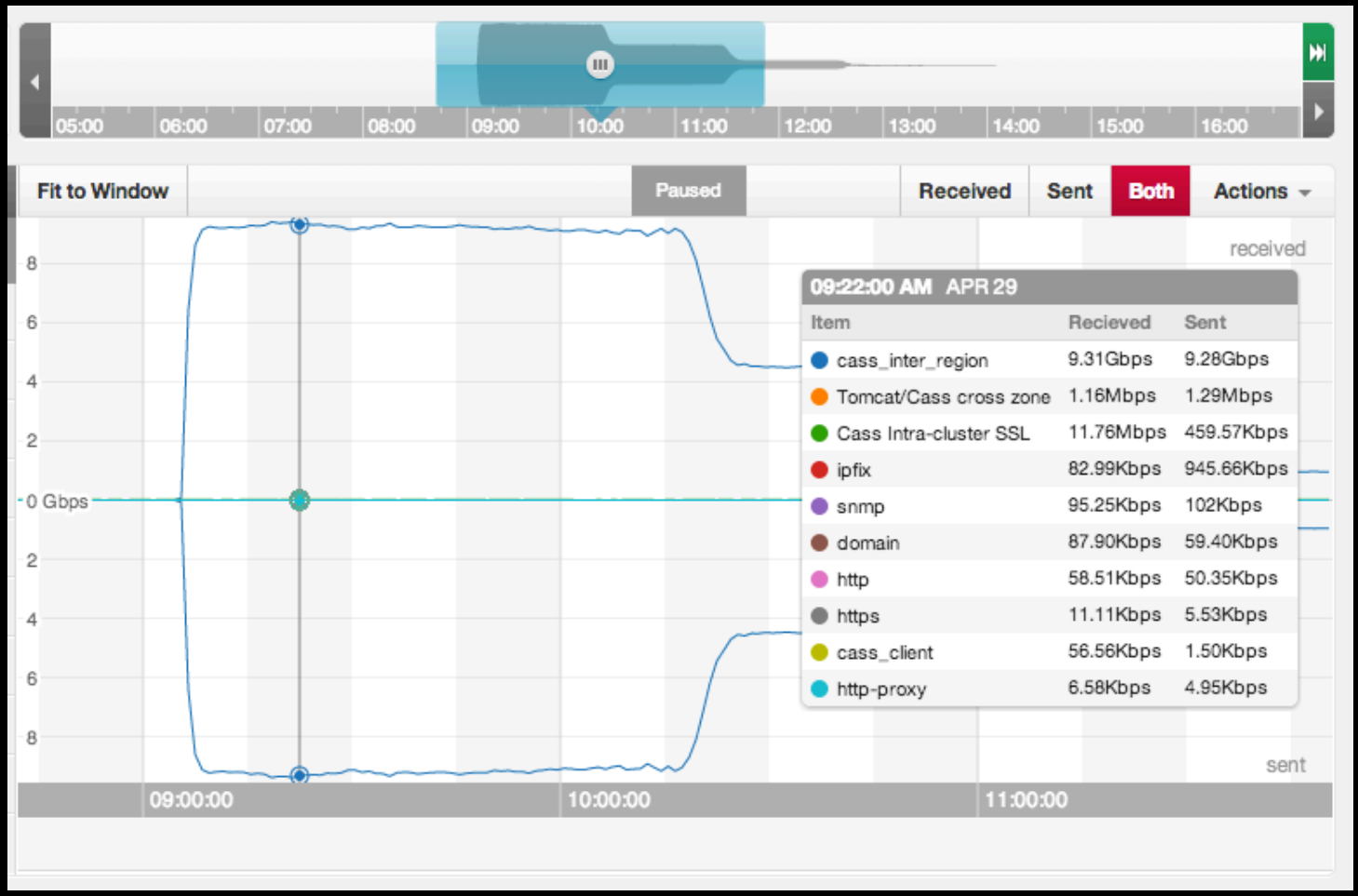
## 16 x hi1.4xlarge SSD nodes per zone = 96 total



# Copying 18TB from East to West

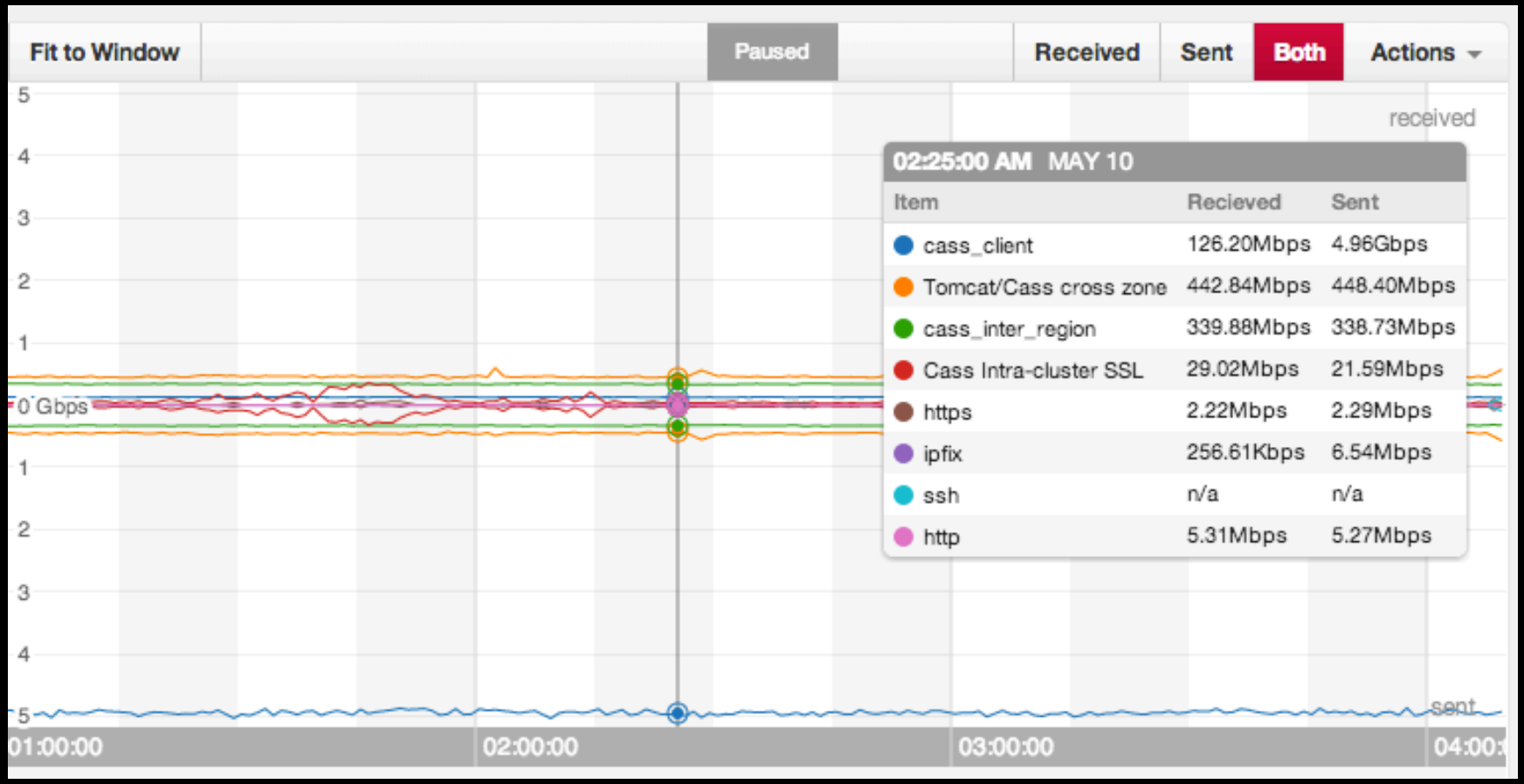
Cassandra bootstrap 9.3 Gbit/s single threaded 48 nodes to 48 nodes

Thanks to boundary.com for these network analysis plots



# Inter Region Traffic Test

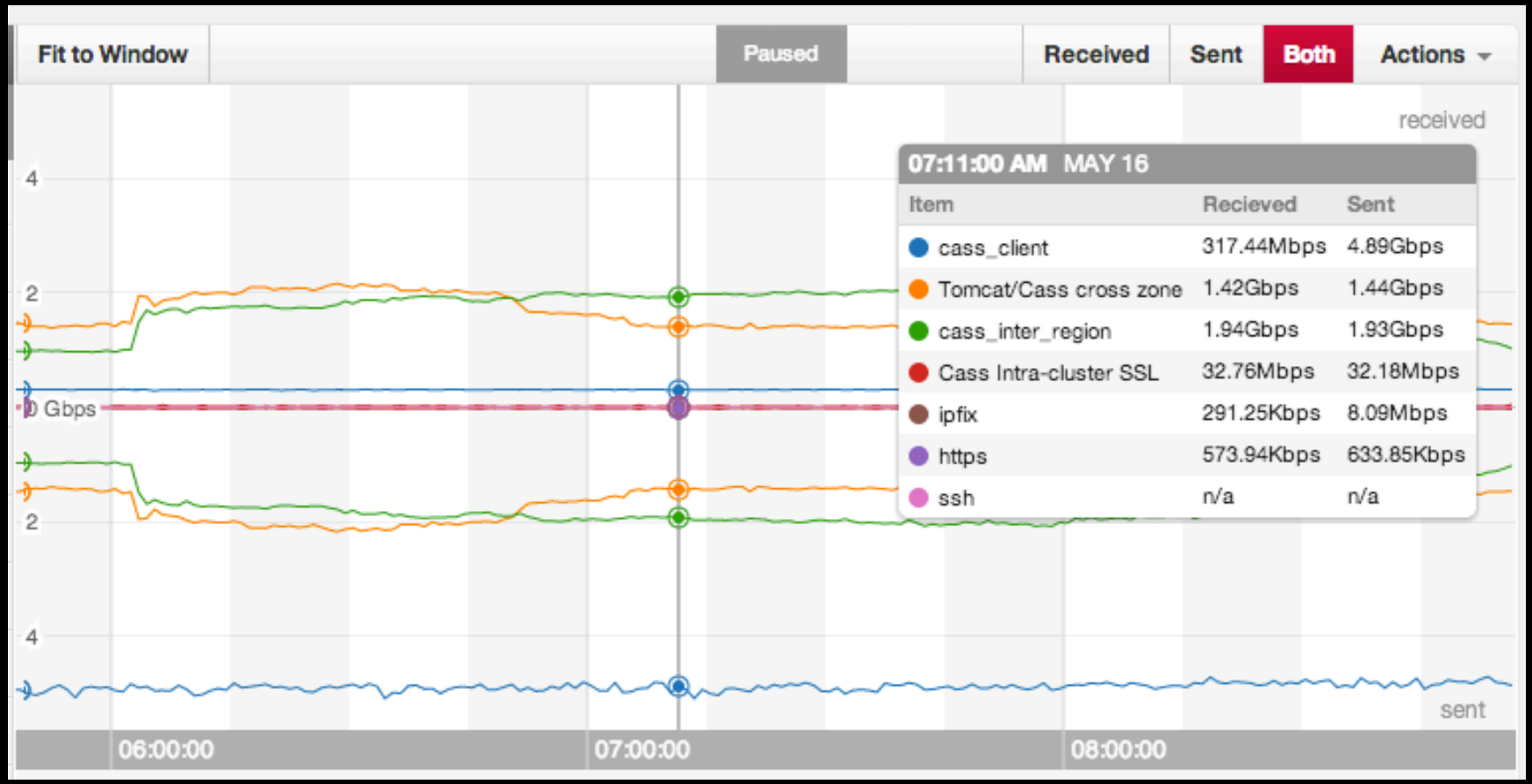
Verified at desired capacity, no problems, 339 MB/s, 83ms latency



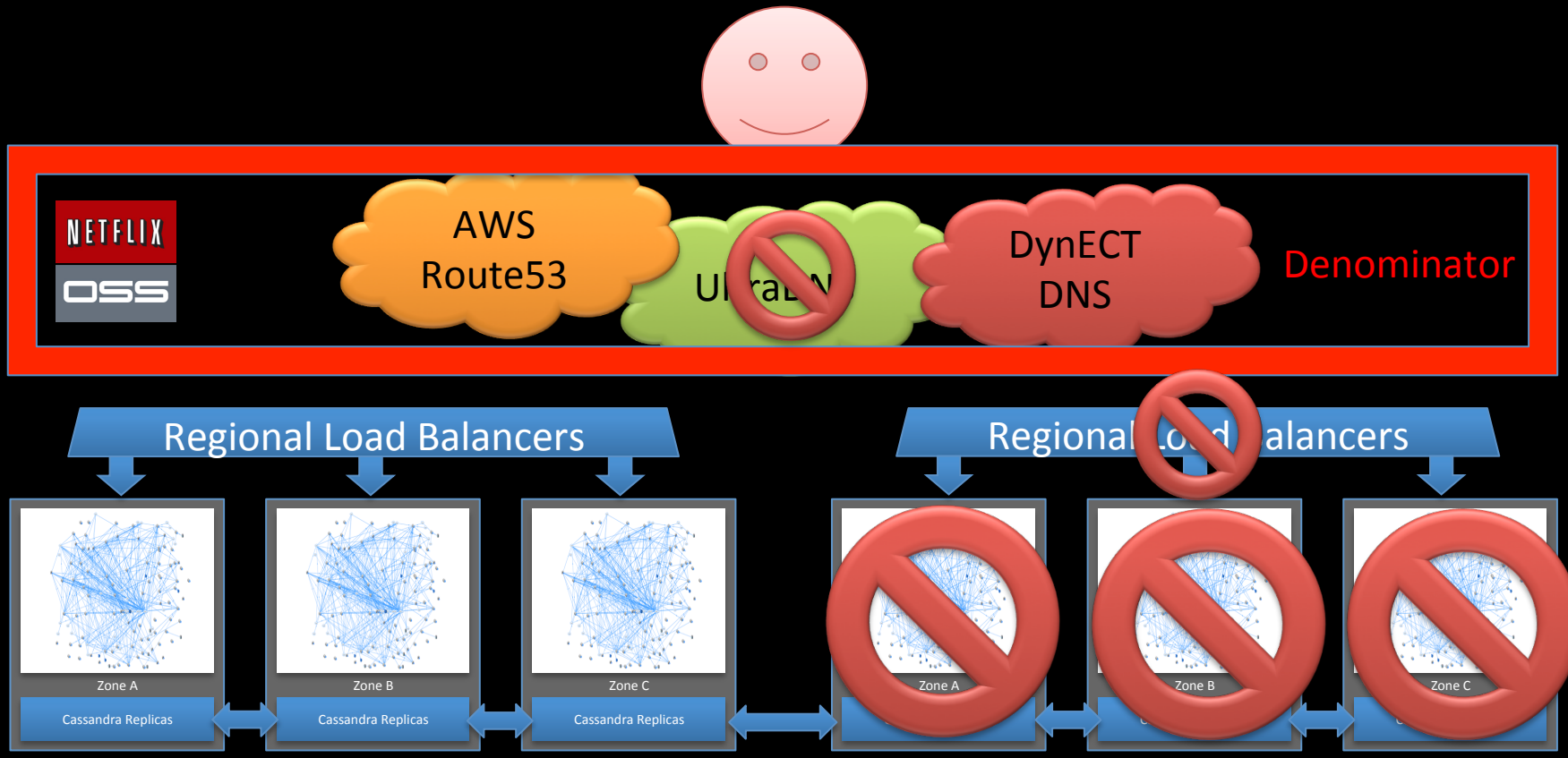
# Ramp Up Load Until It Breaks!

Unmodified tuning, dropping client data at 1.93GB/s inter region traffic

Spare CPU, IOPS, Network, just need some Cassandra tuning for more



# Managing Multi-Region Availability




Denominator – manage traffic via multiple DNS providers


Boosting the @NetflixOSS Ecosystem

See netflix.github.com

Judges choice award

Best example application mash-up

Best usability enhancement

Best portability enhancement

Best new monkey

Best new feature

Best datastore integration

Best contribution to code quality

Best contribution to operational tools

Best contribution to performance

Aino Corry
Program Chair for Qcon/GOTO

Simon Wardley
Strategist

Martin Fowler
Chief Scientist Thoughtworks

Werner Vogels
CTO Amazon

Joe Weinman
SVP Telx, Author “Cloudonomics”

Yury Izrailevsky
VP Cloud Netflix

# What do you win?

One winner in each of the 10 categories

Ticket and expenses to attend AWS Re:Invent 2013 in Las Vegas

A Trophy

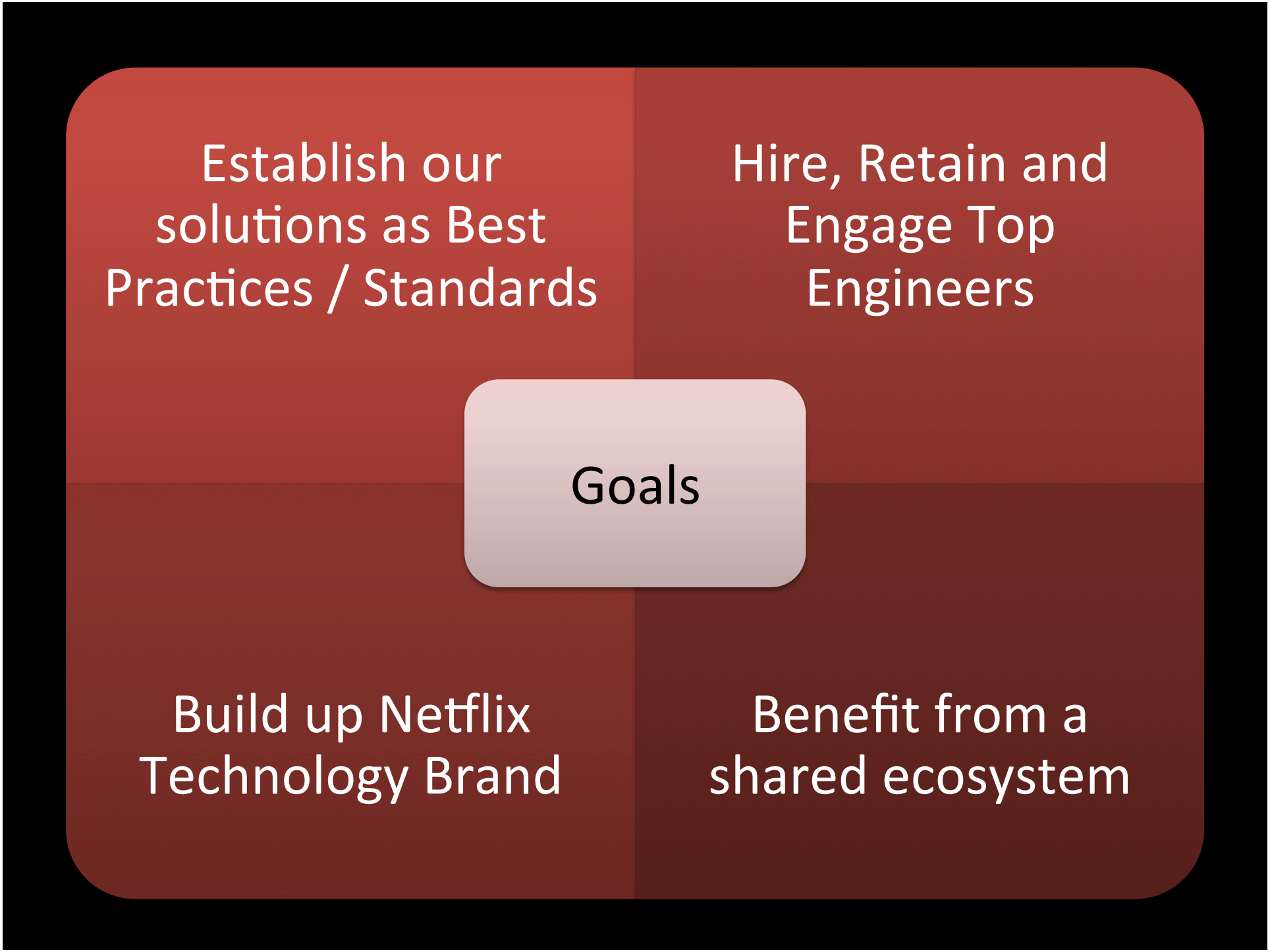
**$10,000 cash and $5,000 in AWS Credits**


A Cloud Native Open Source Platform

See netflix.github.com

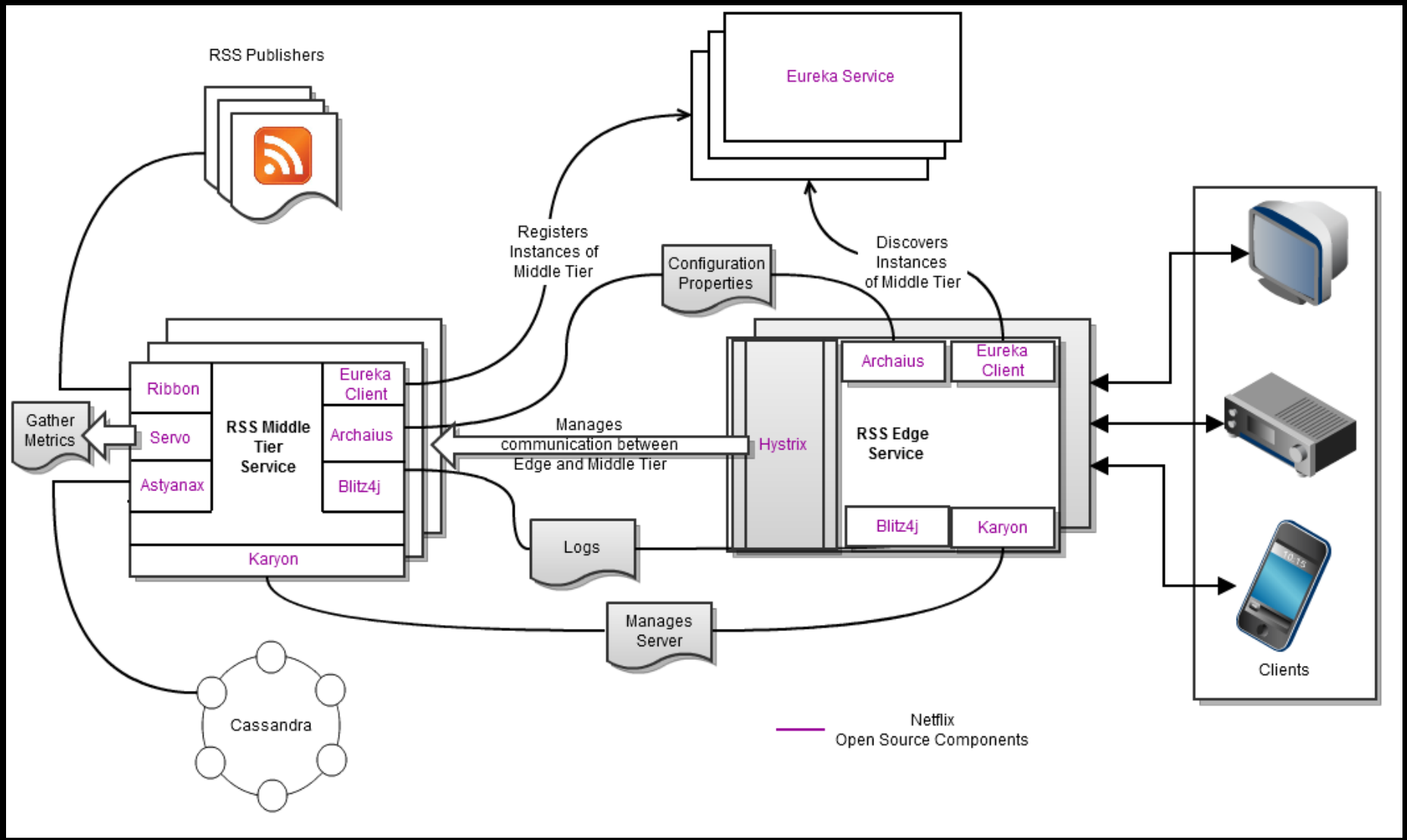
# Netflix Platform Evolution


Netflix ended up several years ahead of the industry, but it's becoming commoditized now

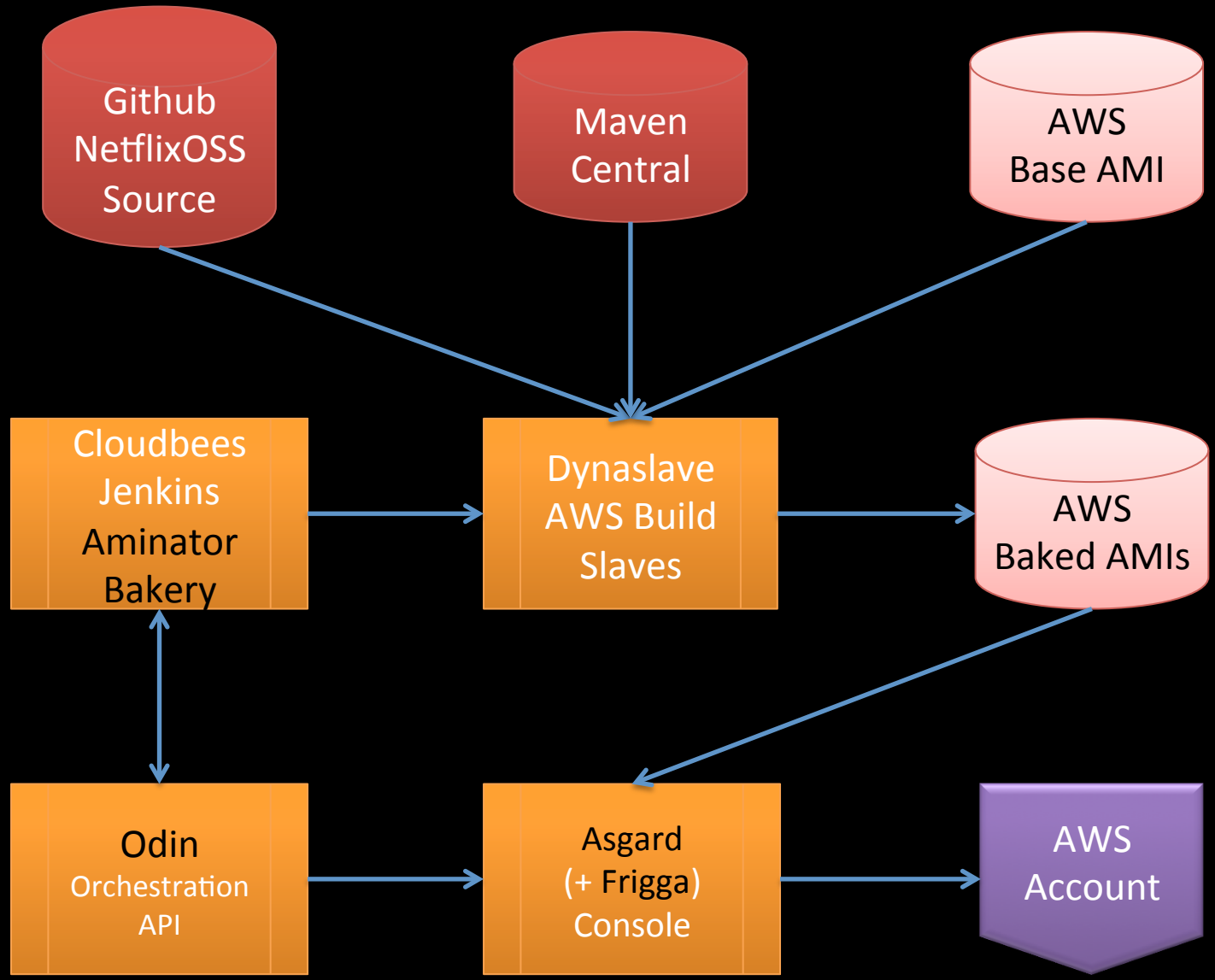

Establish our solutions as Best Practices / Standards
Hire, Retain and Engage Top Engineers
Goals
Build up Netflix Technology Brand
Benefit from a shared ecosystem

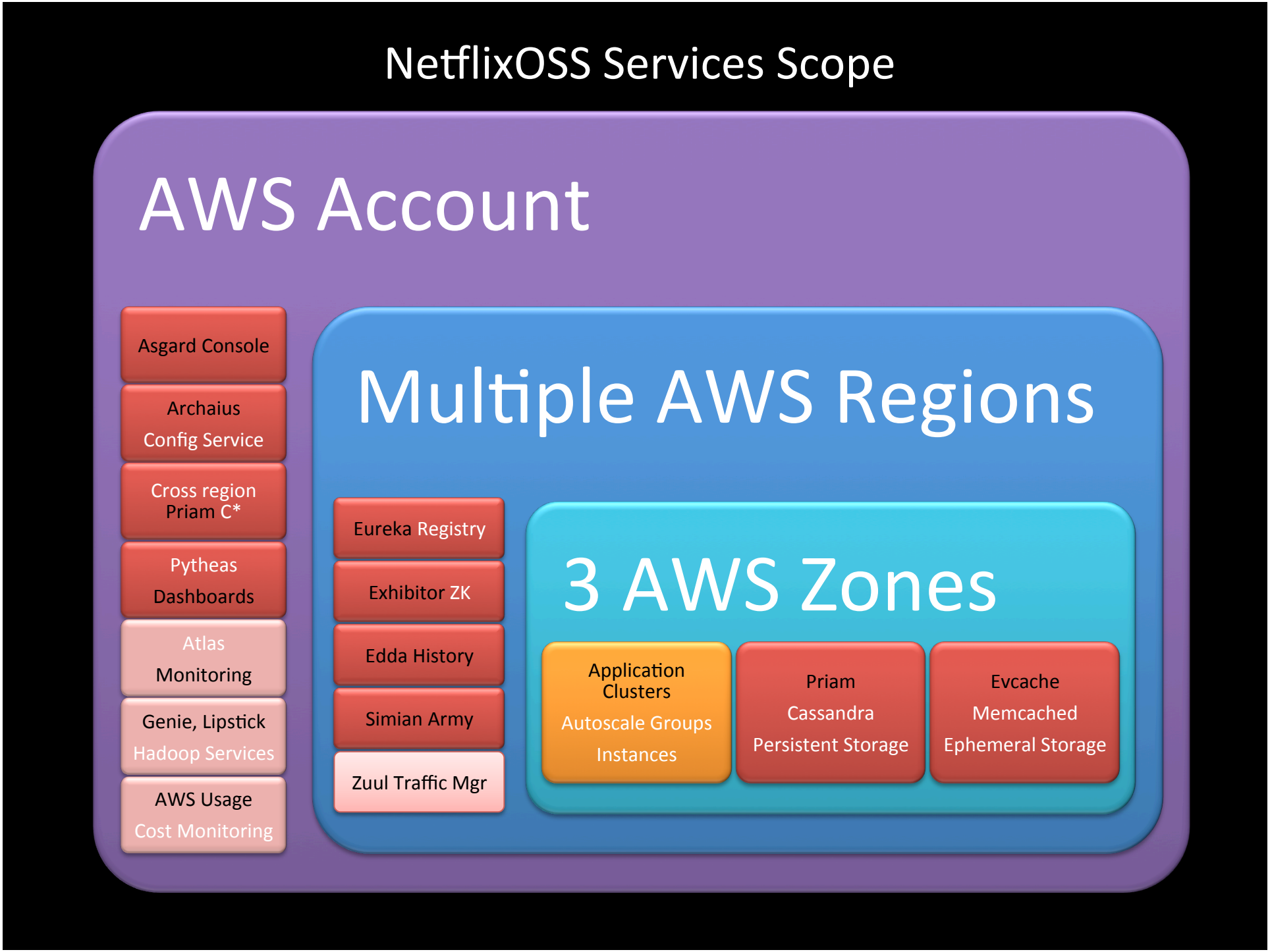
# How does it all fit together?

# Example Application – RSS Reader



# NetflixOSS Continuous Build and Deployment




NetflixOSS Services Scope
AWS Account
Asgard Console
Archaius
Config Service
Cross region
Priam C*
Pytheas
Dashboards
Atlas
Monitoring
Genie, Lipstick
Hadoop Services
AWS Usage
Cost Monitoring
Multiple AWS Regions
Eureka Registry
Exhibitor ZK
Edda History
Simian Army
Zuul Traffic Mgr
3 AWS Zones
Application
Clusters
Autoscale Groups
Instances
Priam
Cassandra
Persistent Storage
Evcache
Memcached
Ephemeral Storage

# NetflixOSS Instance Libraries

**Initialization**

- Baked AMI – Tomcat, Apache, your code
- Governator – Guice based dependency injection
- Archaius – dynamic configuration properties client
- Eureka - service registration client

**Service Requests**

- Karyon - Base Server for inbound requests
- RxJava – Reactive pattern
- Hystrix/Turbine – dependencies and real-time status
- Ribbon - REST Client for outbound calls

**Data Access**

- Astyanax – Cassandra client and pattern library
- Evcache – Zone aware Memcached client
- Curator – Zookeeper patterns
- Denominator – DNS routing abstraction

**Logging**

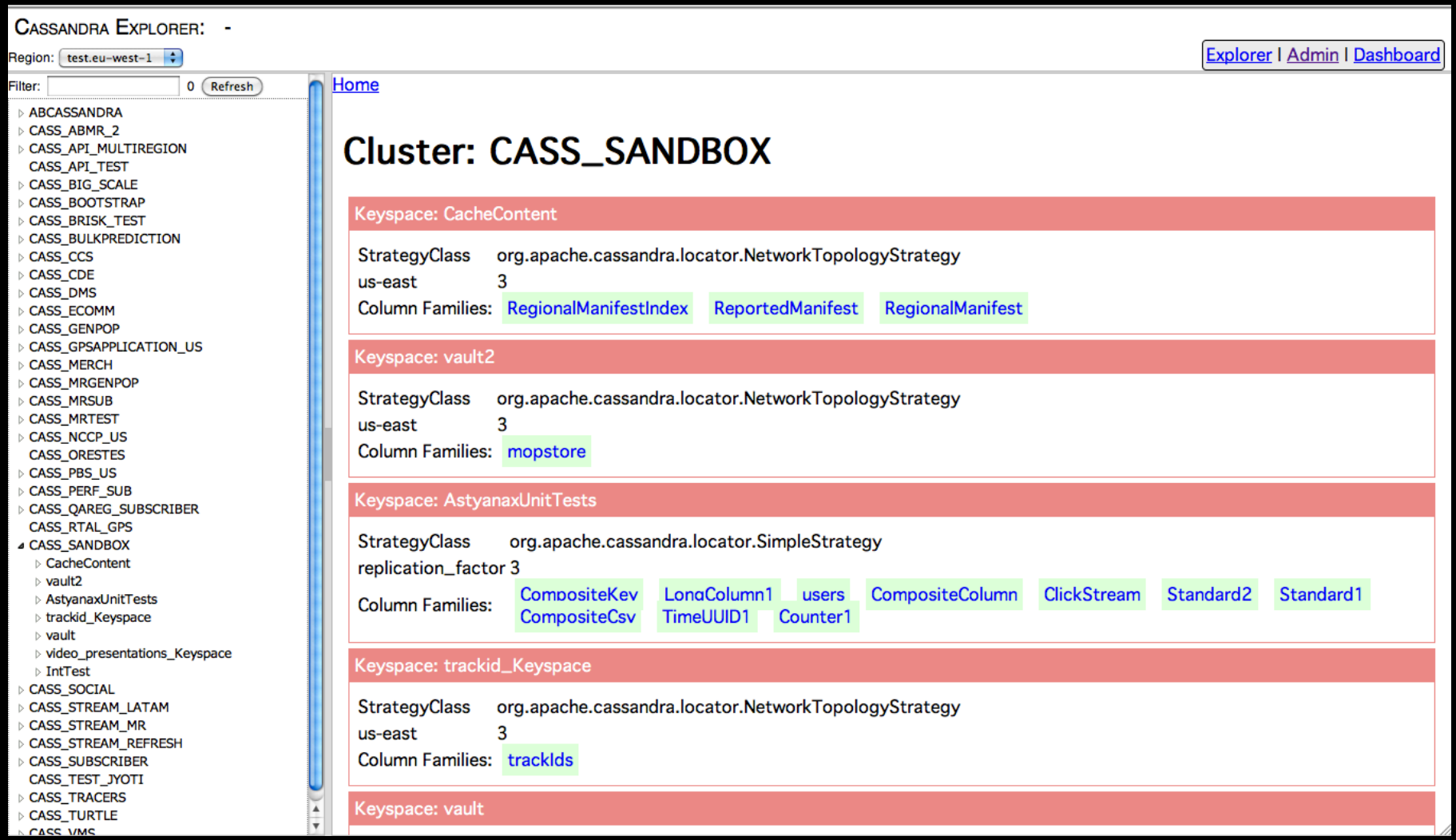
- Blitz4j – non-blocking logging
- Servo – metrics export for autoscaling
- Atlas – high volume instrumentation

# Dashboards with Pytheas (Explorers)

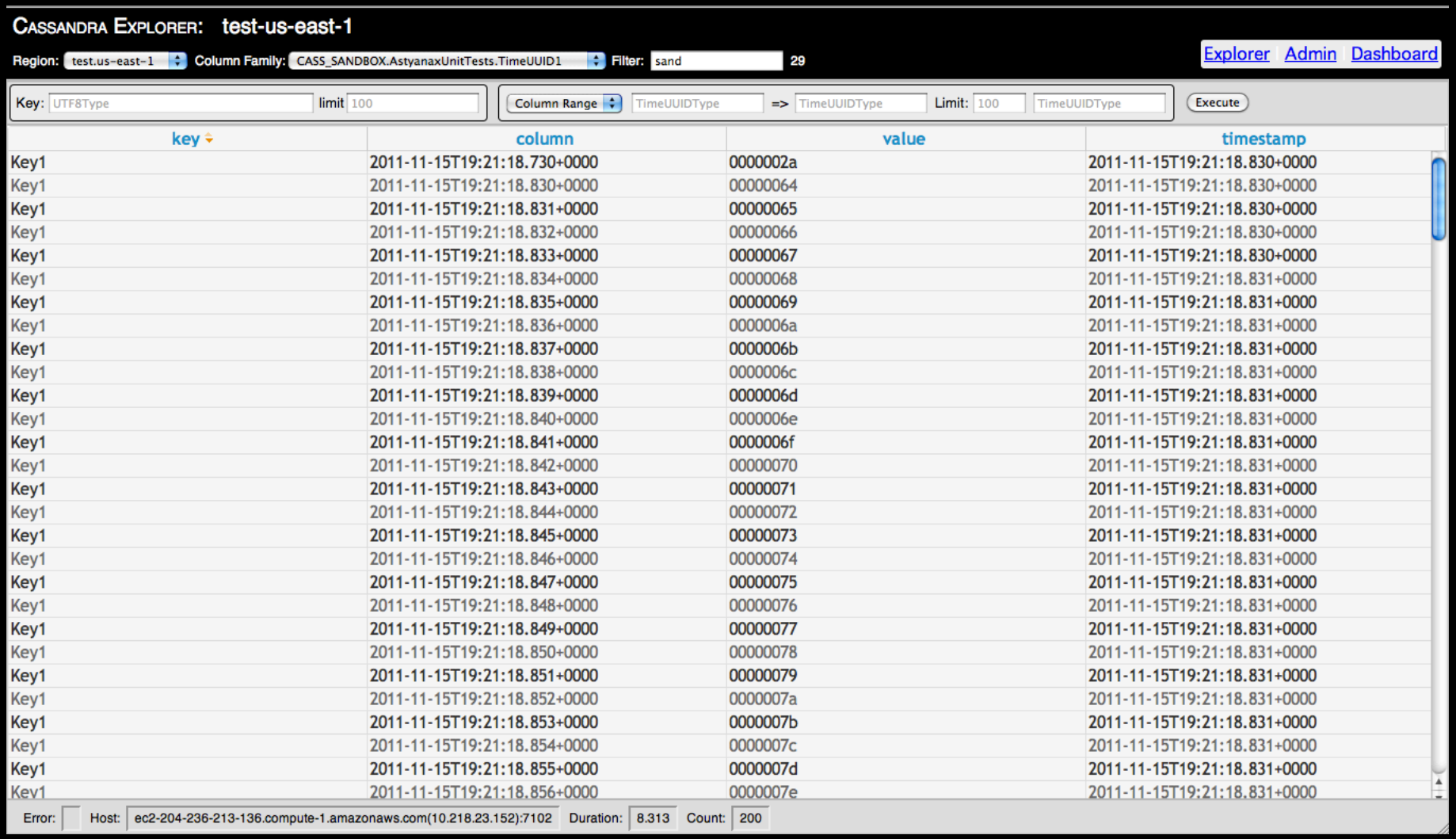
http://techblog.netflix.com/2013/05/announcing-pytheas.html

- Cassandra Explorer
  - Browse clusters, keyspaces, column families
- Base Server Explorer
  - Browse service endpoints configuration, perf
- Anything else you want to build…

# Cassandra Explorer



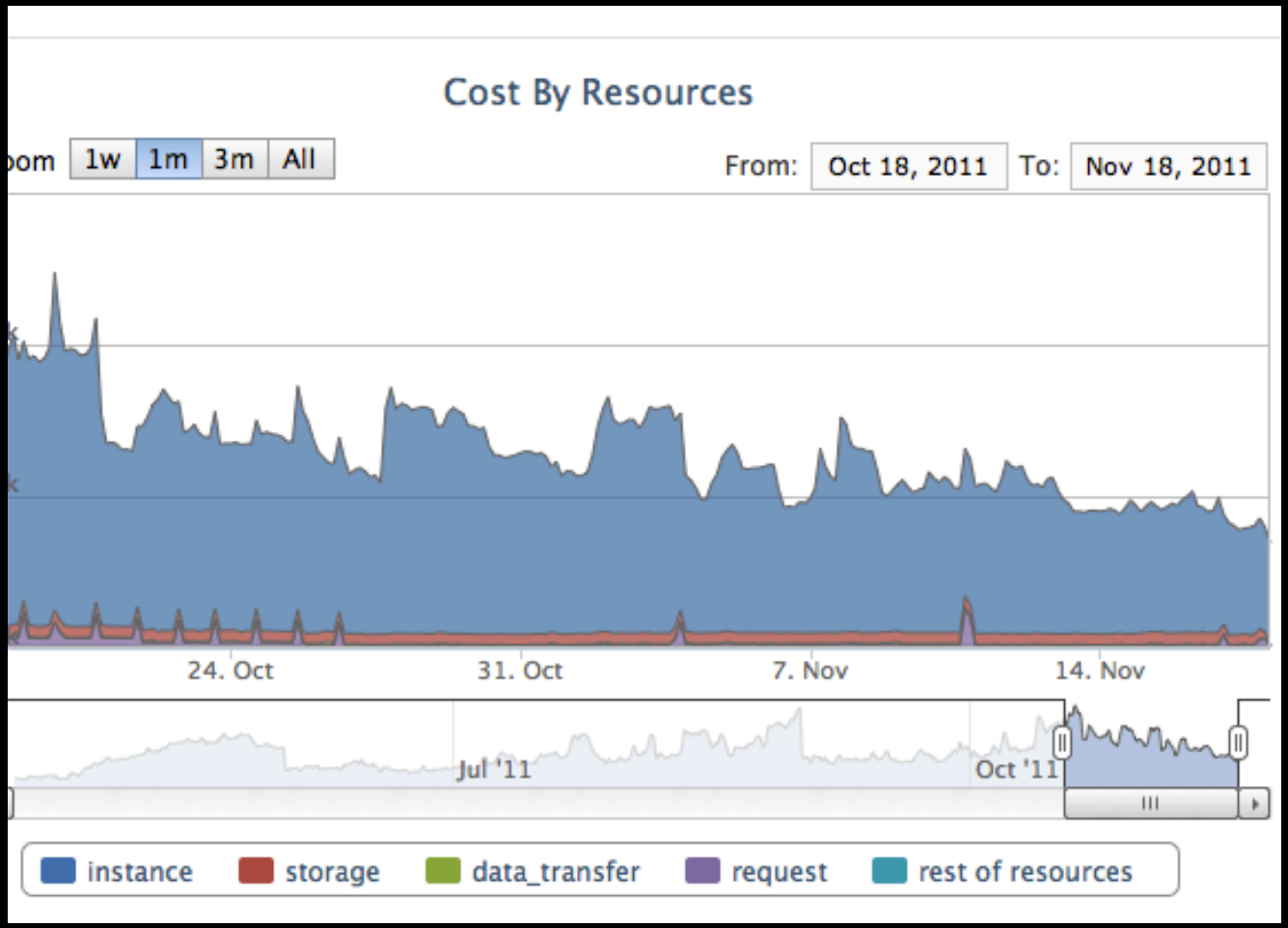
# Cassandra Explorer



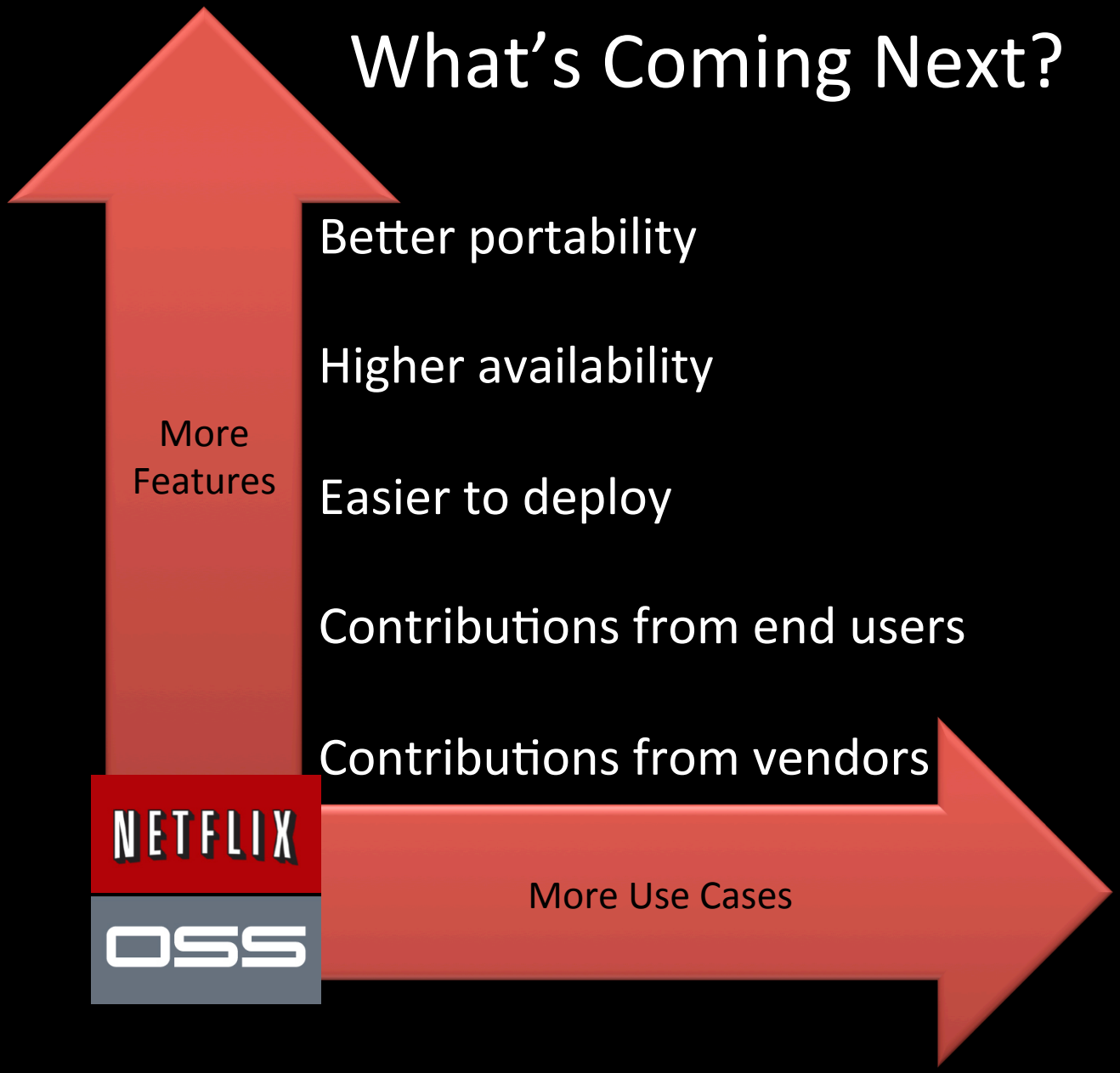
# Cassandra Clusters

# AWS Usage (coming soon)

## Reservation-aware cost monitoring and reporting



# What's Coming Next?




Functionality and scale now, portability coming

Moving from parts to a platform in 2013

Netflix is fostering a cloud native ecosystem

Rapid Evolution - Low MTBIAMSH

(Mean Time Between Idea And Making Stuff Happen)

# Takeaway

*NetflixOSS makes it easier for everyone to become Cloud Native*

http://netflix.github.com
http://techblog.netflix.com
http://slideshare.net/Netflix

http://www.linkedin.com/in/adriancockcroft

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# Slideshare NetflixOSS Details

- Lightning Talks Feb S1E1
  - http://www.slideshare.net/RuslanMeshenberg/netflixoss-open-house-lightning-talks
- Asgard In Depth Feb S1E1
  - http://www.slideshare.net/joesondow/asgard-overview-from-netflix-oss-open-house
- Lightning Talks March S1E2
  - http://www.slideshare.net/RuslanMeshenberg/netflixoss-meetup-lightning-talks-and-roadmap
- Security Architecture
  - http://www.slideshare.net/jason_chan/
- Cost Aware Cloud Architectures – with Jinesh Varia of AWS
  - http://www.slideshare.net/AmazonWebServices/building-costaware-architectures-jinesh-varia-aws-and-adrian-cockroft-netflix

# Amazon Cloud Terminology Reference

See http://aws.amazon.com/ This is not a full list of Amazon Web Service features

- AWS – Amazon Web Services (common name for Amazon cloud)
- AMI – Amazon Machine Image (archived boot disk, Linux, Windows etc. plus application code)
- EC2 – Elastic Compute Cloud
  - Range of virtual machine types m1, m2, c1, cc, cg. Varying memory, CPU and disk configurations.
  - Instance – a running computer system. Ephemeral, when it is de-allocated nothing is kept.
  - Reserved Instances – pre-paid to reduce cost for long term usage
  - Availability Zone – datacenter with own power and cooling hosting cloud instances
  - Region – group of Avail Zones – US-East, US-West, EU-Eire, Asia-Singapore, Asia-Japan, SA-Brazil, US-Gov
- ASG – Auto Scaling Group (instances booting from the same AMI)
- S3 – Simple Storage Service (http access)
- EBS – Elastic Block Storage (network disk filesystem can be mounted on an instance)
- RDS – Relational Database Service (managed MySQL master and slaves)
- DynamoDB/SDB – Simple Data Base (hosted http based NoSQL datastore, DynamoDB replaces SDB)
- SQS – Simple Queue Service (http based message queue)
- SNS – Simple Notification Service (http and email based topics and messages)
- EMR – Elastic Map Reduce (automatically managed Hadoop cluster)
- ELB – Elastic Load Balancer
- EIP – Elastic IP (stable IP address mapping assigned to instance or ELB)
- VPC – Virtual Private Cloud (single tenant, more flexible network and security constructs)
- DirectConnect – secure pipe from AWS VPC to external datacenter
- IAM – Identity and Access Management (fine grain role based security keys)