Scalable Microservices at Netflix. Challenges and Tools of the Trade

AGENDA

- Netflix – background and evolution
- Monolithic Apps
  - Characteristics
- What are Microservices?
- Microservices
  - Why?
  - Challenges
  - Best practices
  - Tools of the trade
- InterProcess Communication
- Takeaways

Netflix - Evolution

Netflix - Evolution

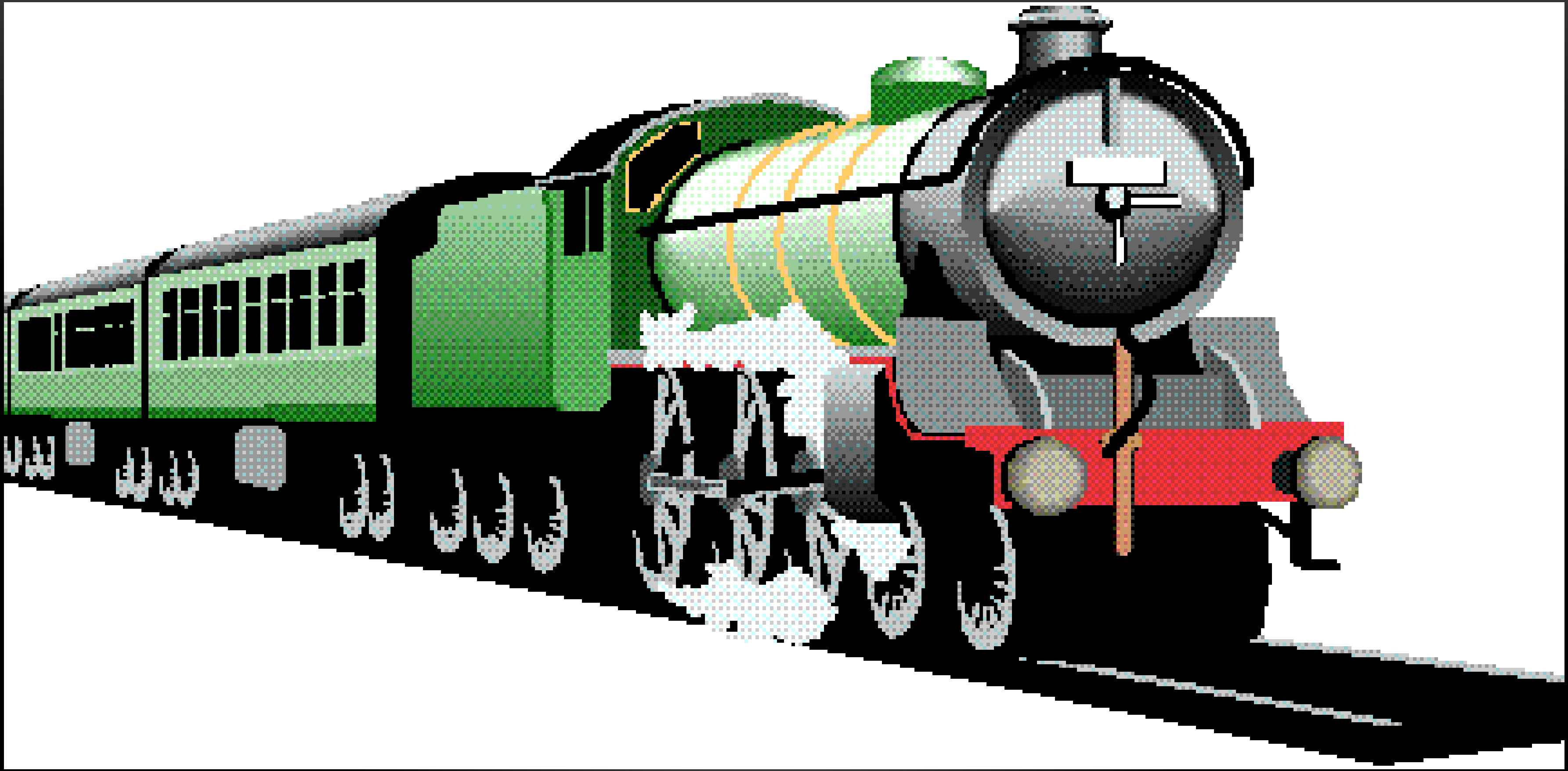
- Old DataCenter (2008)
- Everything in one WebApp (.war)

- AWS Cloud (~2010)
- 100s of Fine Grained Services

Netflix Scale

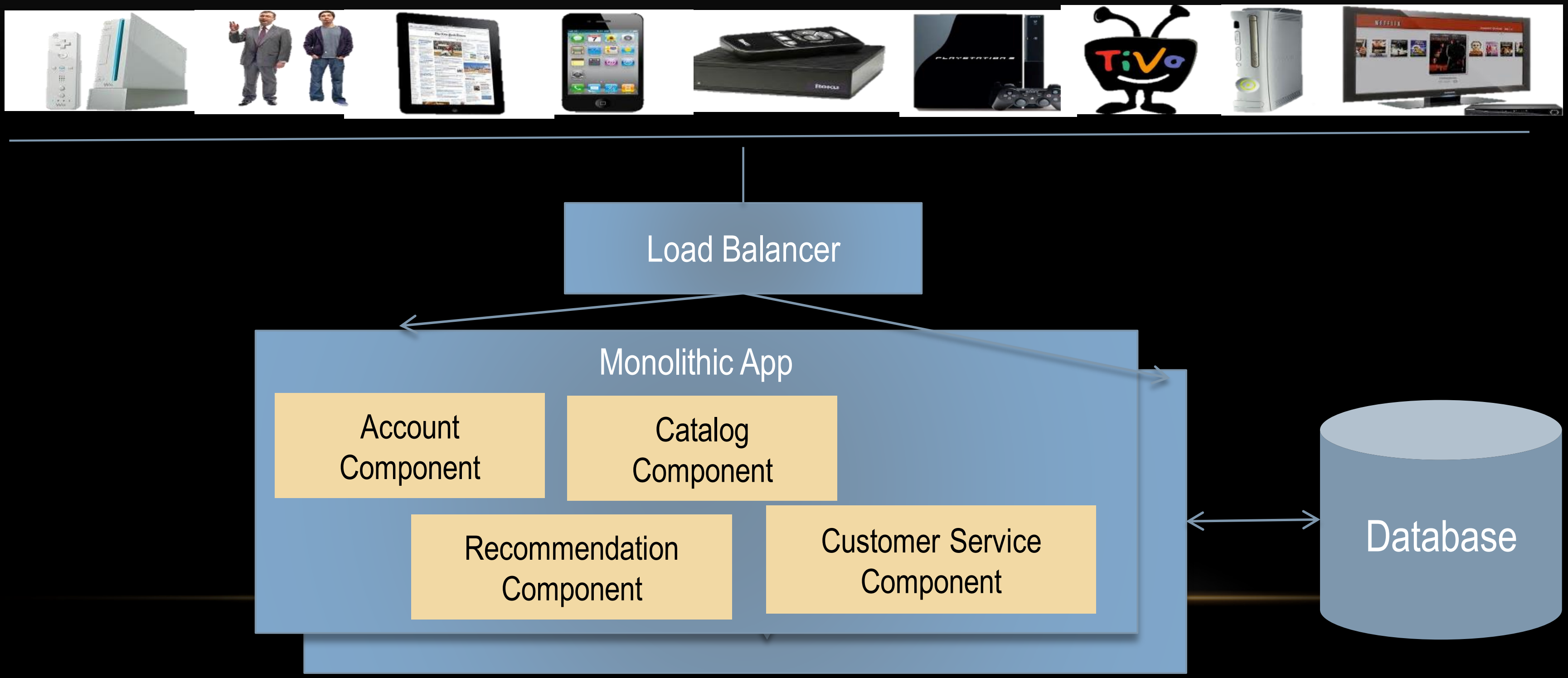
- ~ 1/3 of the peak Internet traffic a day
- ~50M subscribers
- ~2 Billion Edge API Requests/Day
- >500 MicroServices
- ~30 Engineering Teams (owning many microservices)

Monolithic Apps



MONOLITHIC APP

Monolithic Architecture



Load Balancer

Monolithic App

Account Component

Catalog Component

Recommendation Component

Customer Service Component

Database

Characteristics

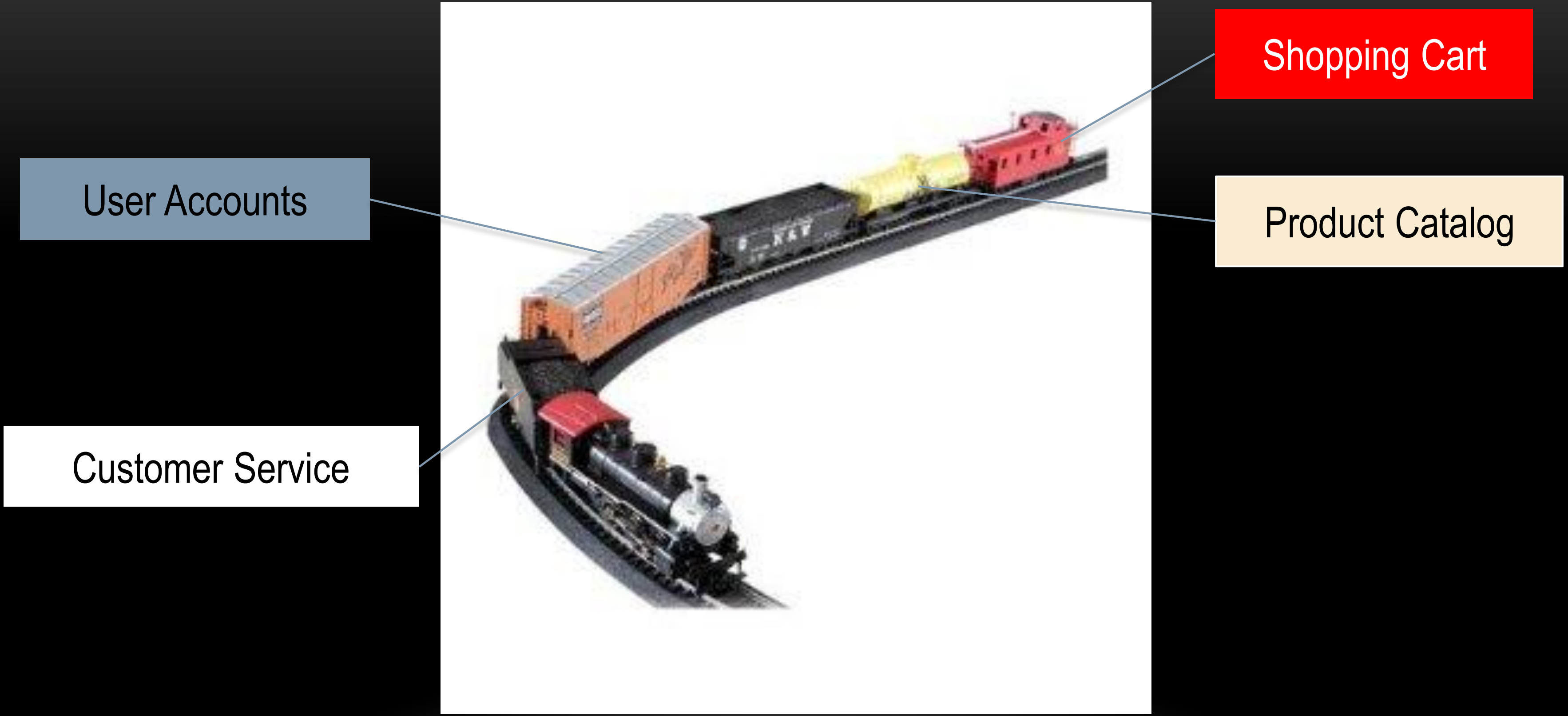
- Large Codebase
- Many Components, no clear ownership
- Long deployment cycles

Pros

- Single codebase
  - Easy to develop/debug/deploy
  - Good IDE support
- Easy to scale horizontally (but can only scale in an “un-differentiated” manner)
- A Central Ops team can efficiently handle

Monolithic App – Evolution

- As codebase increases …
  - Tends to increase “tight coupling” between components
    - Just like the cars of a train
  - All components have to be coded in the same language



User Accounts

Customer Service

Shopping Cart

Product Catalog

Evolution of a Monolithic App

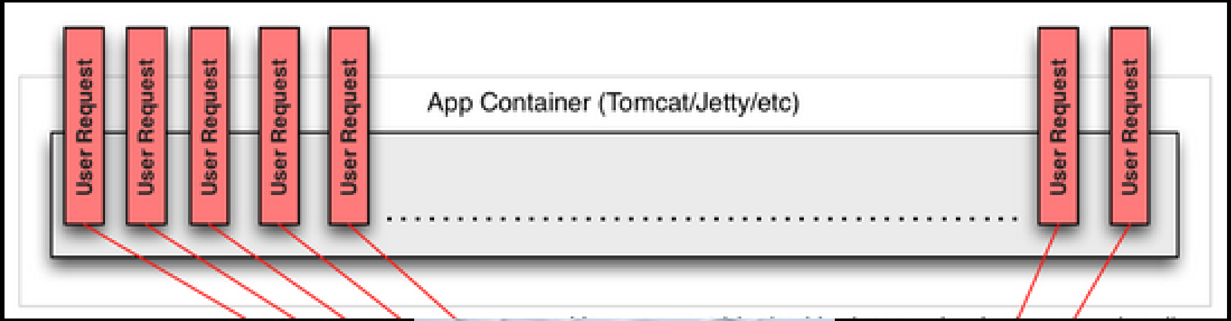
Monolithic App - Scaling

- Scaling is “undifferentiated”
  - Cant scale “Product Catalog” differently from “Customer Service”

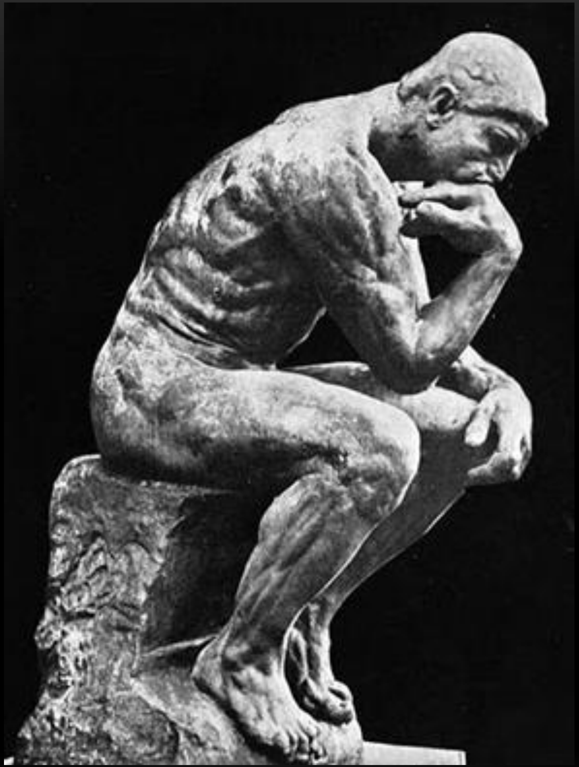
AVAILABILITY

Availability

- A single missing “;” brought down the Netflix website for many hours (~2008)



MONOLITHIC APPS – FAILURE & AVAILABILITY



MicroServices

You Think??

TIPPING POINT

&

&

Organizational Growth

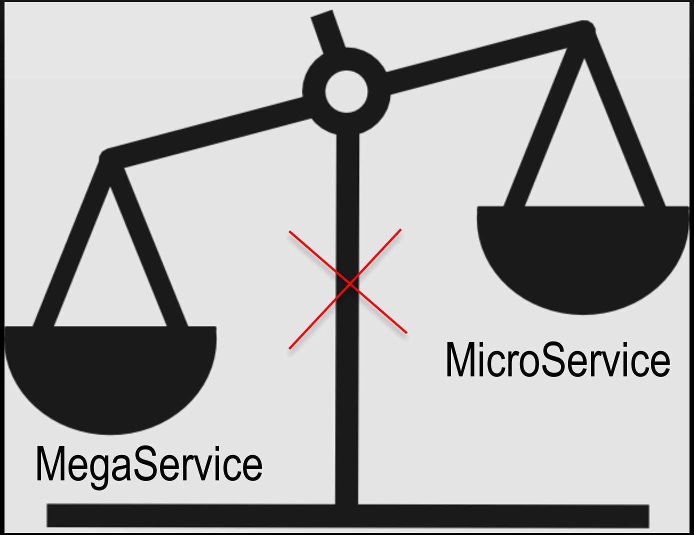
Disverse Functionality

Bottleneck in
Monolithic stack

What are MicroServices?

NOT ABOUT …

- Team size
- Lines of code
- Number of API/EndPoints



CHARACTERISTICS

- Many smaller (fine grained), clearly scoped services
    - Single Responsibility Principle
    - Domain Driven Development
    - Bounded Context
    - Independently Managed
- Clear ownership for each service
    - Typically need/adopt the “DevOps” model

Attribution: Adrian Cockroft, Martin Fowler …

Composability– unix philosophy

- Write programs that do one thing and do it well.
- Write programs to work together

```
tr 'A-Z' 'a-z' < doc.txt | tr -cs 'a-z' '\n' | sort | uniq | comm -23 - /usr/share/dict/words
```

Program to print misspelt words in doc.txt

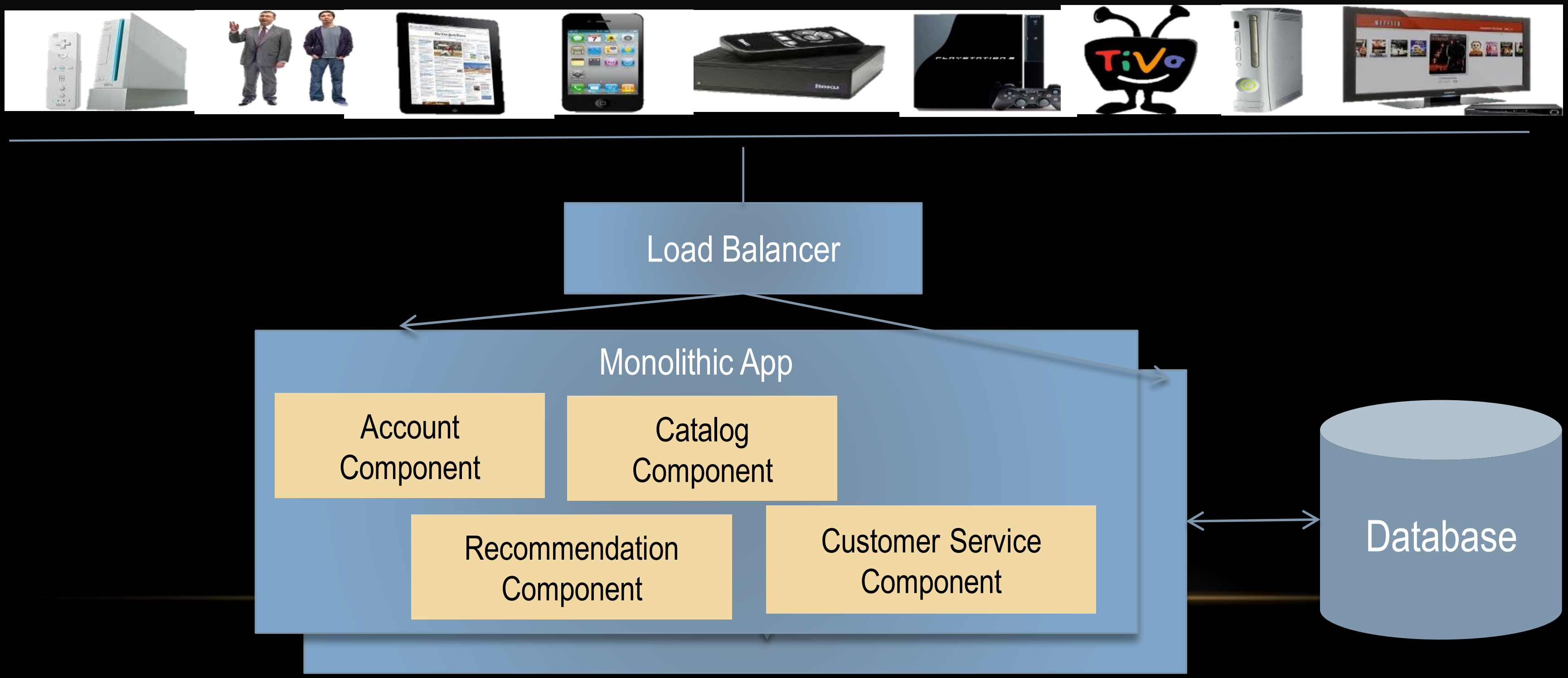
Comparing Monolithic to MicroServices

Apples
Bananas
Grapes
Pineapples
Watermelons
10

MONOLITHIC APP (VARIOUS COMPONENTS LINKED TOGETHER)

MICROSERVICES – SEPARATE SINGLE PURPOSE SERVICES

Monolithic Architecture (Revisiting)



Load Balancer

Monolithic App

Account Component

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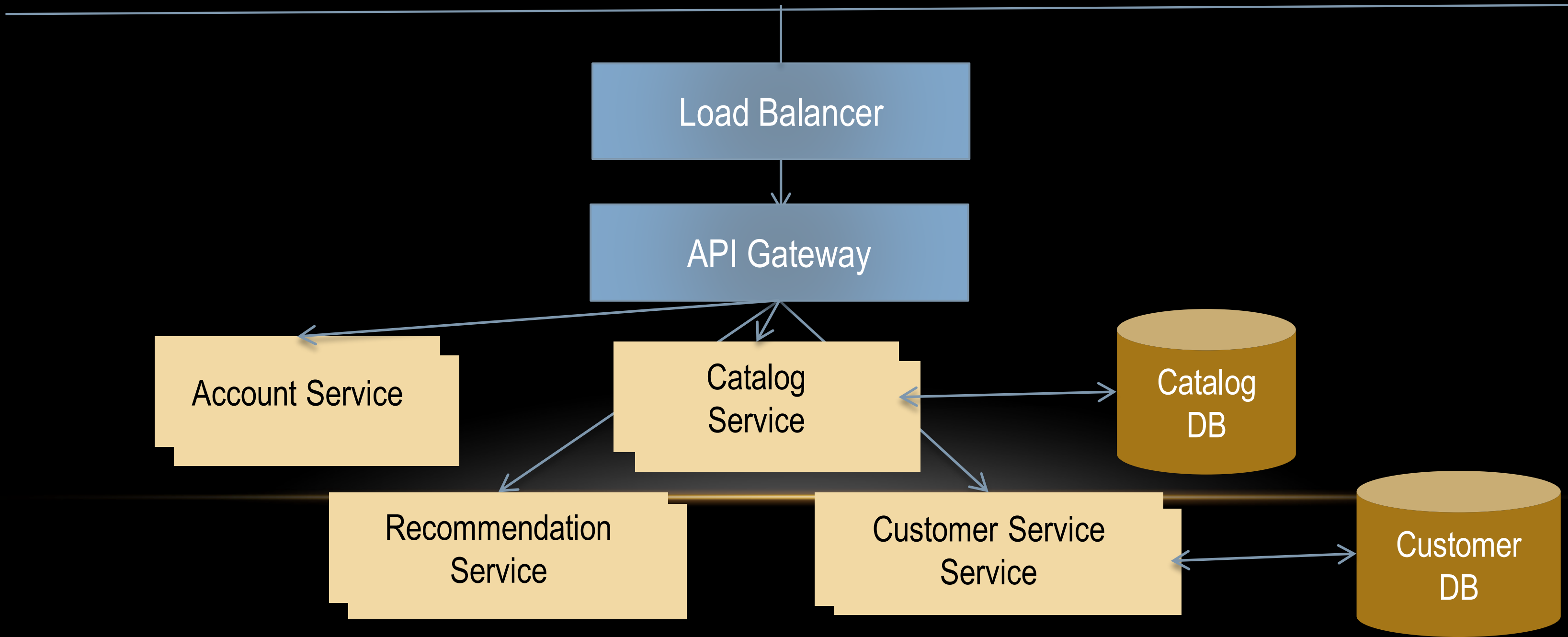
Customer Service Component

Database

Microservices Architecture



Load Balancer

API Gateway

Account Service

Catalog Service

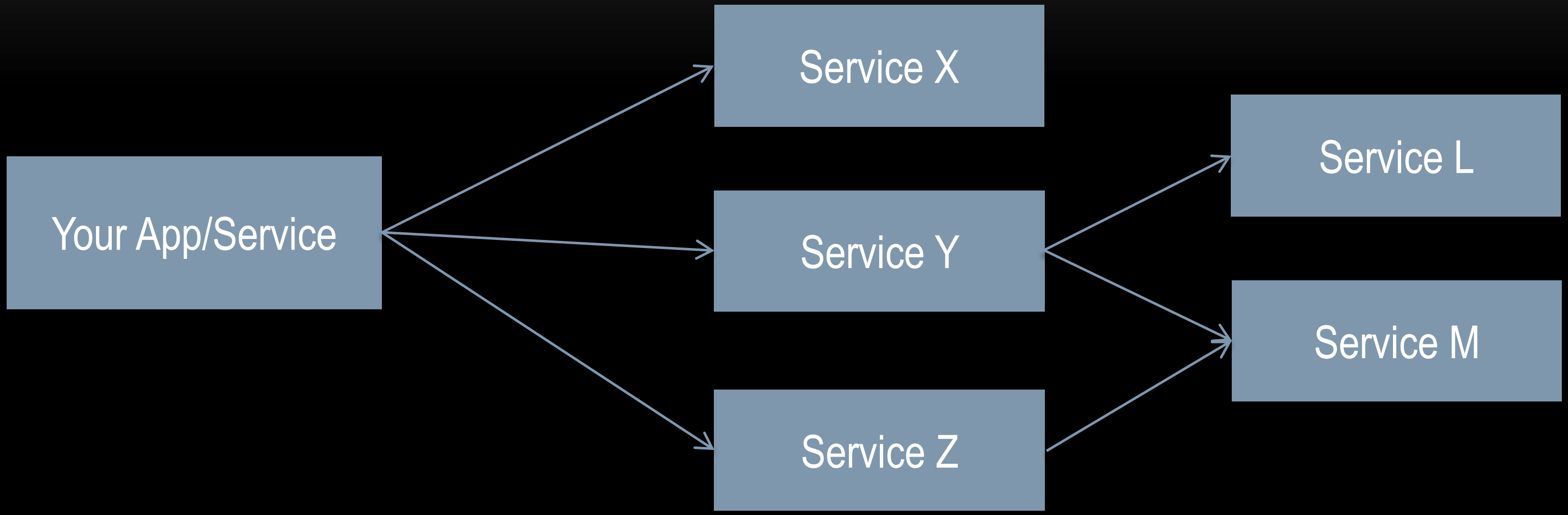
Catalog DB

Recommendation Service

Customer Service Service

Customer DB

Concept -> Service Dependency Graph



Your App/Service

Service X

Service Y

Service Z

Service L

Service M

MicroServices - Why?

WHY?

- Faster and simpler deployments and rollbacks
  - Independent Speed of Delivery (by different teams)
- Right framework/tool/language for each domain
  - Recommendation component using Python?, Catalog Service in Java ..
- Greater Resiliency
  - Fault Isolation
- Better Availability
  - If architected right ☺

MicroServices - Challenges

CHALLENGES

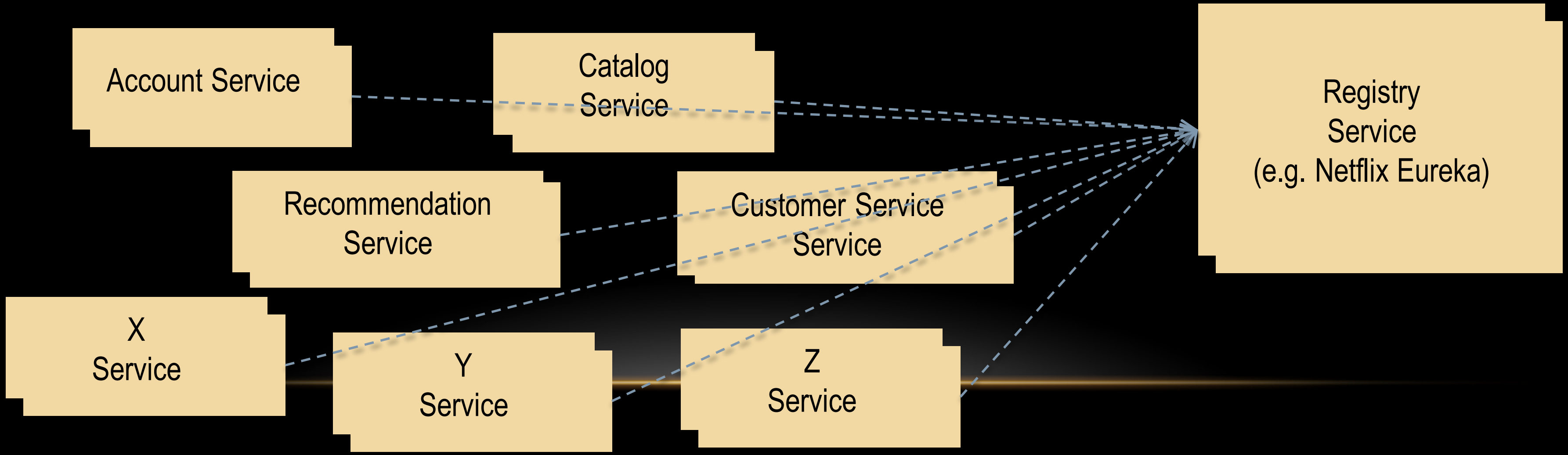
Can lead to chaos if not designed right …

OVERALL COMPLEXITY

- Distributed Systems are inherently Complex
  - N/W Latency, Fault Tolerance, Retry storms ..
- Operational Overhead
  - TIP: Embrace DevOps Model

SERVICE DISCOVERY

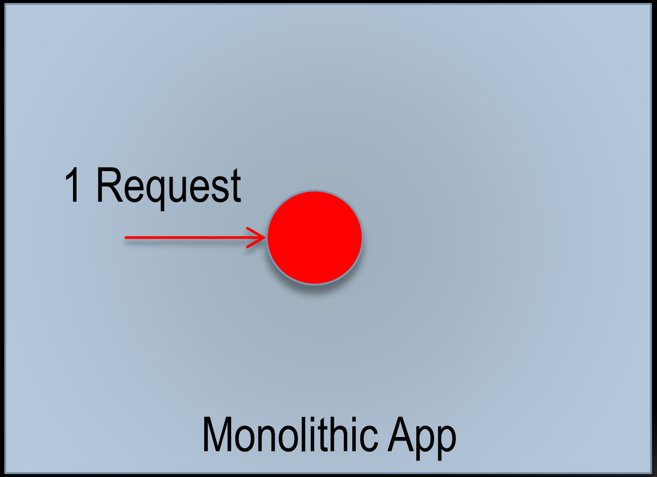
- 100s of MicroServices
  - Need a Service Metadata Registry (Discovery Service)

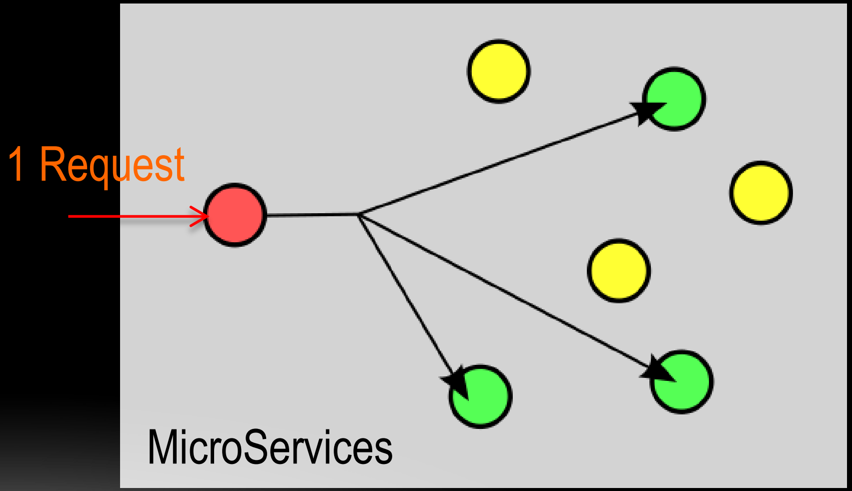


CHATTINESS (AND FAN OUT)

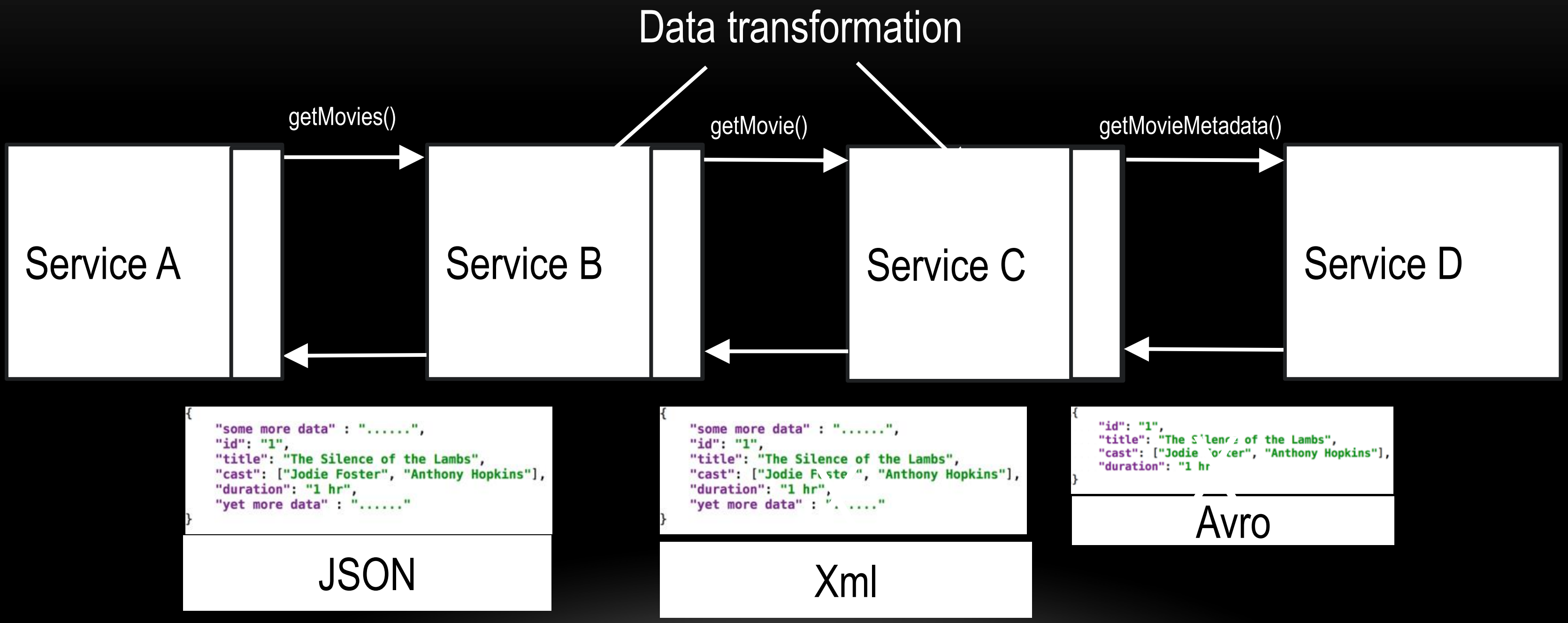
~2 Billion Requests per day on Edge Service

Results in ~20 Billion Fan out requests in ~100 MicroServices





DATA SERIALIZATION OVERHEAD



```
{
   "some more data" : "......",
   "id": "1",
   "title": "The Silence of the Lambs",
   "cast": ["Jodie Foster", "Anthony Hopkins"],
   "duration": "1 hr",
   "yet more data" : "......"
}
```

```
{
   "some more data" : "......",
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{
   "id": "1",
   "title": "The Silence of the Lambs",
   "cast": ["Jodie Foster", "Anthony Hopkins"],
   "duration": "1 hr
}
```

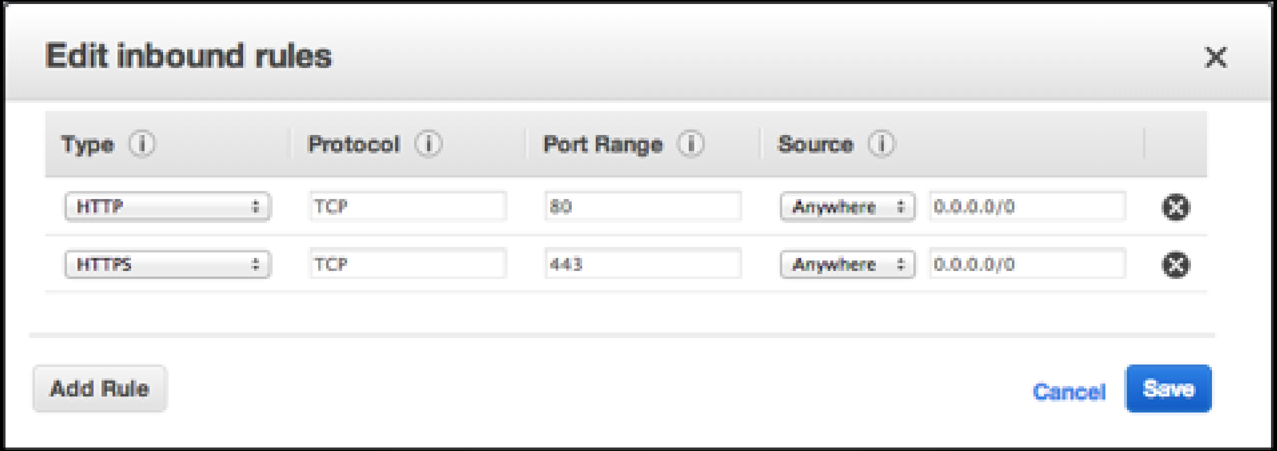
CHALLENGES - SUMMARY

- Service Discovery
- Operational Overhead (100s of services; DevOps model absolutely required)
- Distributed Systems are inherently Complex
  - N/W Latency, Fault Tolerance, Serialization overhead ..
- Service Interface Versioning, Mismatches?
- Testing (Need the entire ecosystem to test)
- Fan out of Requests -> Increases n/w traffic

Best Practices/Tips

Best Practice -> Isolation/Access

- TIP: In AWS, use Security Groups to isolate/restrict access to your MicroServices



Edit inbound rules

Type	Protocol	Port Range	Source	
HTTP	TCP	80	Anywhere	0.0.0.0/0
HTTPS	TCP	443	Anywhere	0.0.0.0/0

http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-network-security.html

Best Practice -> Loadbalancers

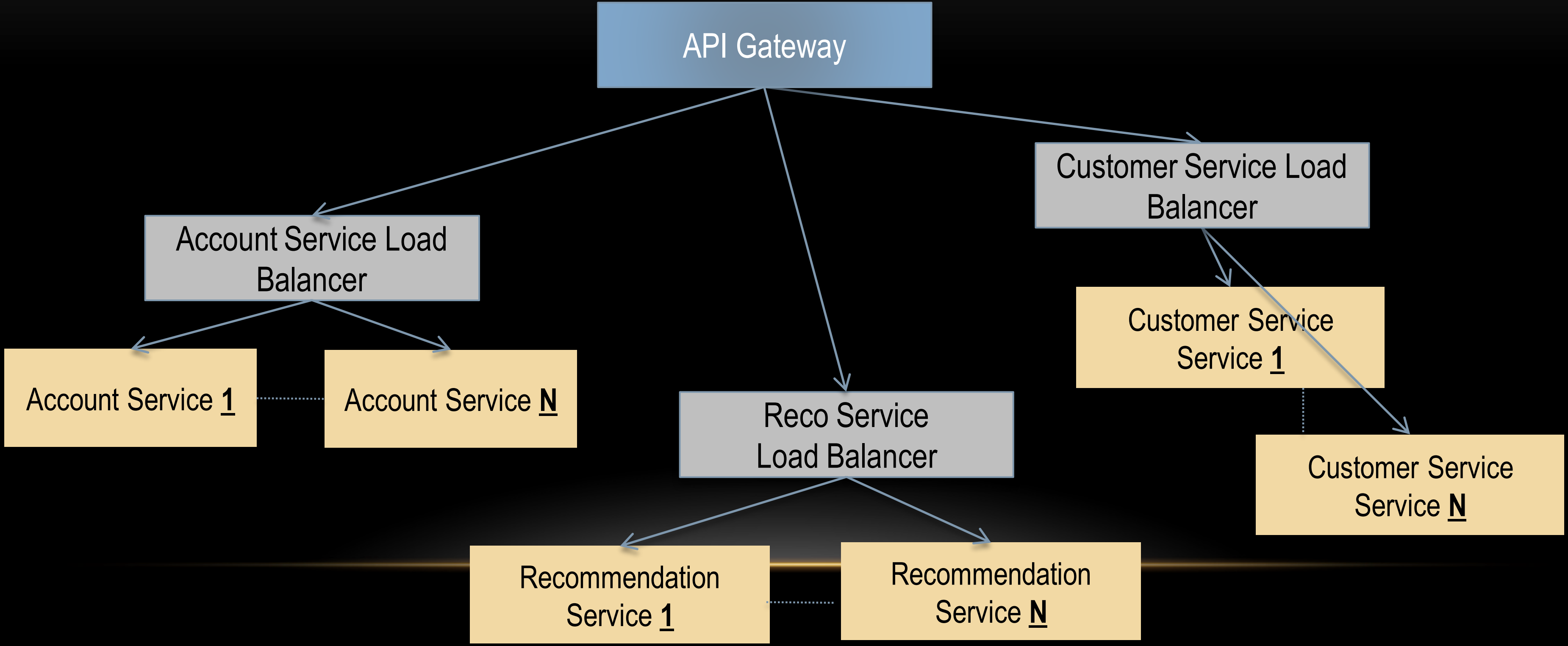
Choice

1. Central Loadbalancer? (H/W or S/W)

OR

2. Client based S/W Loadbalancer?

Central (Proxy) Loadbalancer



API Gateway

Account Service Load Balancer

Reco Service Load Balancer

Customer Service Load Balancer

Account Service **1**

Account Service **N**

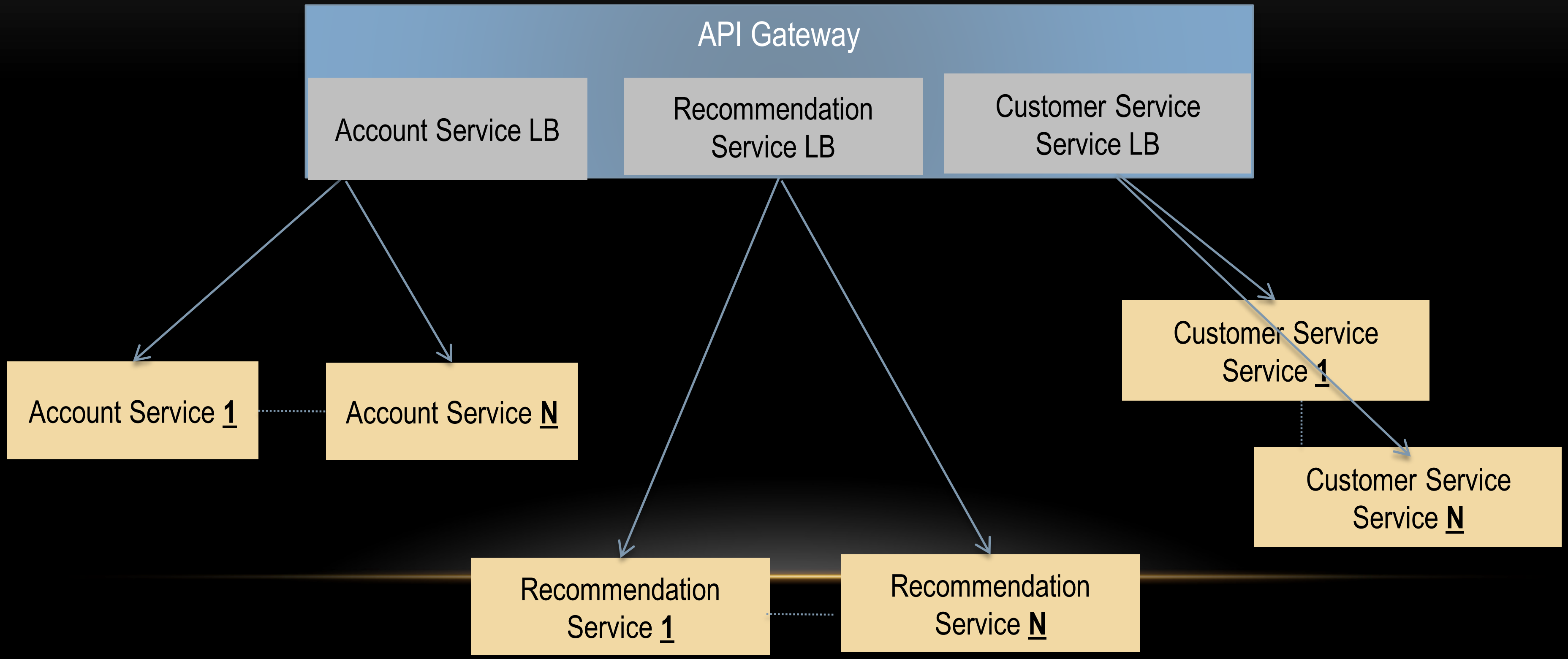
Recommendation Service **1**

Recommendation Service **N**

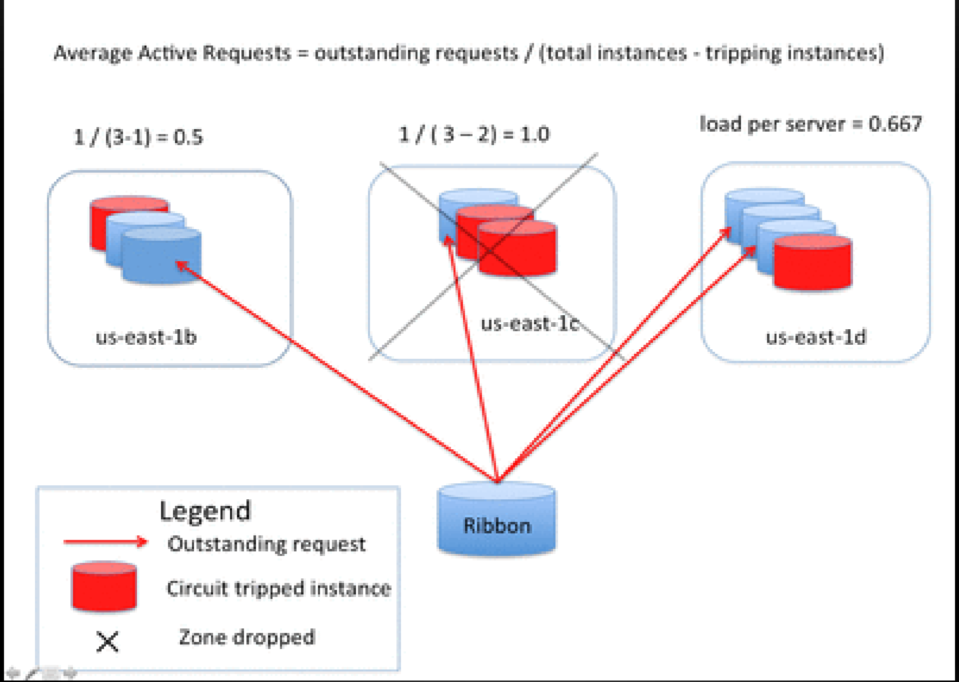
Customer Service Service **1**

Customer Service Service **N**

Client Loadbalancer


API Gateway
Account Service LB
Recommendation Service LB
Customer Service Service LB
Account Service **1**
Account Service **N**
Recommendation Service **1**
Recommendation Service **N**
Customer Service Service **1**
Customer Service Service **N**

Client based Smart Loadbalancer



Use Ribbon (http://github.com/netflix/ribbon)

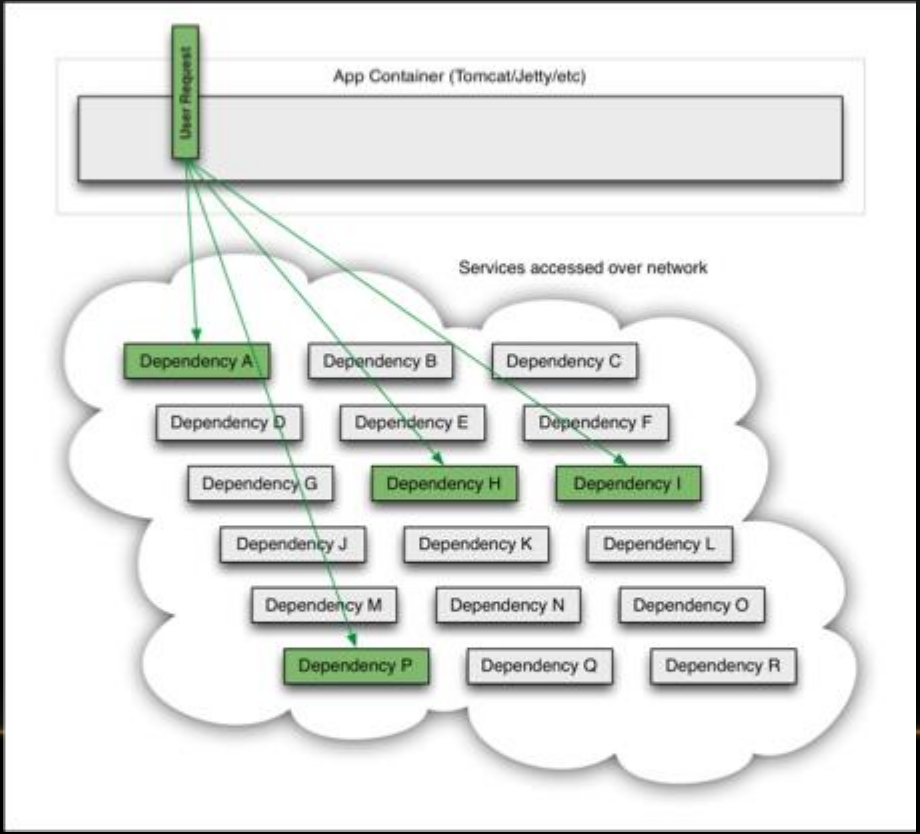
Best Practice -> LoadBalancers

- TIP: Use Client Side Smart LoadBalancers

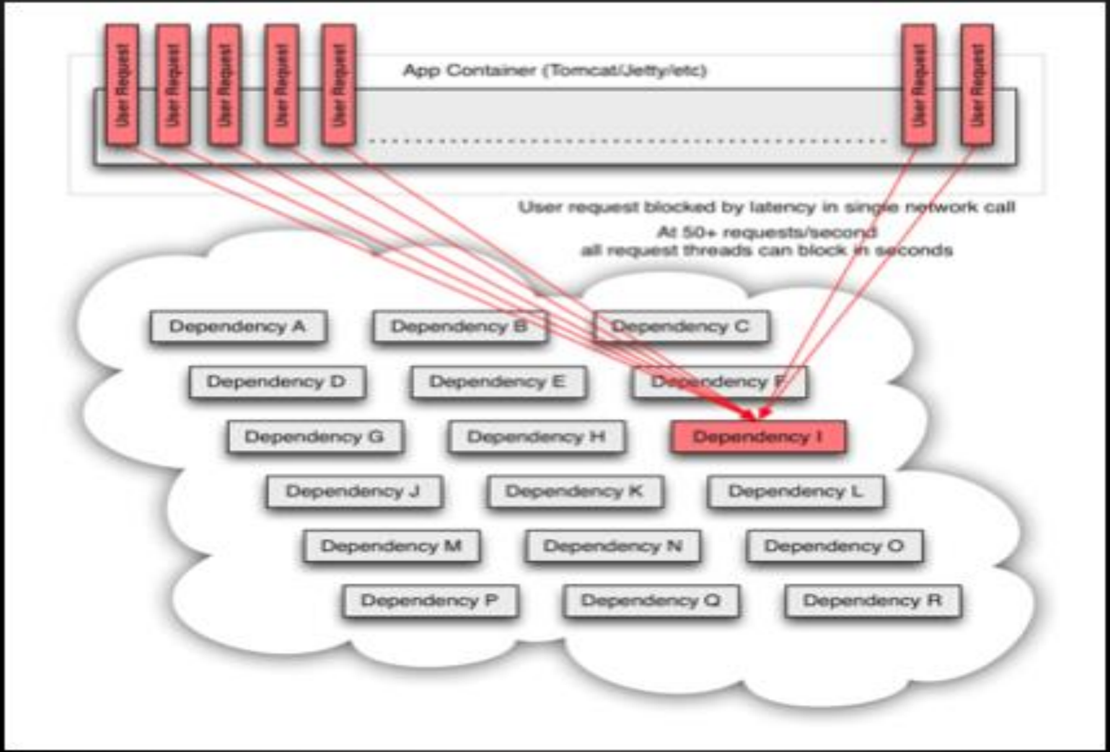
BEST PRACTICES CONTD..

- Dependency Calls
  - Guard your dependency calls
  - Cache your dependency call results
  - Consider Batching your dependency calls
  - Increase throughput via Async/ReactiveX patterns

Dependency Resiliency



Service Hosed!!



A single "bad" service can still bring your service down

AVAILABILITY

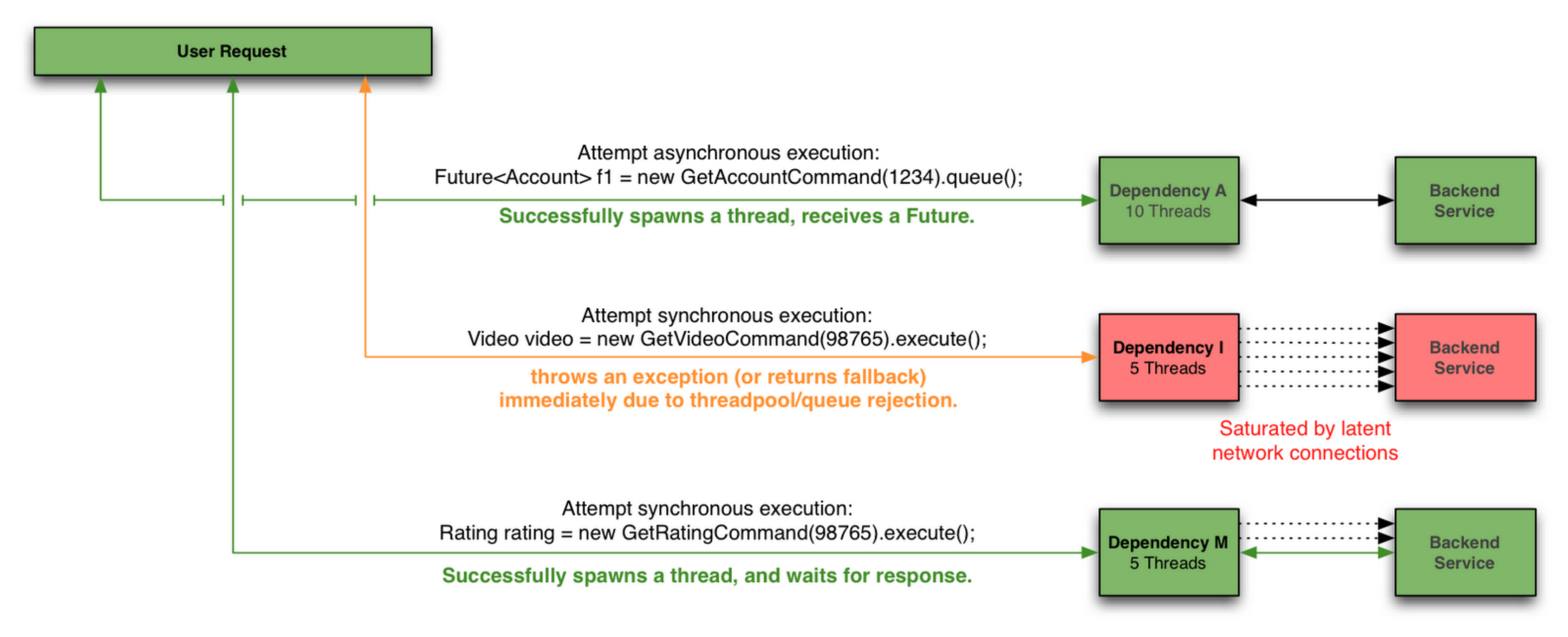
MicroServices does not automatically mean better Availability

- Unless you have Fault Tolerant Architecture

Resiliency/Availability

HYSTRIX
DEFEND YOUR APP

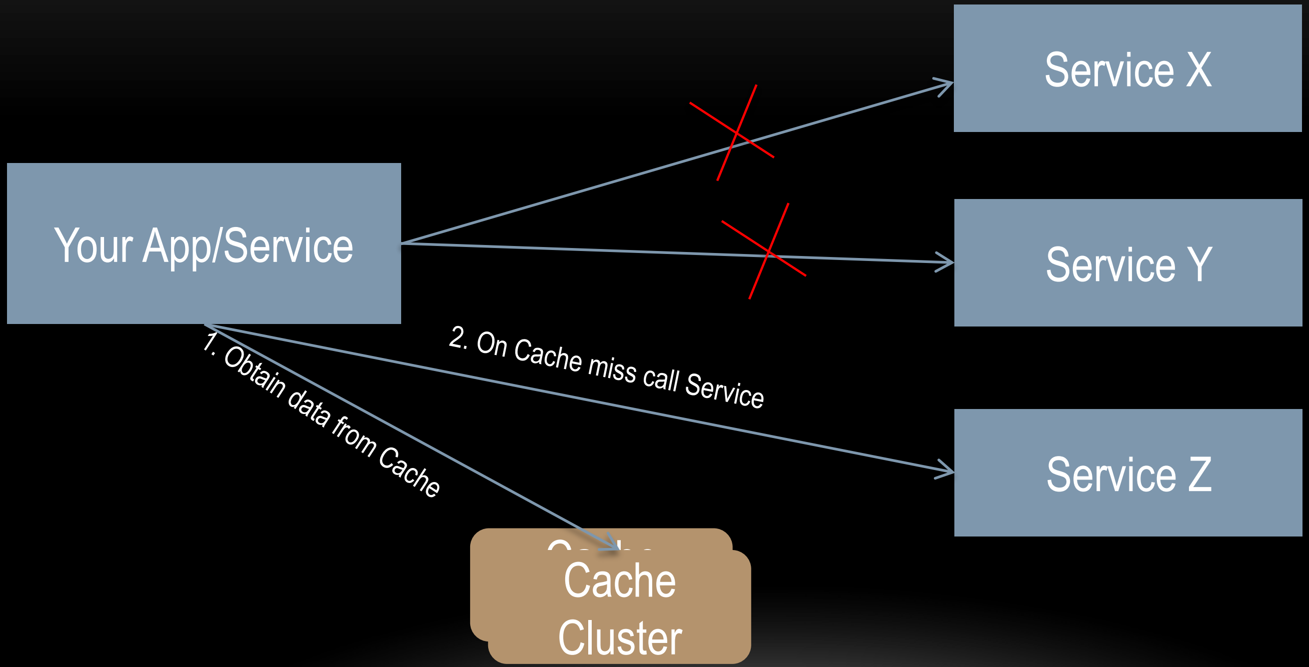
NETFLIX | OSS


User Request
Attempt asynchronous execution:
Future<Account> f1 = new GetAccountCommand(1234).queue();
Successfully spawns a thread, receives a Future.
Dependency A
10 Threads
Backend Service
Attempt synchronous execution:
Video video = new GetVideoCommand(98765).execute();
throws an exception (or returns fallback) immediately due to threadpool/queue rejection.
Dependency I
5 Threads
Backend Service
Saturated by latent network connections
Attempt synchronous execution:
Rating rating = new GetRatingCommand(98765).execute();
Successfully spawns a thread, and waits for response.
Dependency M
5 Threads
Backend Service

Circuit Breaker, Retries, Bulk Heading and Fallbacks

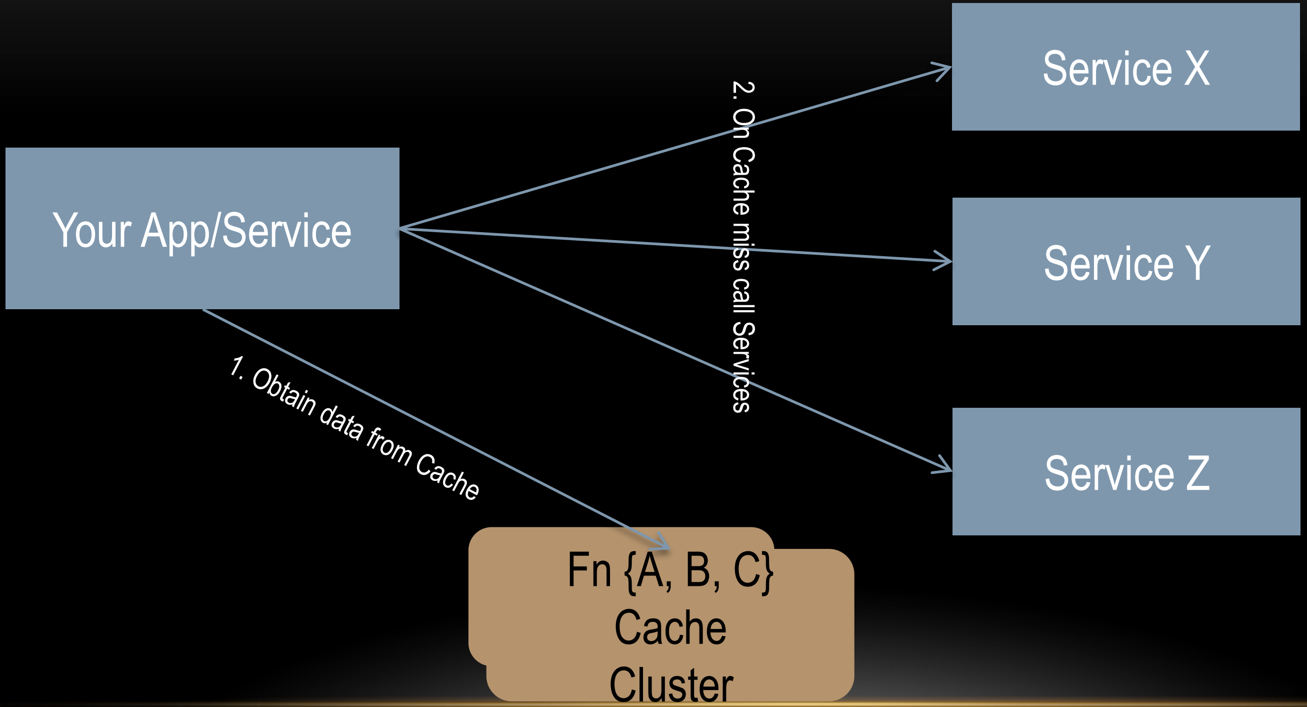
HANDLING FAN OUTS

SERVER CACHING



Tip: Config your TTL based on flexibility with data staleness!

Composite (Materialized View) Caching



Your App/Service

Service X

Service Y

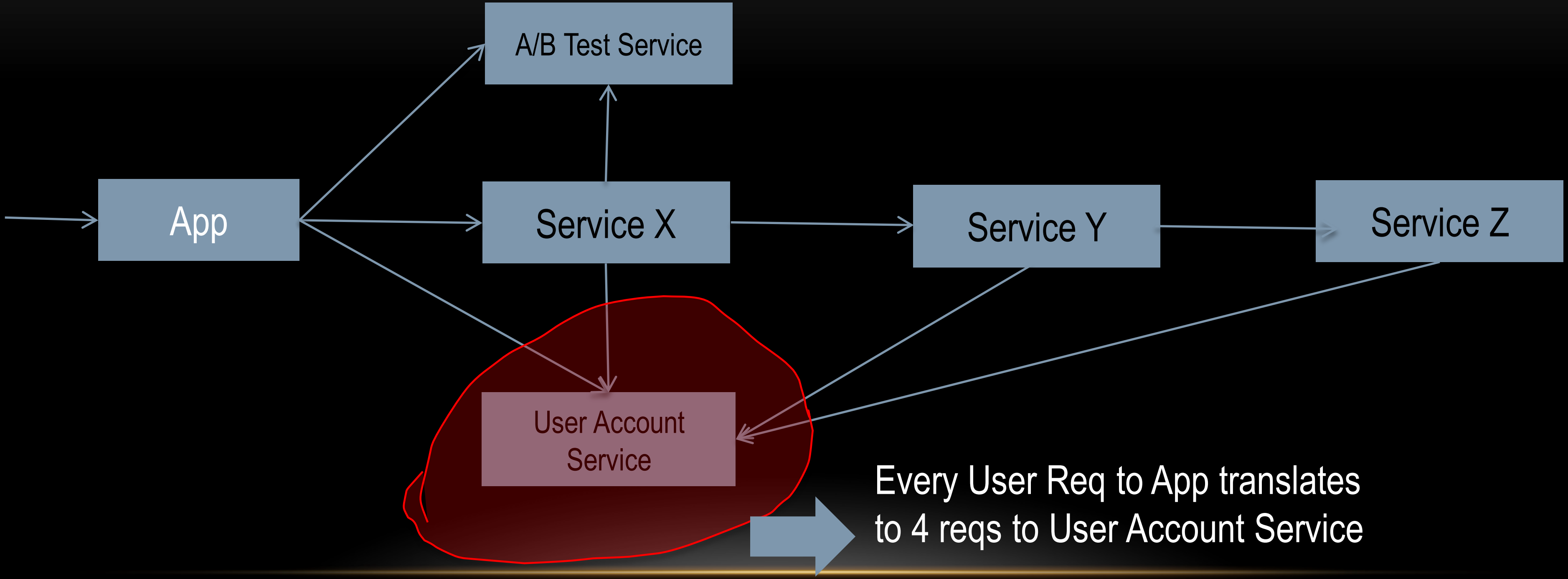
Service Z

Fn {A, B, C} Cache Cluster

1. Obtain data from Cache

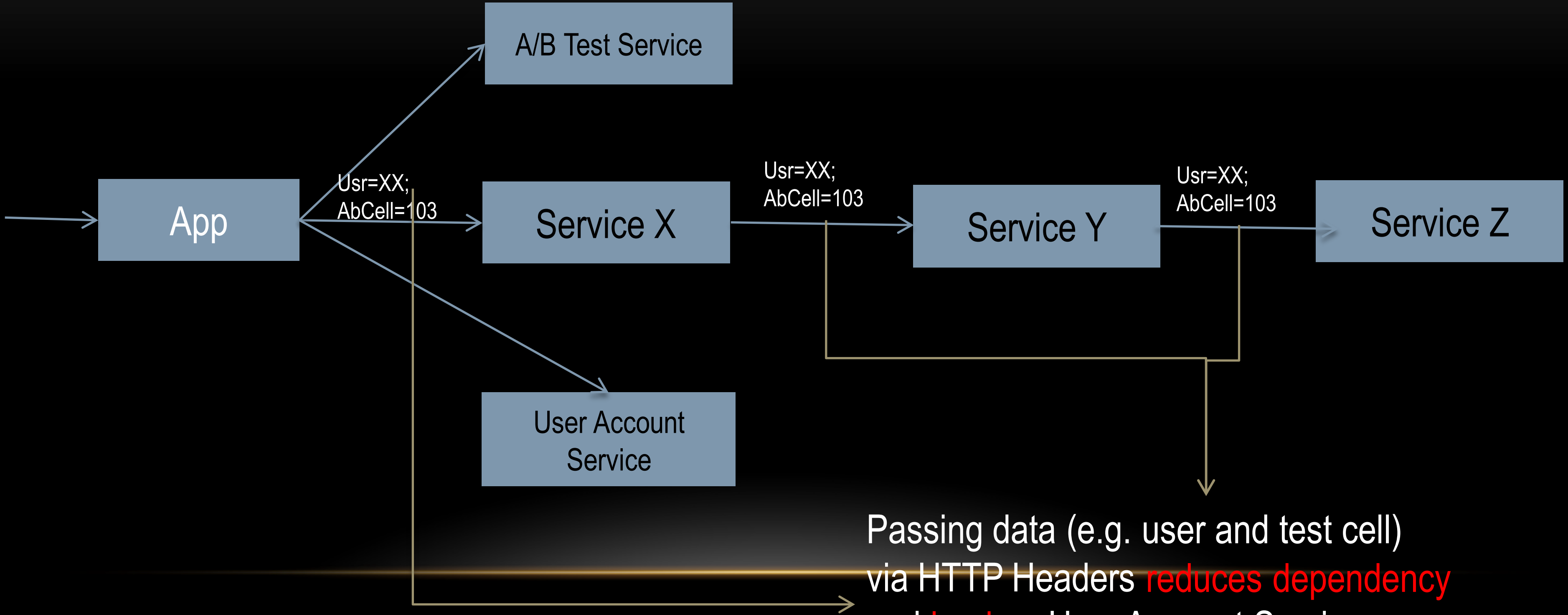
2. On Cache miss call Services

BottleNecks/HotSpots



Every User Req to App translates to 4 reqs to User Account Service

Tip: Pass data via Headers



Passing data (e.g. user and test cell) via HTTP Headers reduces dependency and load on User Account Service

TEST RESILIENCY (of Overall MicroServices)

- There are only two things certain in life*
  - Death
  - Taxes

* Benjamin Franklin

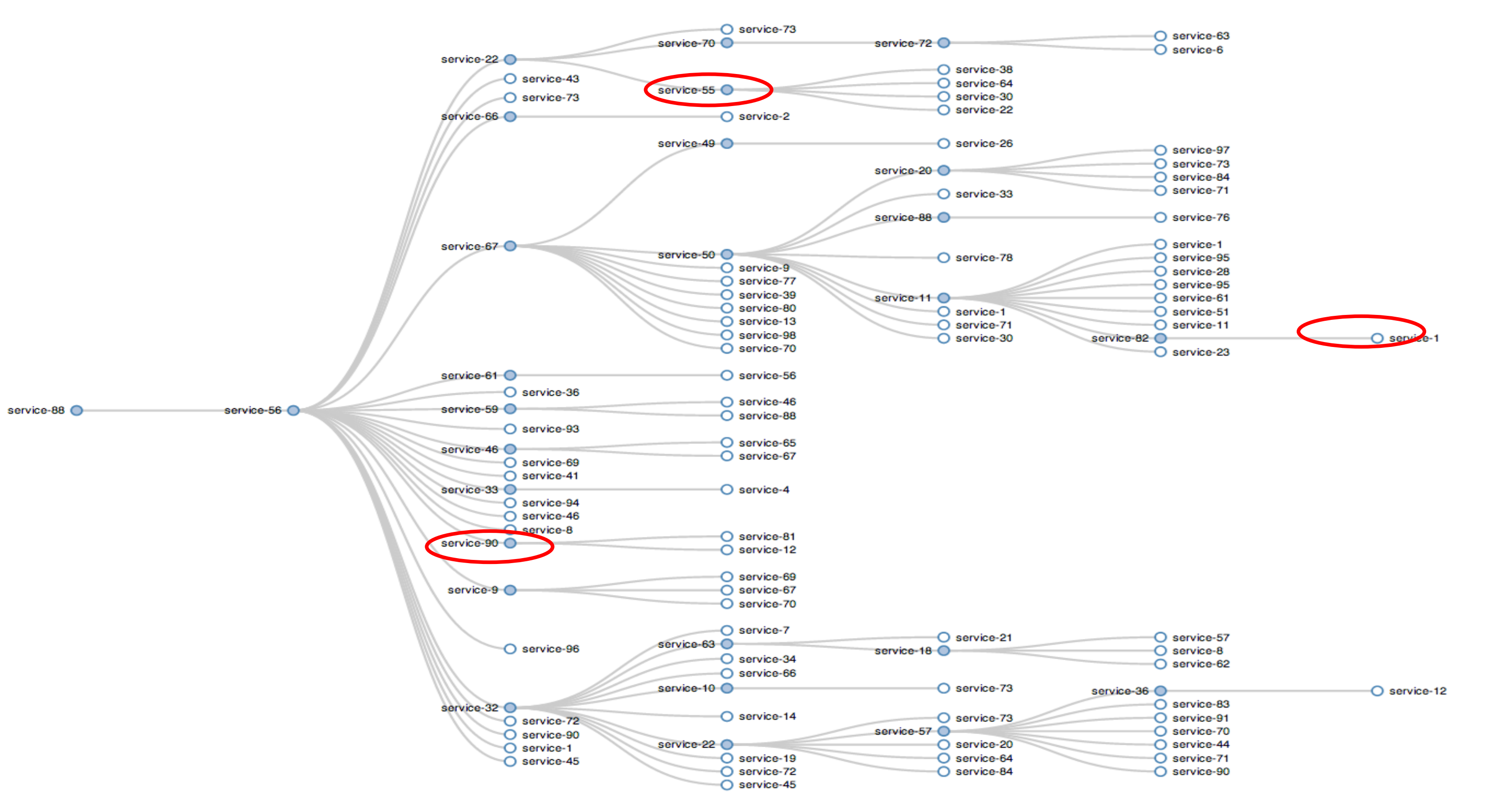
- There are only **three** things certain in life*
  - Death
  - Taxes
  - **Outages in Production**

* Inspired by Benjamin Franklin

Best Practices contd..

- Test Services for Resiliency
  - Latency/Error tests (via Simian Army)
  - Dependency Service Unavailability
  - Network Errors

Test Resiliency – to dependencies



TEST RESILIENCY

Use Simian Army https://github.com/Netflix/SimianArmy

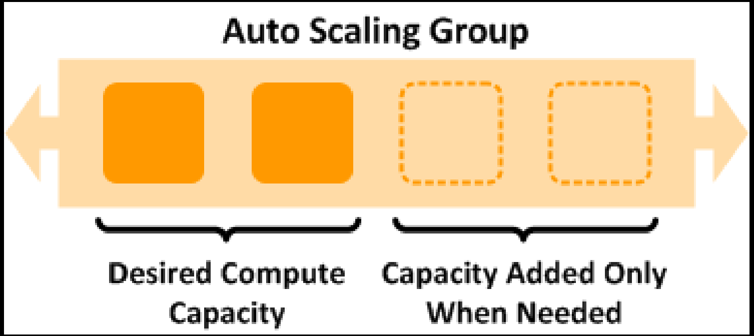
BEST PRACTICES - SUMMARY

- Isolate your services (Loosely Coupled)
- Use Client Side Smart LoadBalancers
- Dependency Calls
  - Guard your dependency calls
  - Cache your dependency call results
  - Consider Batching your dependency calls
  - Increase throughput via Async/ReactiveX patterns
- Test Services for Resiliency
  - Latency/Error tests (via Simian Army)
  - Dependency Service Unavailability
  - Network Errors

Tools of the Trade

AUTO SCALING

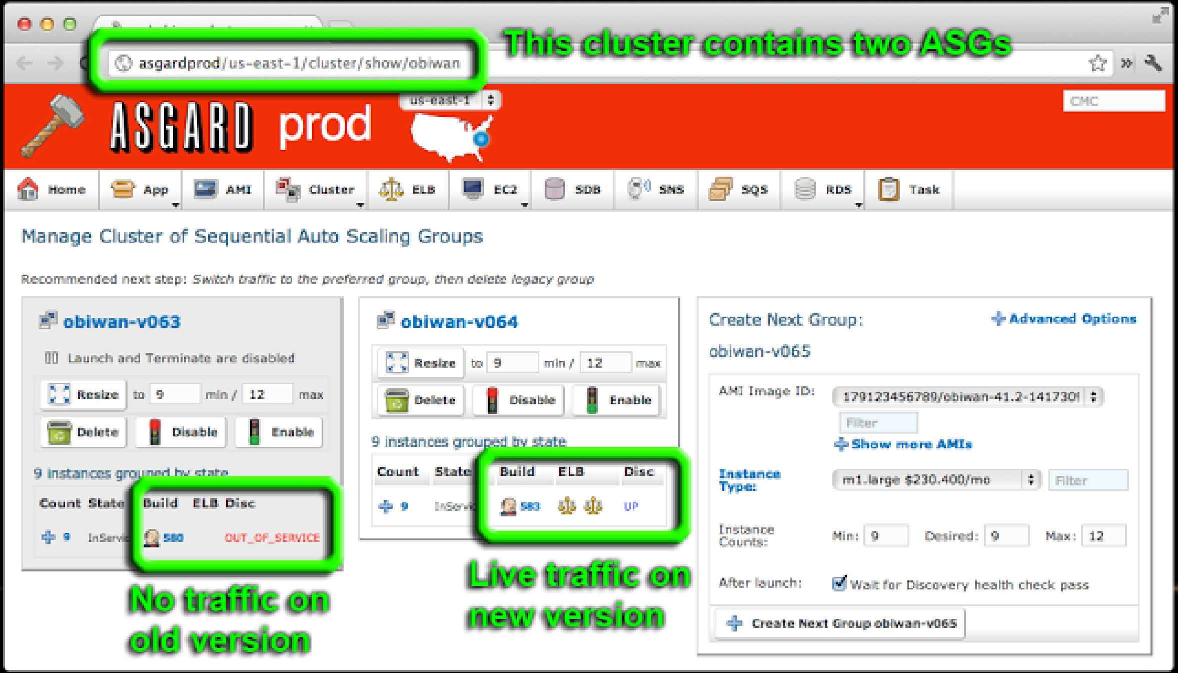
- Use AWS Auto Scaling Groups to automatically scale your microservices
  - RPS or CPU/LoadAverage via **CloudWatch** are typical metrics used to scale



http://docs.aws.amazon.com/AutoScaling/latest/DeveloperGuide/WhatIsAutoScaling.html

USE CANARY, RED/BLACK PUSHES

- NetflixOSS Asgard helps manage deployments



This cluster contains two ASGs

Manage Cluster of Sequential Auto Scaling Groups

Recommended next step: *Switch traffic to the preferred group, then delete legacy group*

obiwan-v063

Launch and Terminate are disabled

Resize to 9 min / 12 max

Delete | Disable | Enable

9 instances grouped by state

Count	State	Build	ELB	Disc
9	InServ	580		OUT_OF_SERVICE

No traffic on old version

obiwan-v064

Resize to 9 min / 12 max

Delete | Disable | Enable

9 instances grouped by state

Count	State	Build	ELB	Disc
9	InServ	583		UP

Live traffic on new version

Create Next Group: obiwan-v065

Advanced Options

AMI Image ID: 179123456789/obiwan-41.2-141730!

Filter

Show more AMIs

Instance Type: m1.large $230.400/mo Filter

Instance Counts: Min: 9 Desired: 9 Max: 12

After launch: ☑ Wait for Discovery health check pass

Create Next Group obiwan-v065

Service Dependency Visualization

MicroServices at Netflix

SERVICE DEPENDENCY GRAPH

How many dependencies does **my service** have?

What is the Call Volume on my Service?

Are any Dependency Services running **Hot**?

What are the **Top N Slowest** “Business Transactions”?

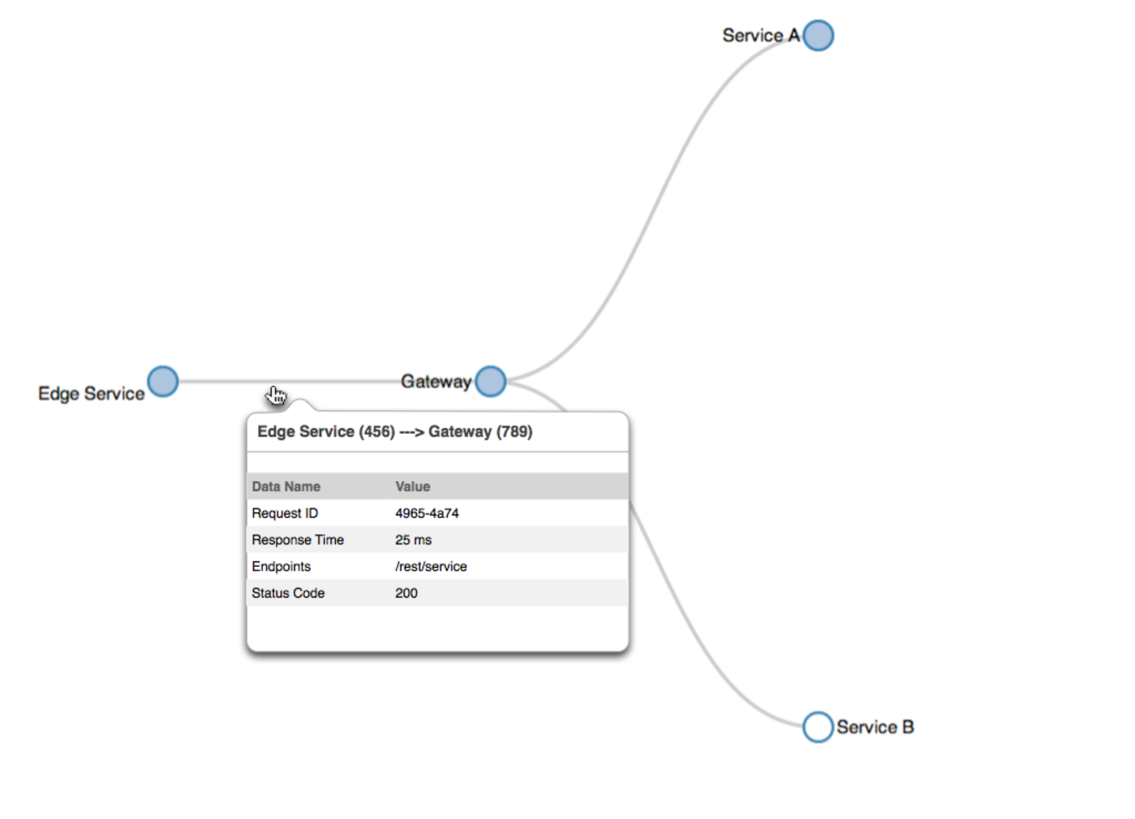
What are the **sample HTTP Requests/Responses** that had a 500 Error Code in the last 30 minutes?

SERVICE DEPENDENCY VISUALIZATION

Your Service Dependency Graph

You

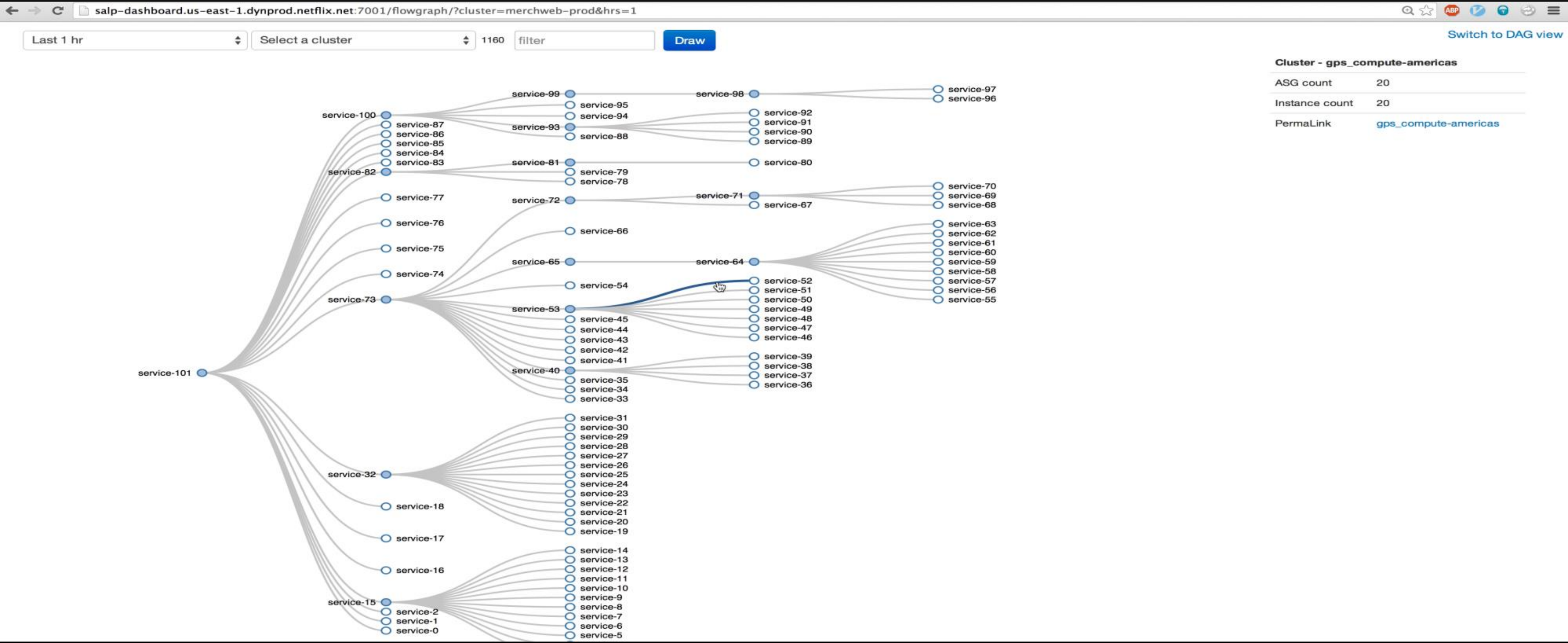
Service Dependency Visualization



Edge Service (456) ---> Gateway (789)

Data Name	Value
Request ID	4965-4a74
Response Time	25 ms
Endpoints	/rest/service
Status Code	200

Dependency Visualization

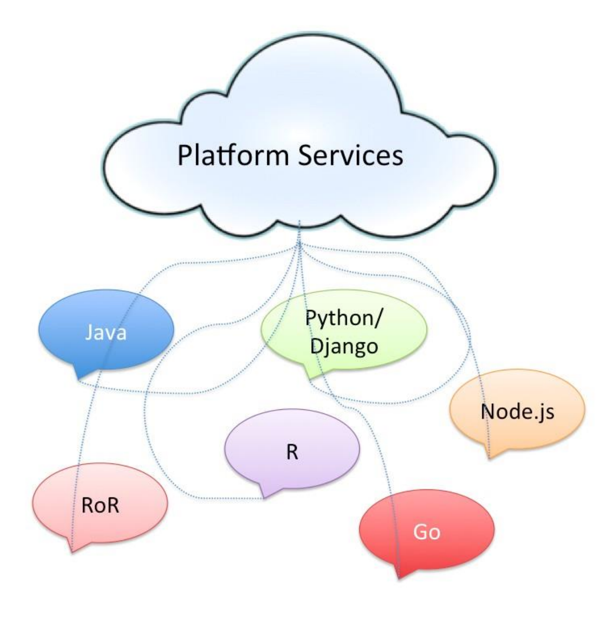


salp-dashboard.us-east-1.dynprod.netflix.net:7001/flowgraph/?cluster=merchweb-prod&hrs=1

Cluster - gps_compute-americas	
ASG count	20
Instance count	20
PermaLink	gps_compute-americas

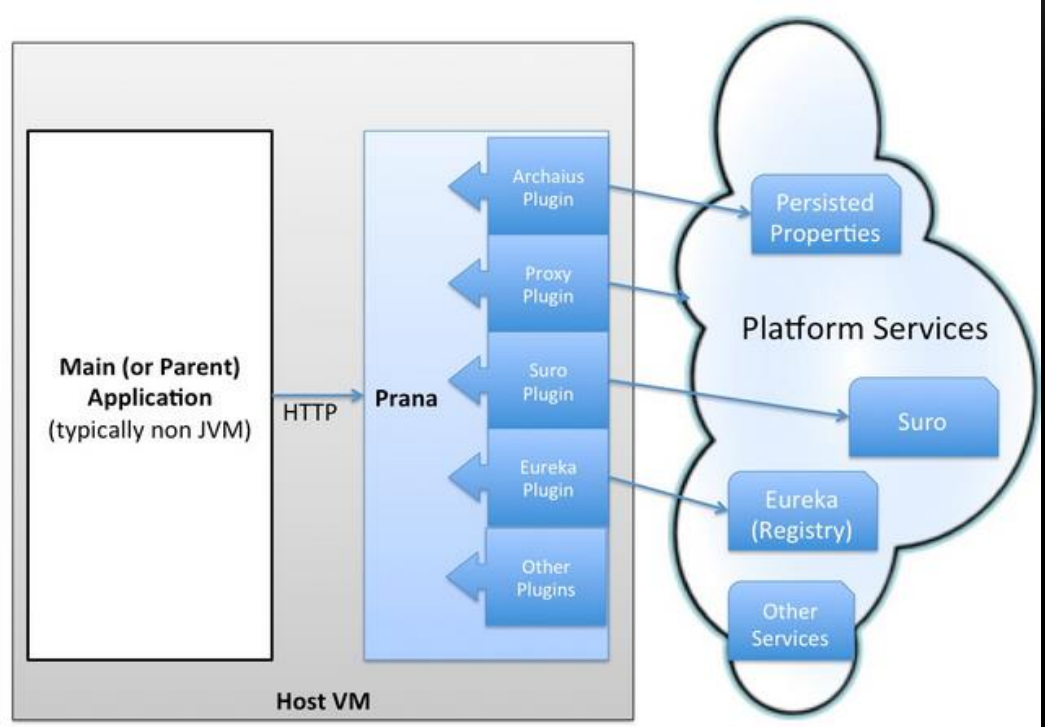
Polyglot Ecosystem

Homogeneity in A Polyglot Ecosystem



TIP: USE A SIDECAR

- Provides a common homogenous Operational/Infrastructural component for all your non-JVM
  based MicroServices

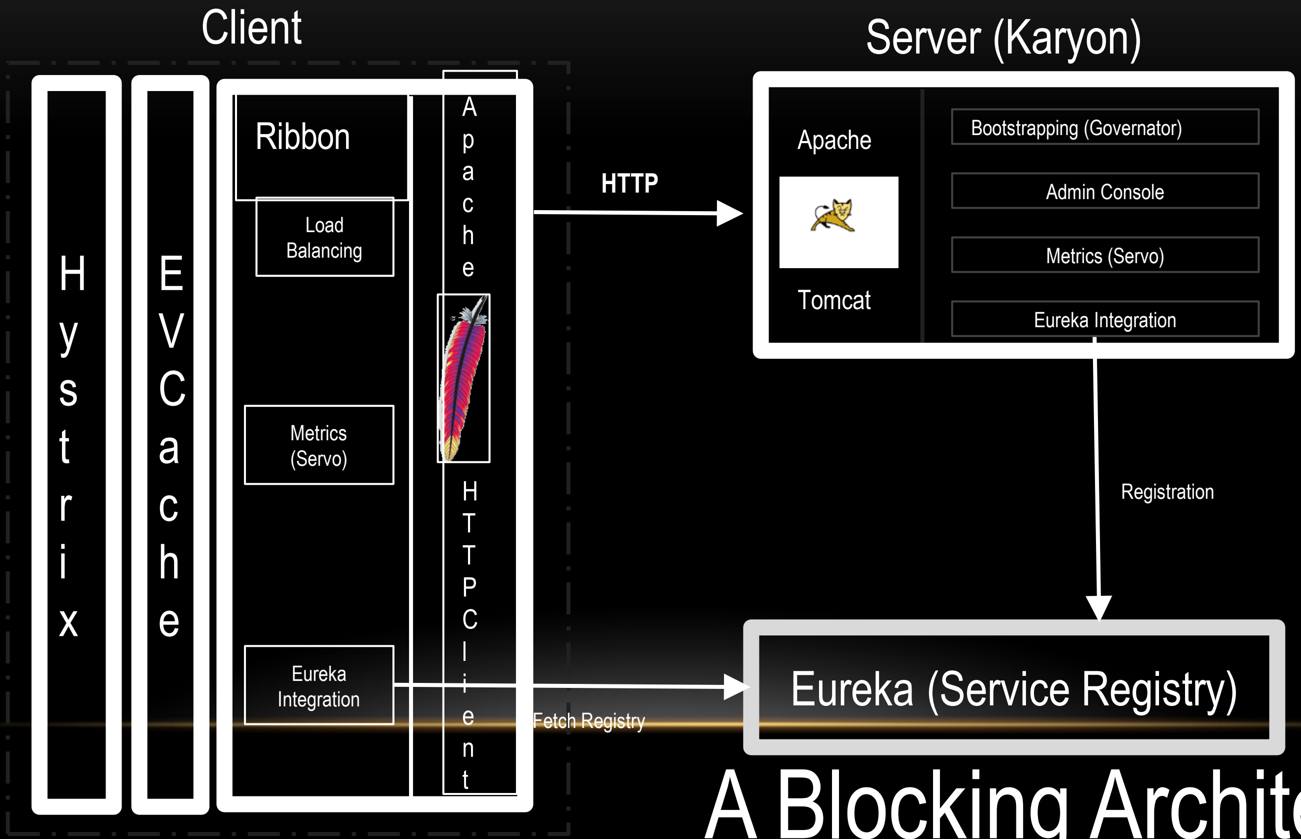


Prana Open Sourced!

- Just this morning!
- http://github.com/netflix/Prana

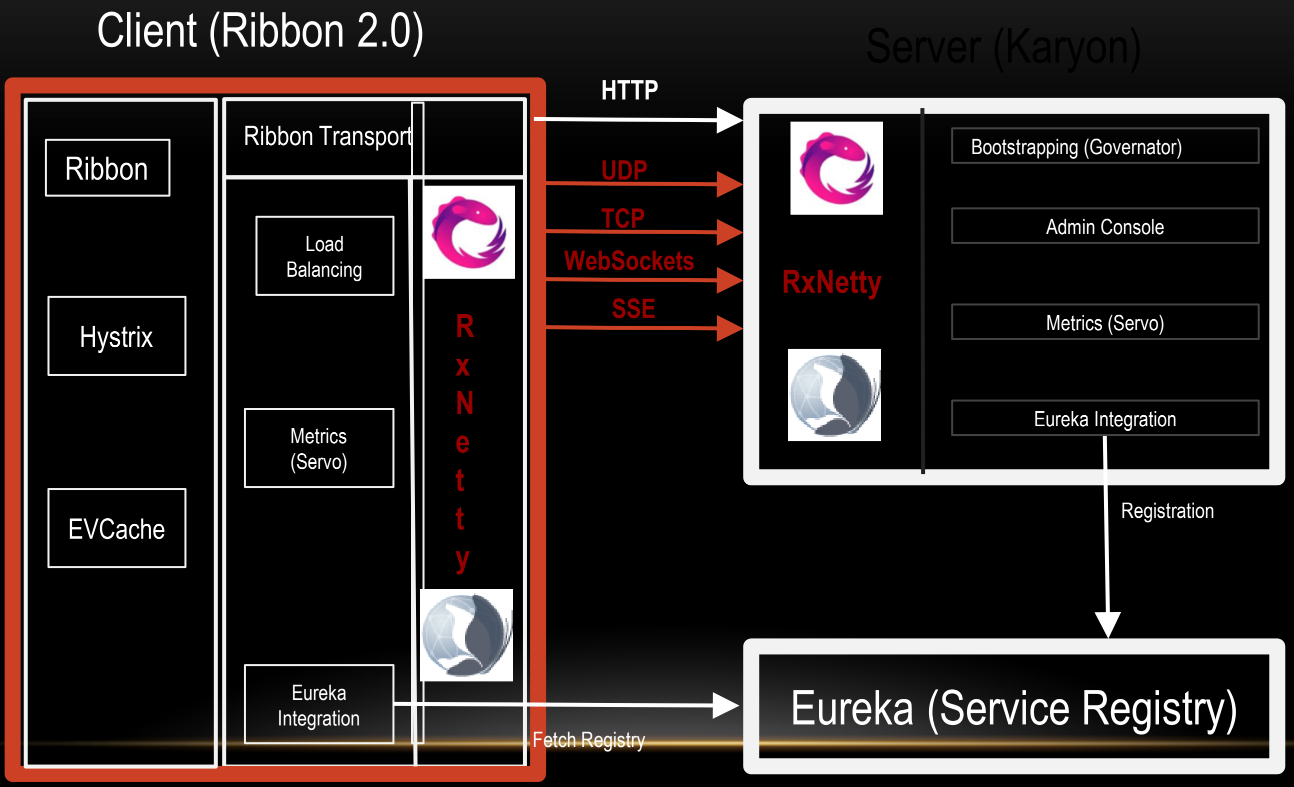
Inter Process Communication

Netflix IPC Stack (1.0)



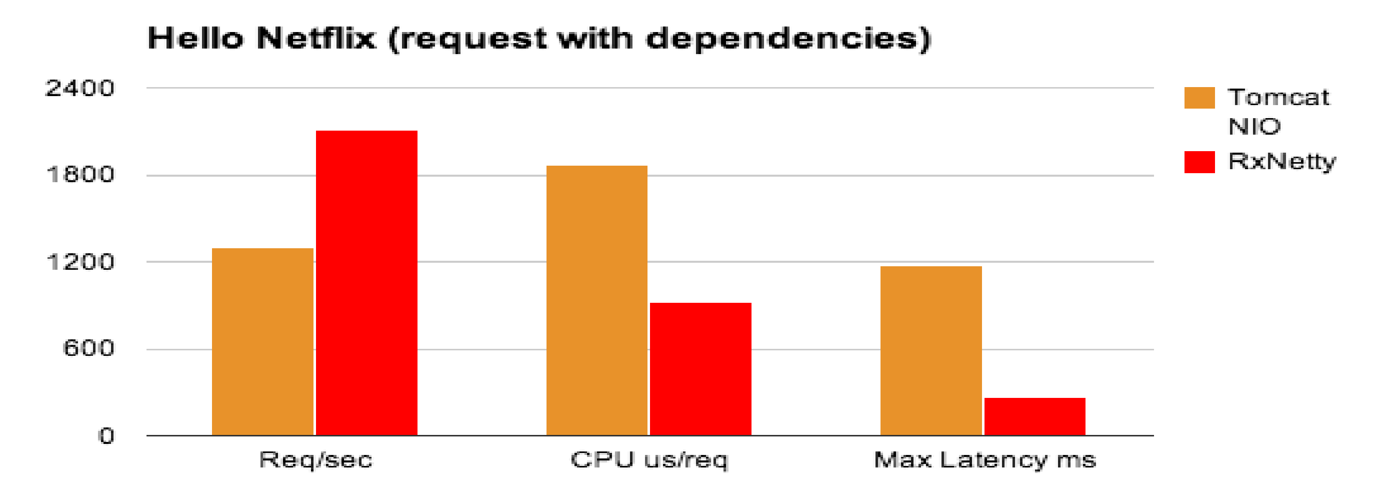
A Blocking Architecture

Netflix IPC Stack (2.0)



A Completely Reactive Architecture

Performance – Throughput

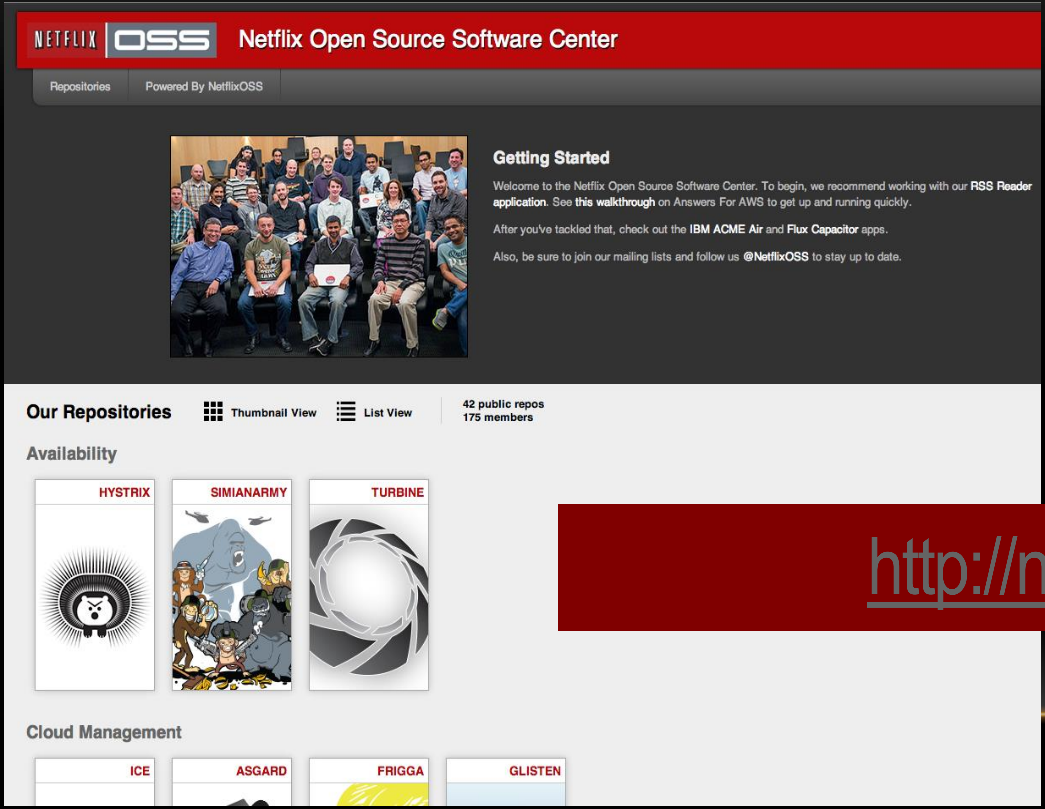


Bounded Thread model (Tomcat) vs Reactive Async (RxNetty)

Details: http://www.meetup.com/Netflix-Open-Source-Platform/events/184153592/

NetflixOSS

LEVERAGE NETFLIXOSS



Netflix Open Source Software Center

Getting Started

Welcome to the Netflix Open Source Software Center. To begin, we recommend working with our **RSS Reader application**. See **this walkthrough** on Answers For AWS to get up and running quickly.

After you've tackled that, check out the **IBM ACME Air** and **Flux Capacitor** apps.

Also, be sure to join our mailing lists and follow us **@NetflixOSS** to stay up to date.

Our Repositories

42 public repos
175 members

Availability

Cloud Management

http://netflix.github.co

NETFLIX | OSS

- Eureka – for Service Registry/Discovery
- Karyon – for Server (Reactive or threaded/servlet container based)
- Ribbon – for IPC Client
  - And Fault Tolerant Smart LoadBalancer
- Hystrix – for Fault Tolerance and Resiliency
- Archaius – for distributed/dynamic Properties
- Servo – unified Feature rich Metrics/Insight
- EVCache – for distributed cache
- Curator/Exhibitor – for zookeeper based operations
- …

Takeaways

Takeaways

- Monolithic apps – good for small organizations
- MicroServices – have its challenges, but the benefits are many
  - Consider adopting when your **organization scales**
  - Leverage Best Practices
    - An Elastic Cloud provides the **ideal** environment (Auto Scaling etc.)
    - NetflixOSS has many libraries/samples to aid you

Questions?