Design Patterns for High Availability

Lessons learned building Amazon CloudFront

CTD303

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amazon web services

What to Expect from the Session

- Learn about the design patterns for high availability of Amazon CloudFront

- Learn how you can implement the patterns in your own services or applications built on top of AWS

What is a Content Delivery Network (CDN)?

Amazon CloudFront locations worldwide

68 POPs

21 Countries

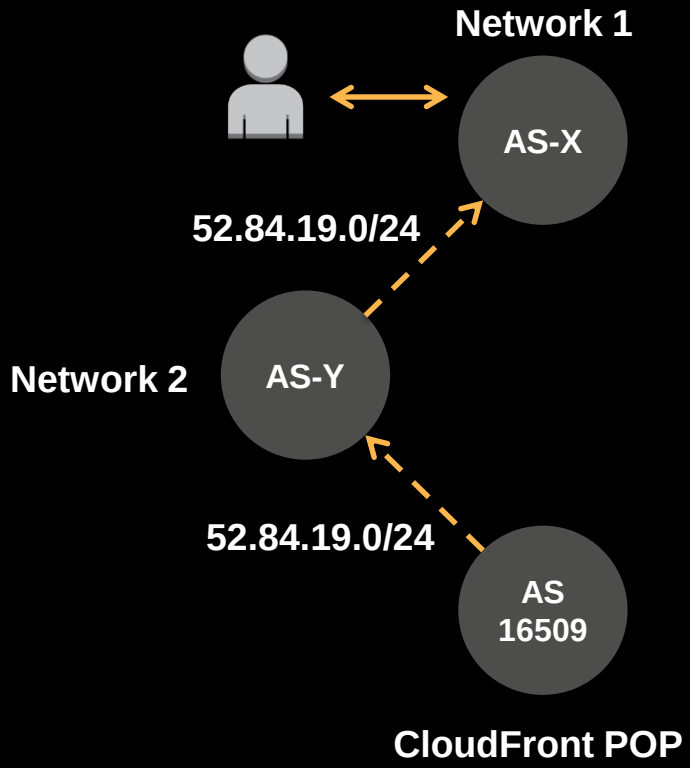
43 Cities

5 Continents

North America | South America | EMEA | APAC

AWS Region CloudFront Edge Location

How does Amazon CloudFront work?



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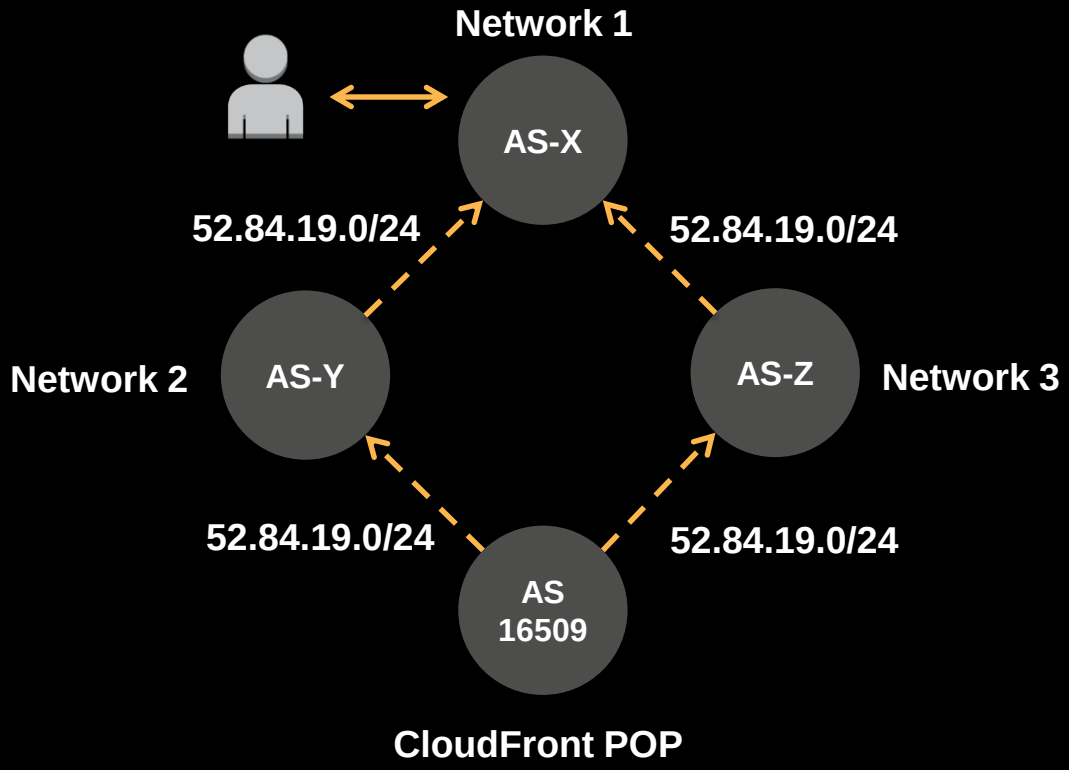
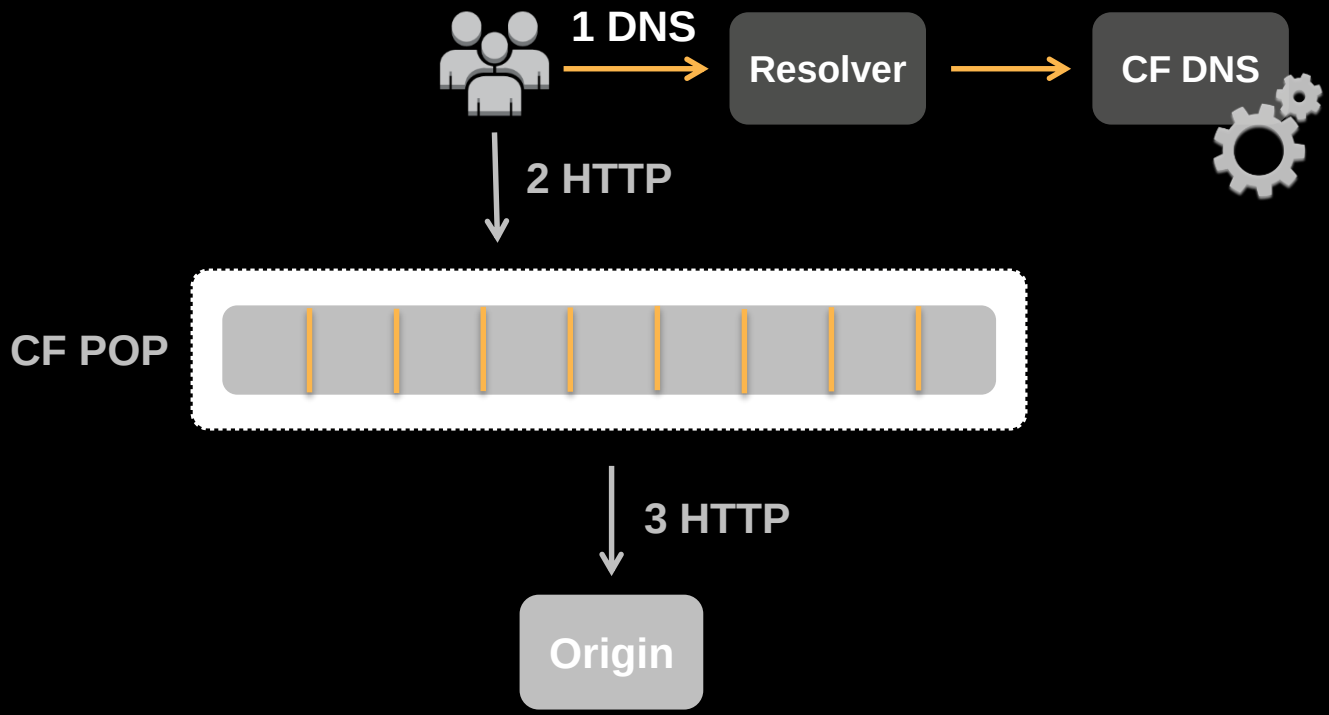


Sequence of events



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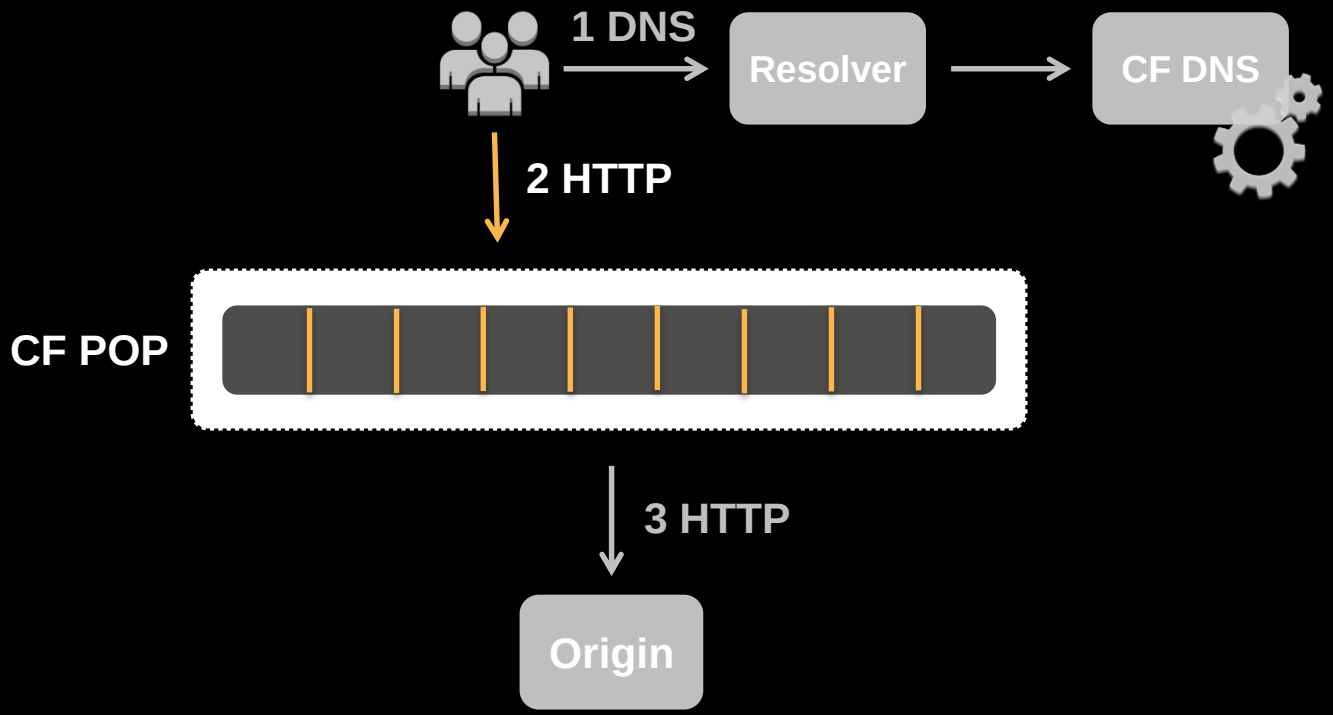

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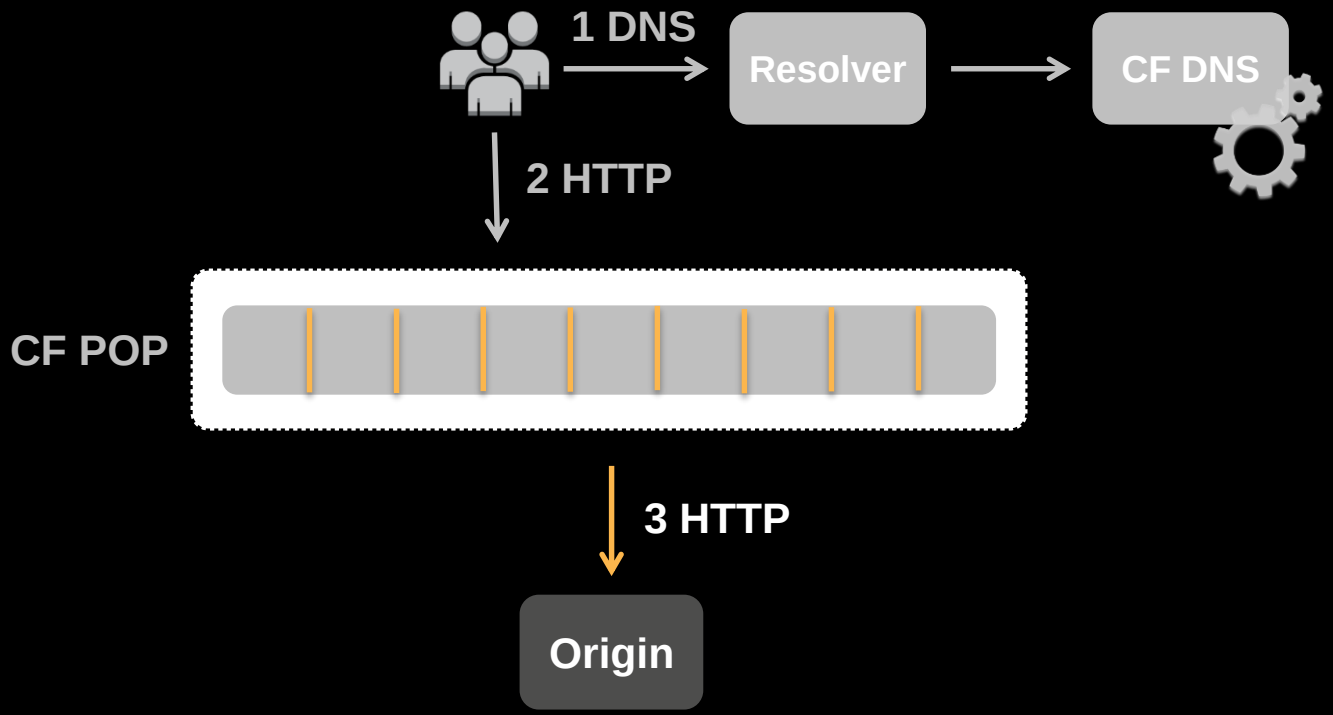
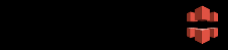
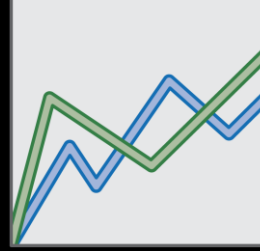


How to monitor availability

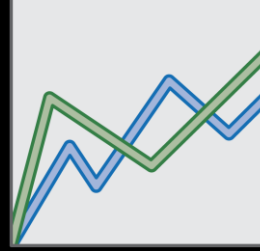


How CloudFront monitors availability



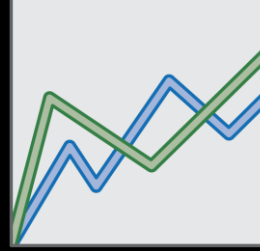
1. Analysis of server-side metrics

How CloudFront monitors availability



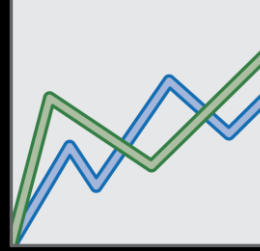
1. Analysis of server-side metrics
2. **Canaries**

How CloudFront monitors availability



1. Analysis of server-side metrics
2. Canaries
3. **Third-party global HTTP tests**

How CloudFront monitors availability



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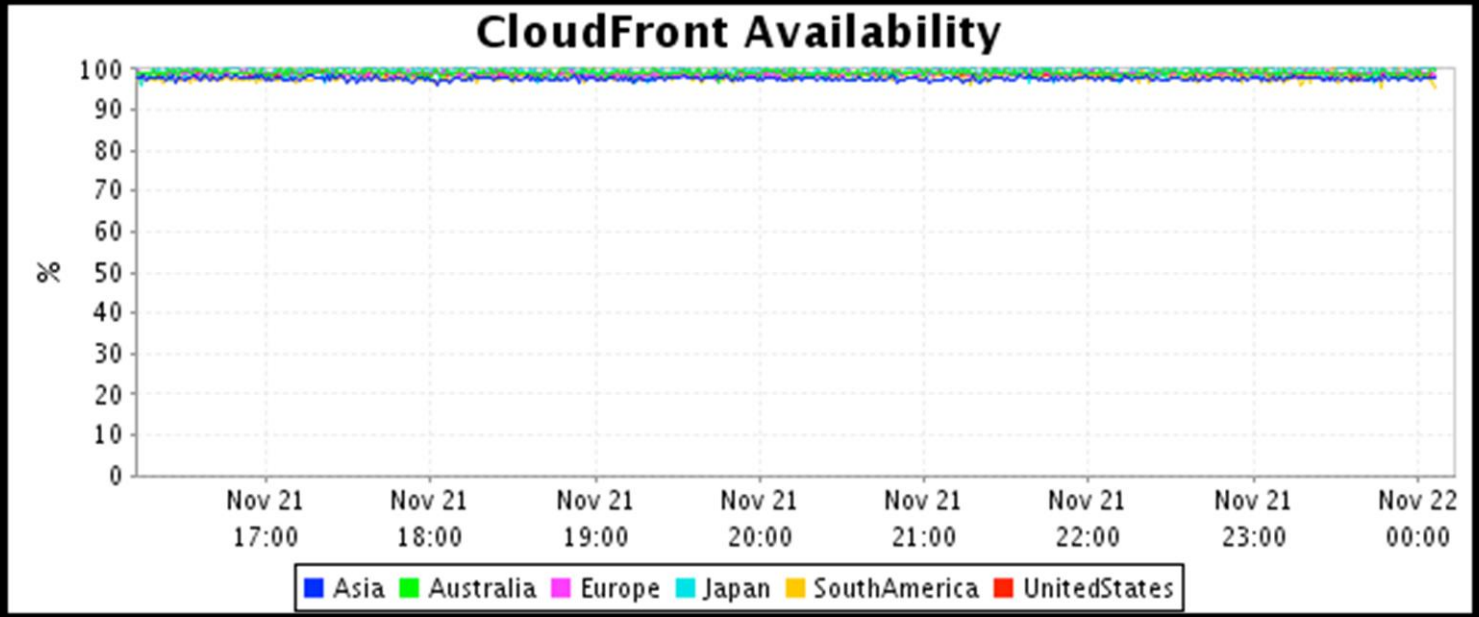
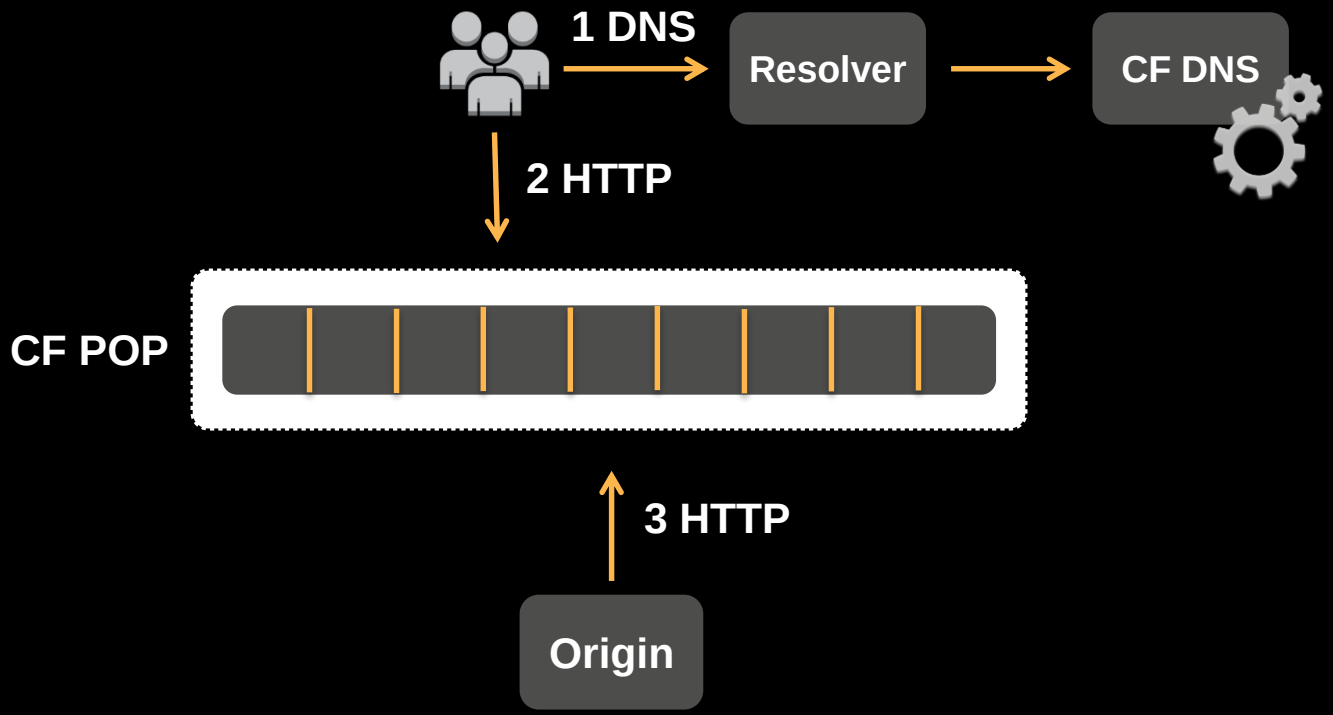


Availability interruption

Segfault in CloudFront DNS server

```
27: int dns_get_domain_length(const char *domain) {  /* <== domain is NULL */
28:     const char *pos;
29:     unsigned char ch;
30:
31:     pos = domain;
32:     while ((ch = *pos++) != 0)          /* <== SEGFAULT */
33:         pos += (unsigned int) ch;
34:
35:     return pos - domain;
36: }
```

Potential causes of application failure



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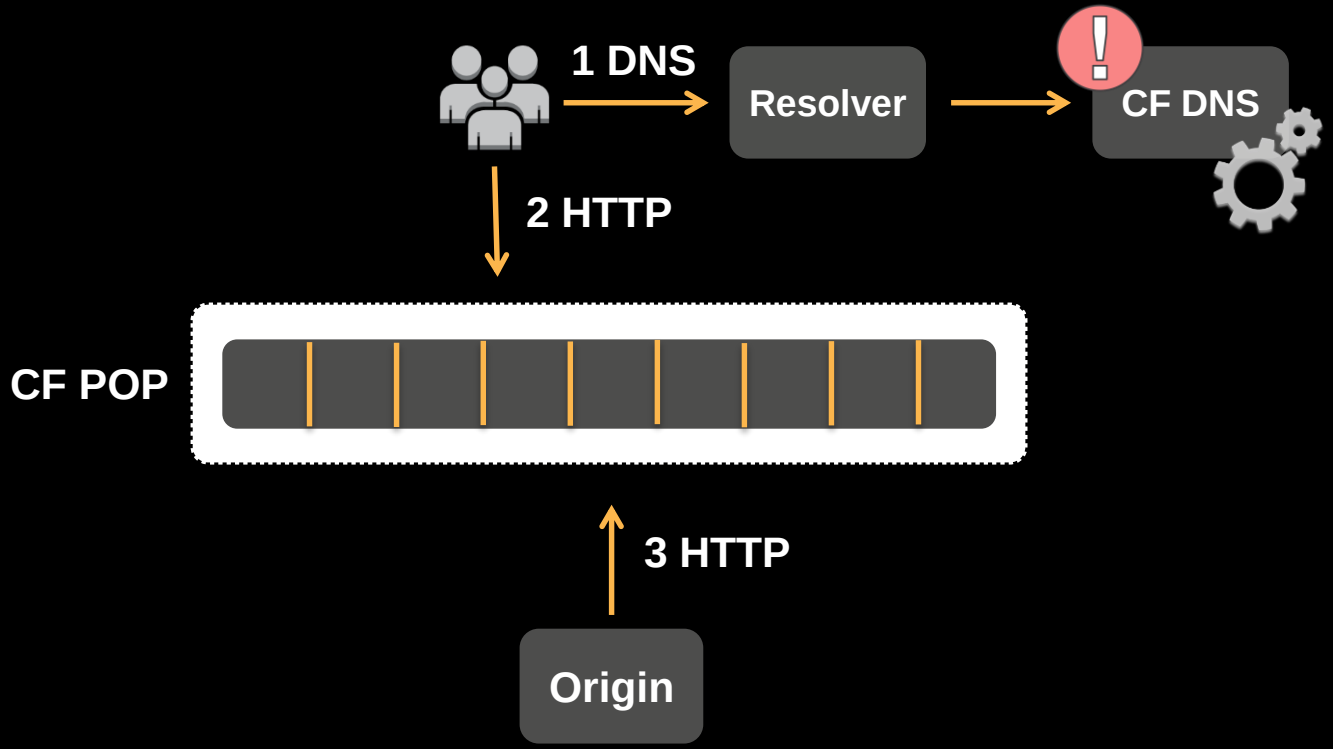

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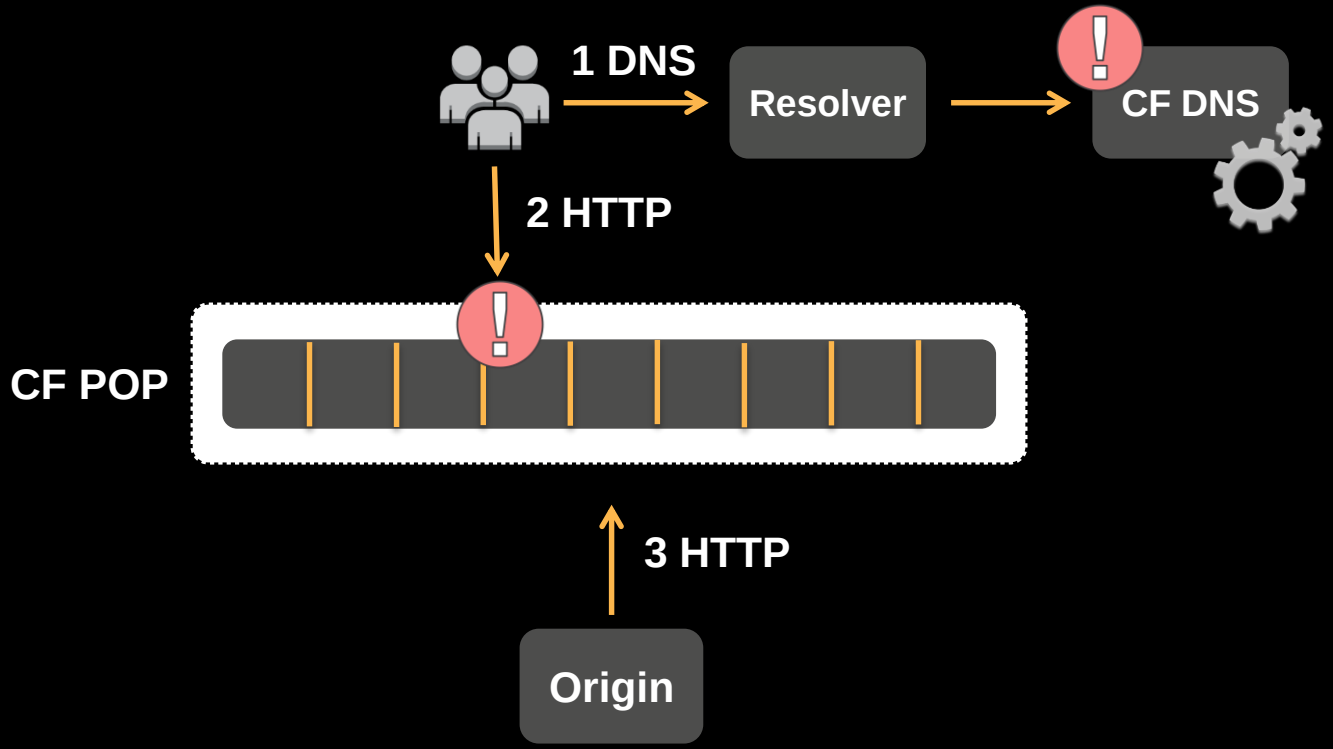

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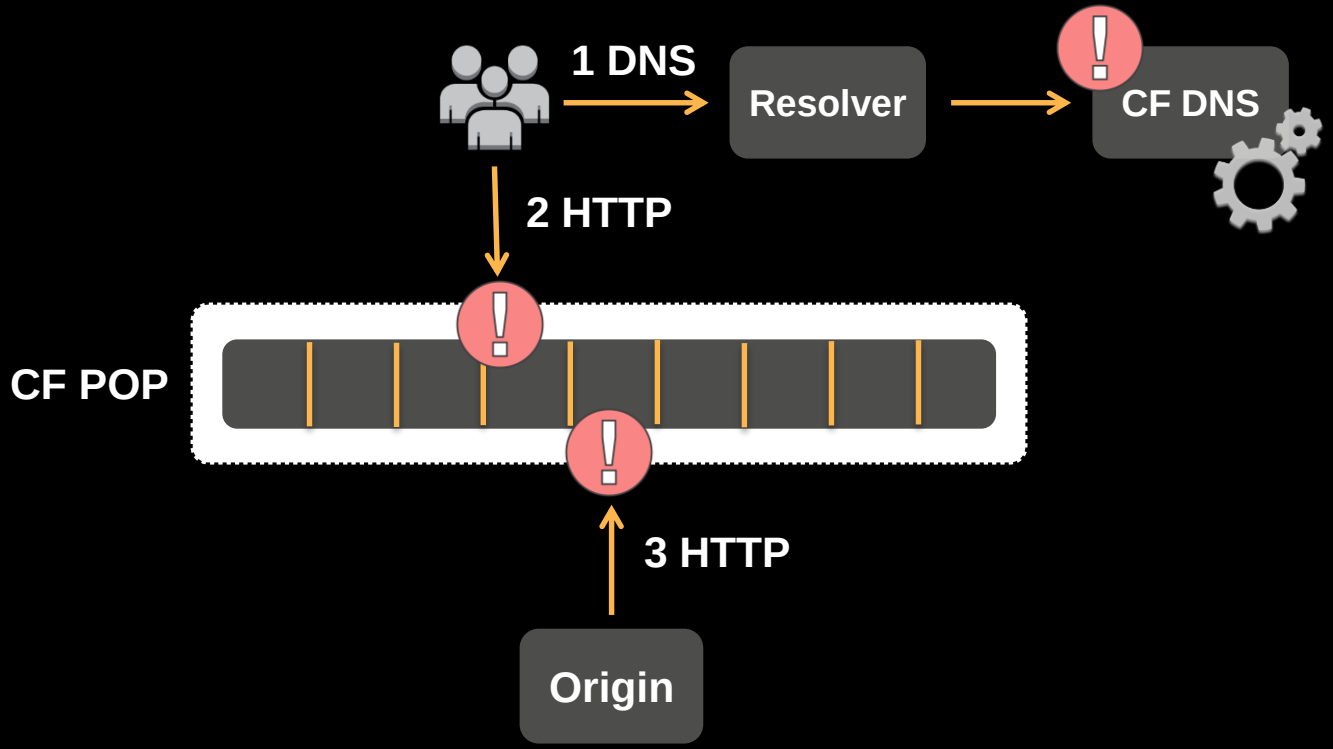

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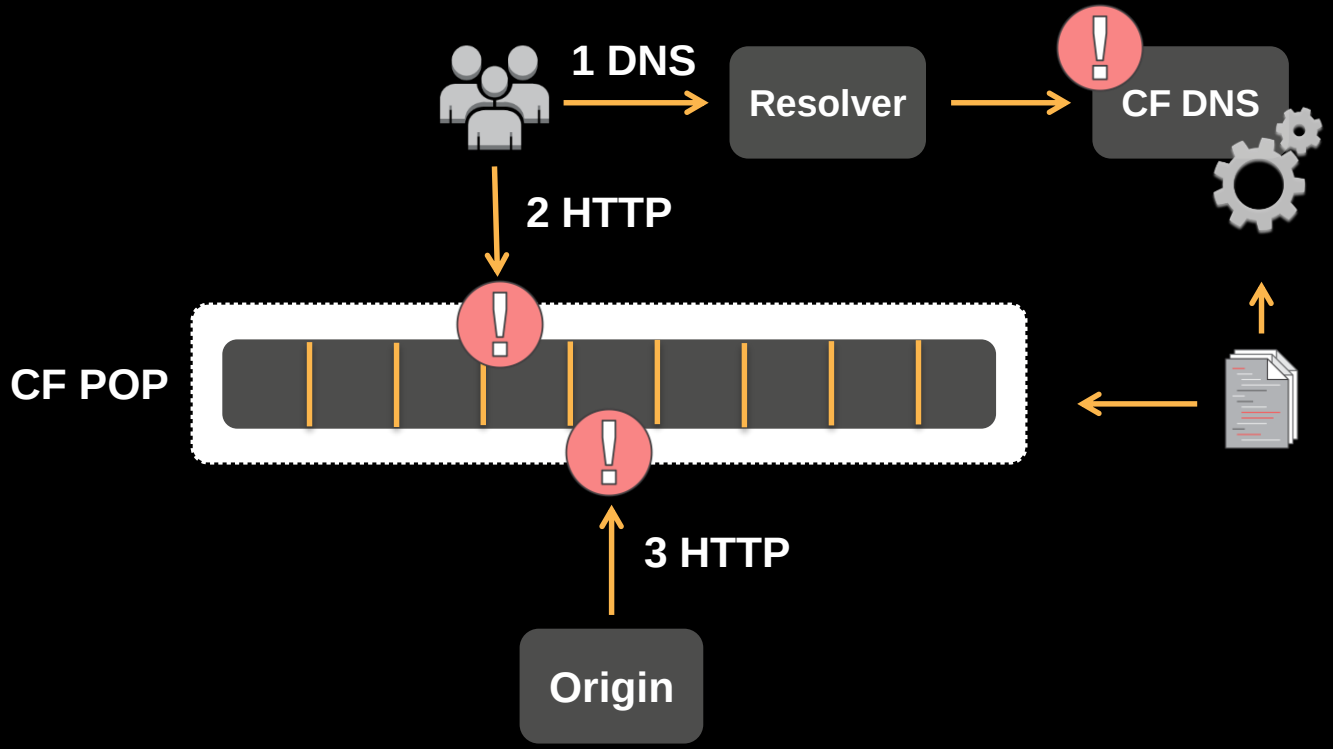

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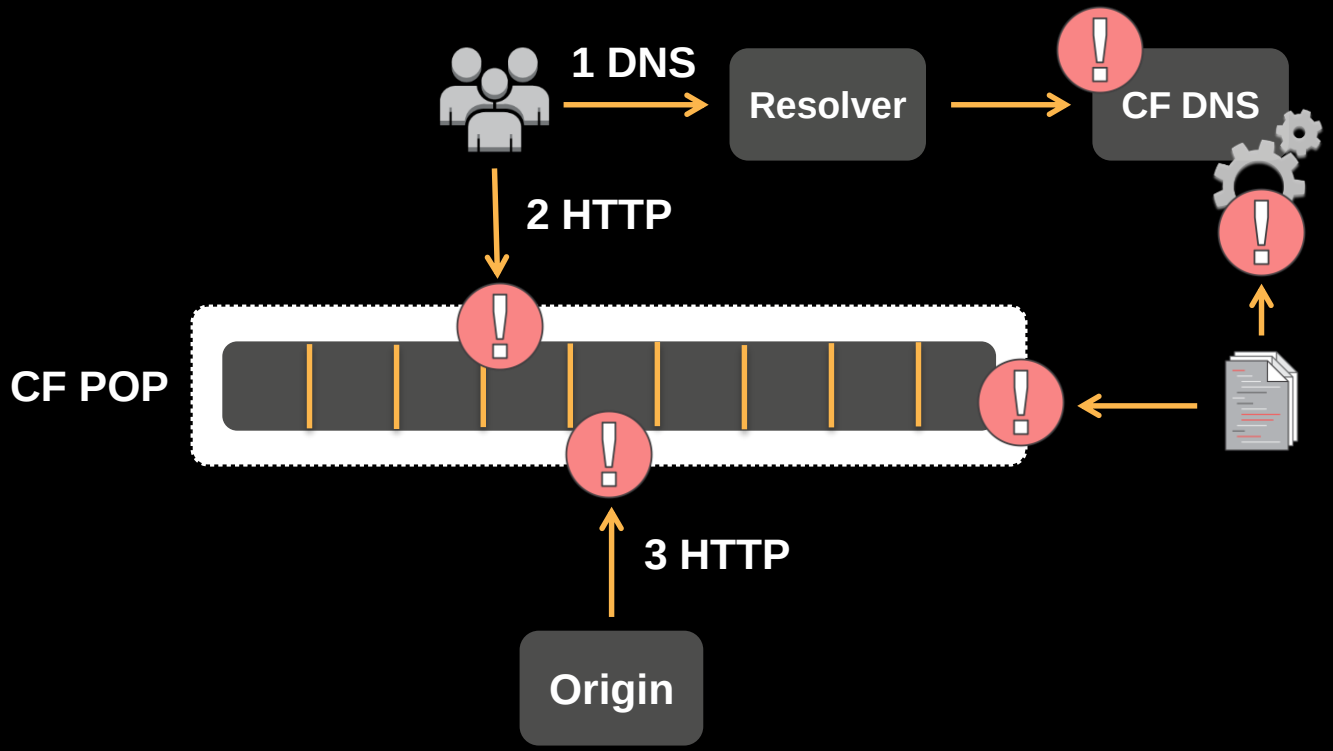

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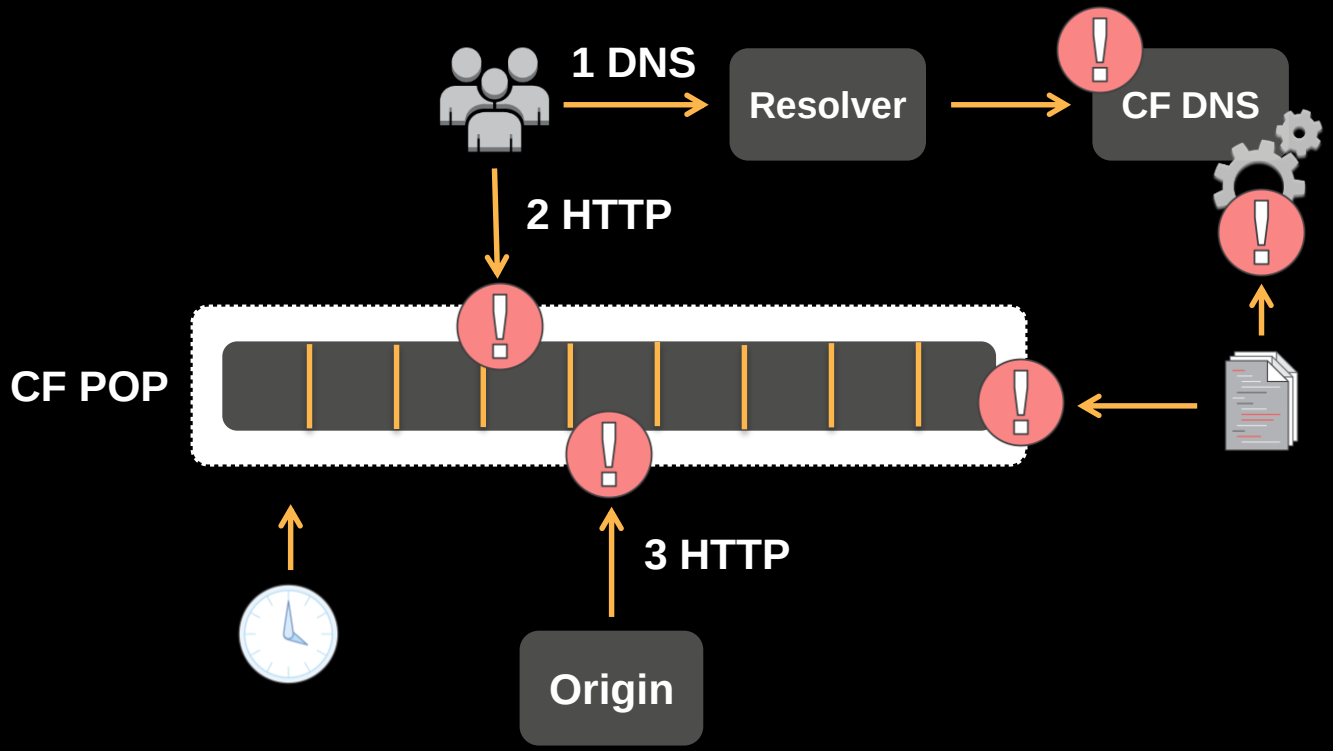

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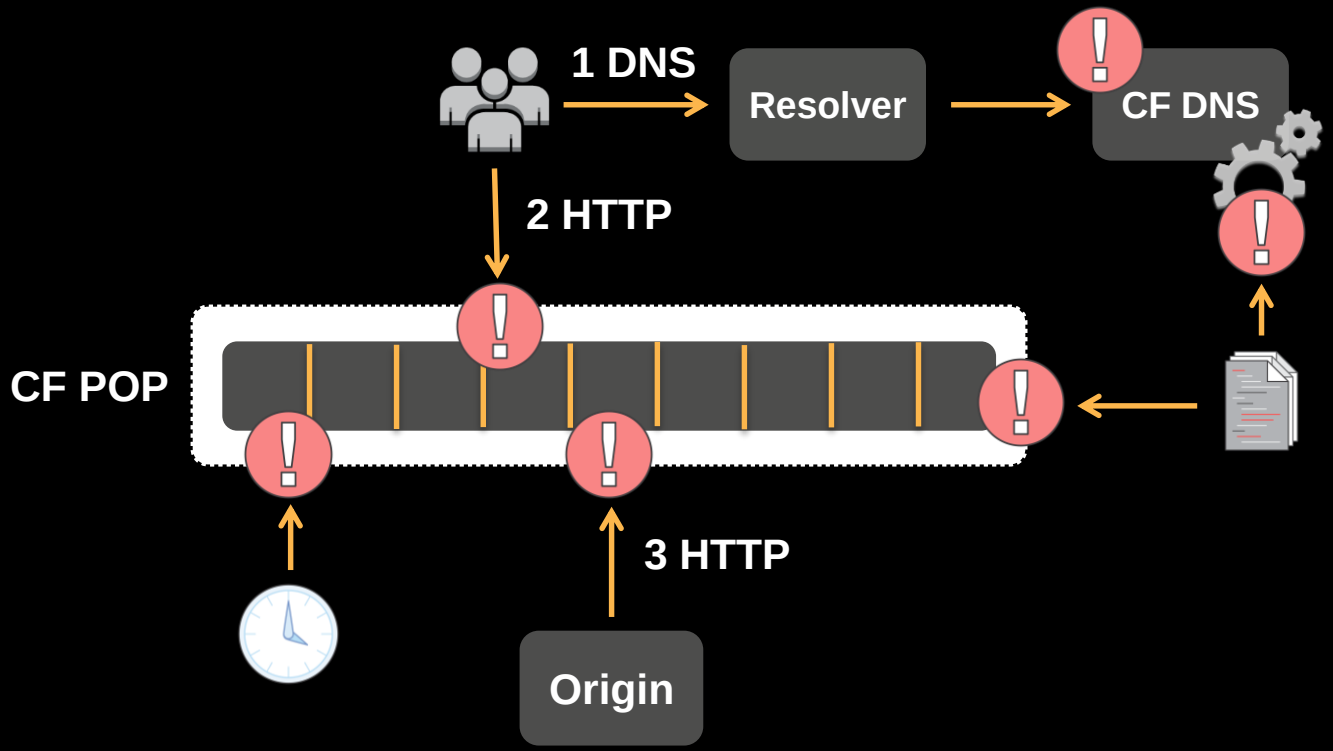

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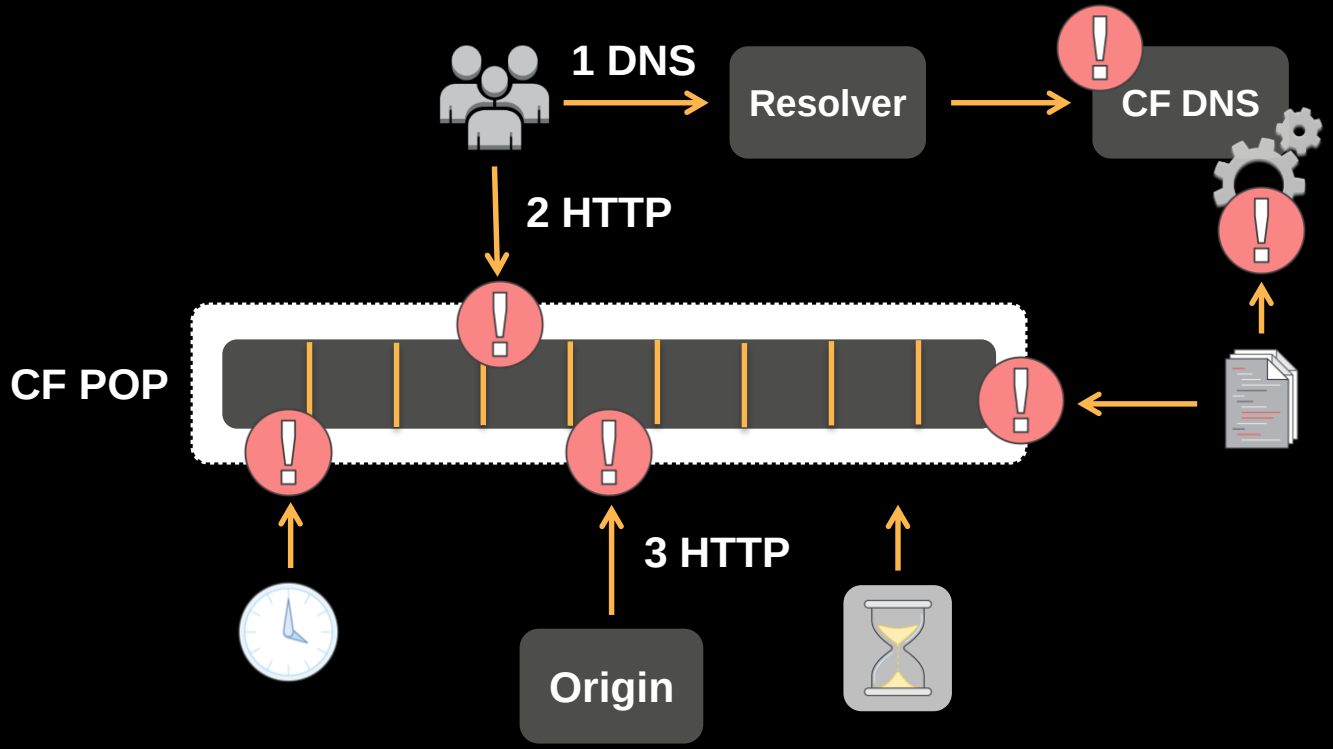

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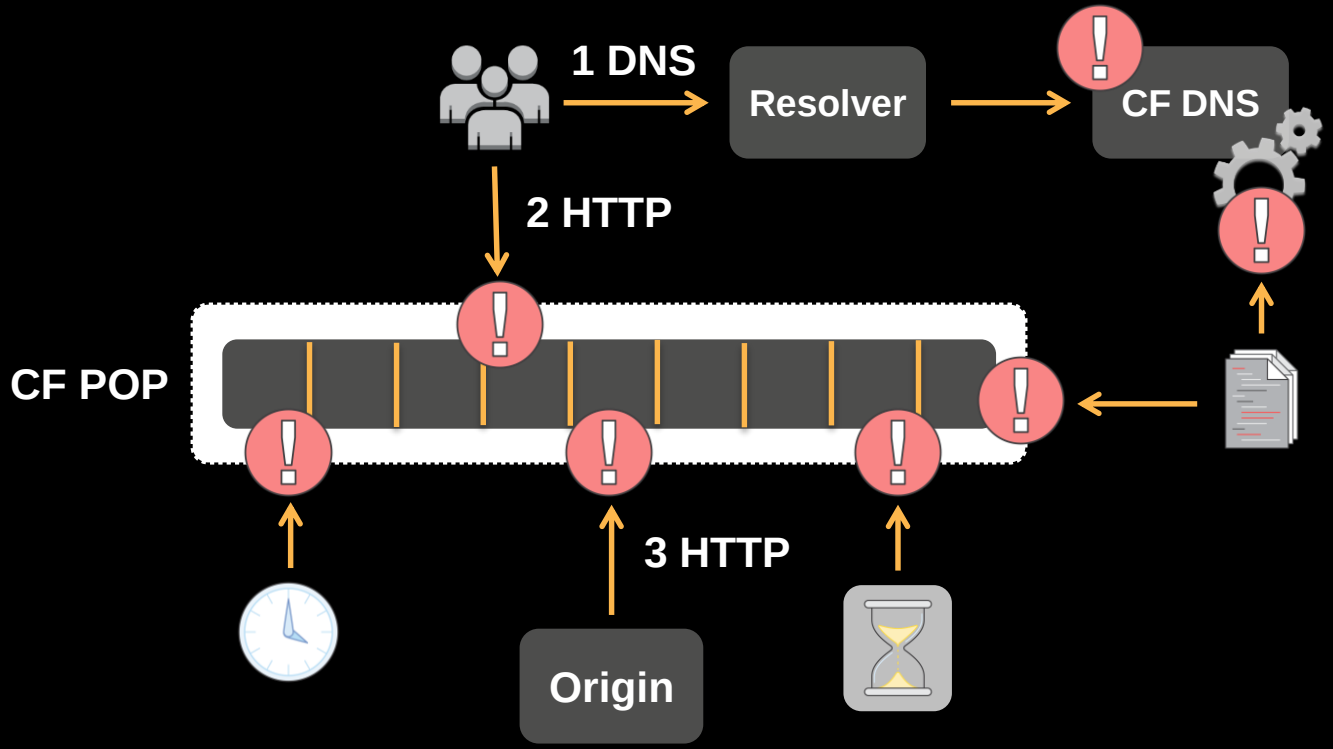
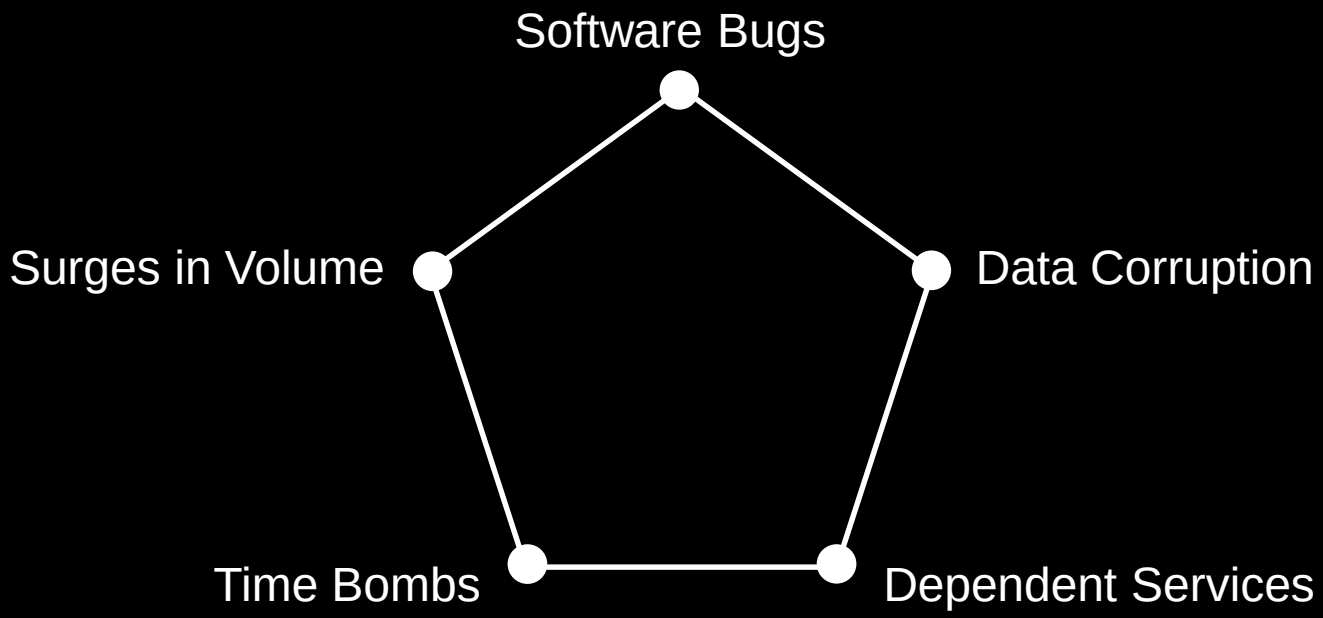


Risks to availability



Rapid Iteration on Capabilities

2008

- CloudFront Launched with 14 POPs

2009

- Access Logs
- Lower Pricing Tiers
- Management Console
- Private Content
- RTMP Streaming

2010

- 1-Hour TTLs
- Custom Origins
- Default Root Object
- HTTPS Support
- Invalidations
- Price Drop, SLA
- Private Streaming
- RTMP Access Logs
- Singapore
- New York City
- Jacksonville

2011

- File Size Increase
- IAM Integration
- Live Streaming
- Price Drop
- Paris
- Stockholm
- Sao Paulo
- San Jose
- South Bend
- Los Angeles (2nd)
- New York City (2nd)

2012

- Geo-Blocking
- Live Streaming Update
- Multiple Cache Behaviors
- Multiple Origins
- QueryString Forwarding
- Zero TTL Support
- Osaka
- Milan
- Virginia (2nd)
- Singapore (2nd)
- Frankfurt (2nd)
- London (2nd)
- Dallas (2nd)

2013

- Cookie Based Caching
- Custom SSL Support
- Enhanced Logs
- HTTP 1.1
- Lower Inter-Region Pricing
- Price Classes
- Private Content Console Support
- Zone Apex Support
- Chennai & Mumbai
- Seoul
- Hayward
- Madrid
- Sydney
- Paris (2nd)
- Amsterdam (2nd)
- Tokyo (2nd)
- Hong Kong (2nd)
- New York City (3rd)
- Virginia (3rd)

2014

- Smooth Streaming
- SNI Custom SSL
- HTTP to HTTPS Redirect
- Usage Charts
- Free Tier
- EDNS Client Subnet
- CloudTrail
- Device Detection, Geo Targeting, Host Header Forwarding
- Advanced SSL Features
- Wildcard Cookies
- Monitoring & Alarming
- Content Charts
- Price Reduction
- Zero Rate AWS Origin Traffic
- Directory Path as Origin
- Viewer Charts
- Rio de Janeiro
- Taipei
- Melbourne

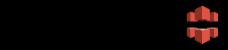
2015

- Signed Cookie Support
- Smart TV Device Detection
- Devices Report
- Usage Metrics CSV Export
- Wildcard Invalidations
- Default TTLs
- Max TTLs
- PCI DSS Compliance
- AWS WAF Integration
- Auto Gzip Compression
- Modify Request Headers
- Chicago
- Seoul (2nd)

2016

- Enforce HTTPS Connections
- TLSv1.1 and TLSv1.2 to Origin
- AWS Certificate Manager Integration
- Cost Allocation Tagging
- Query String Whitelisting
- HTTP/2
- Toronto
- Montreal
- New Delhi
- Atlanta (2nd)
- Mumbai (2nd)
- Seoul (3rd)
- Frankfurt (2nd)
- Japan (4th)
- Hong Kong (3rd)
- London (4th)
- Berlin
- Minneapolis
- IPv6
- ACM Cert Import
- Regional Edge Caches
- […]

Design patterns for availability



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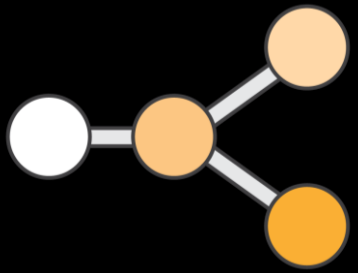
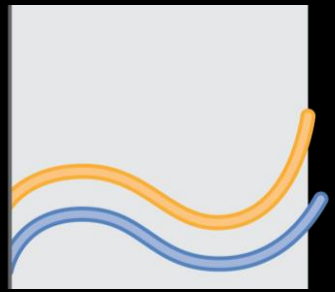


Maximizing availability with Food Tasting

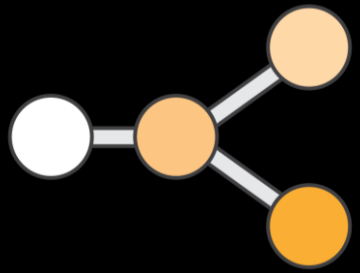


Flash Crowds without scaling for the peak

Defense in Depth Strategies

Time Bomb Jitter Protection

Design pattern 1: FoodTaster



Maximizing availability with Food Tasting

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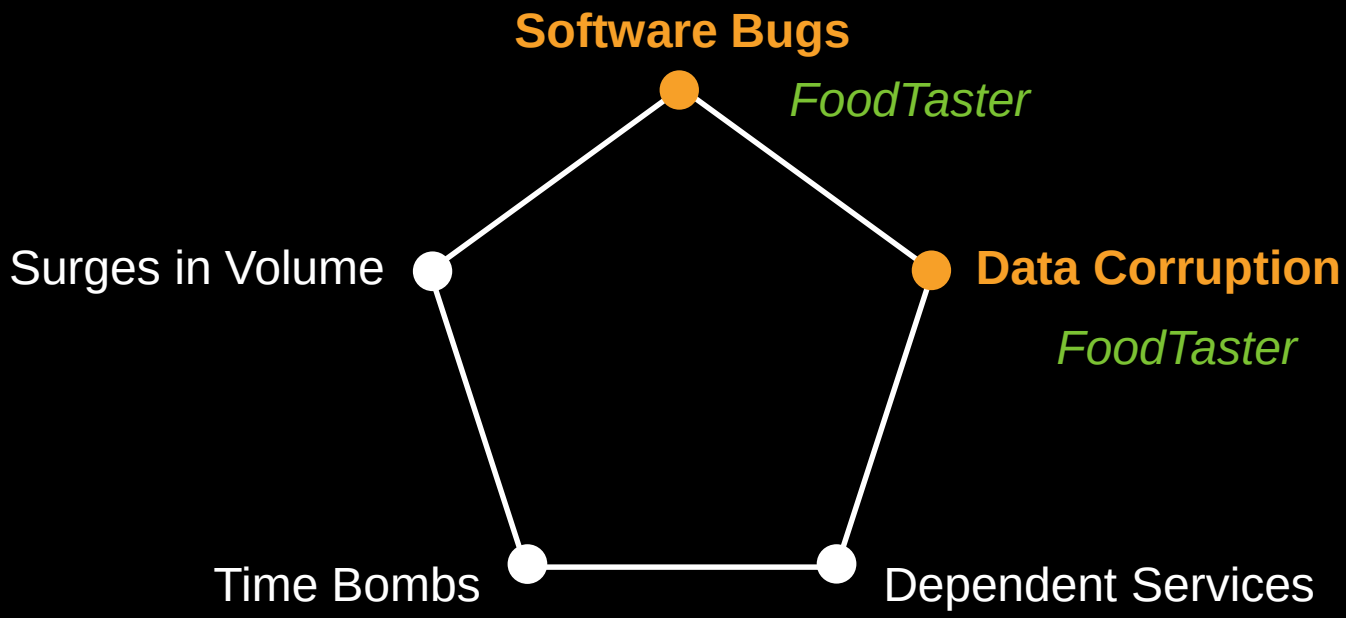
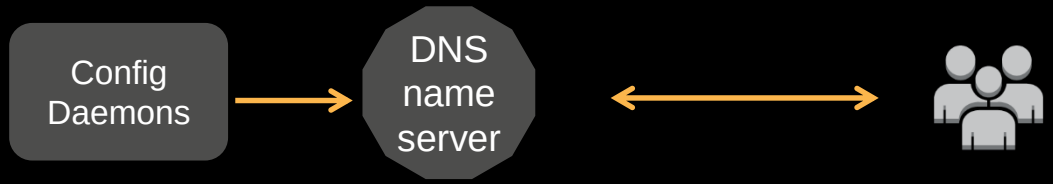
Risks to availability

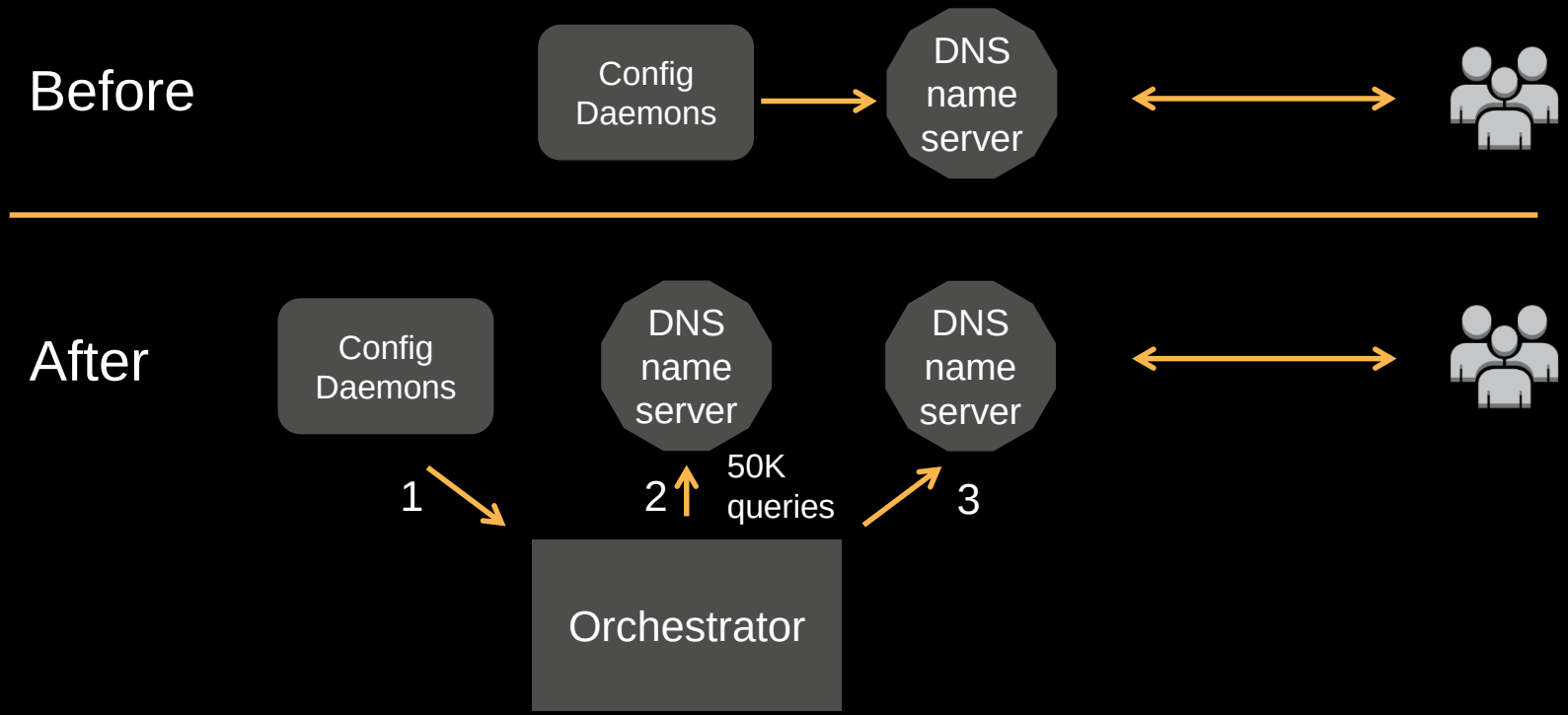


Praegustator – DNS FoodTaster

Before



Praegustator – DNS FoodTaster



Praegustator – DNS FoodTaster

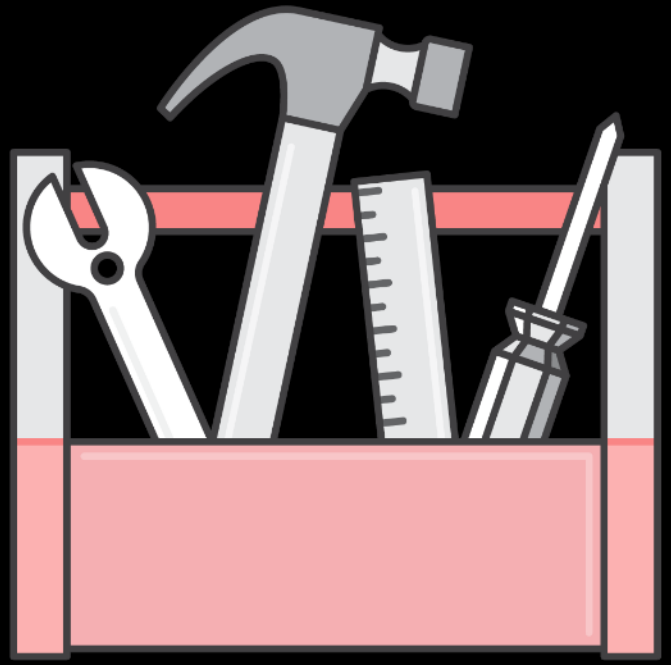
```
$ ls
dns/ foodtaster/ landing/

$ ls foodtaster/
customer.data@      pop.data@
resolvers.data@     routing.data

$ ls dns/
customer.data       pop.data
resolvers.data      routing.data
```

Food Tasting in AWS

- Straightforward approach
- Deployments are inexpensive, redeployments more too
- Approaches like CodeDeploy make life even easier



Food Tasting in AWS

- Example - **GeoIP Database**
- Automatically pushed out to every host
- Likely already have checks
- More to consider than just invalid user configuration

Food Tasting in AWS

- Simple is better (Works for Amazon CloudFront!)
- Assume we already use a deployment system (e.g., AWS CodeDeploy)
- Complete in-situ tests before returning complete

CodeDeploy AppSec example

```
hooks:
    BeforeInstall:
        - location: Scripts/UnzipResourceBundle.sh
        - location: Scripts/UnzipDataBundle.sh
    AfterInstall:
        - location: Scripts/RunResourceTests.sh
          timeout: 180
    ApplicationStart:
        - location: Scripts/RunFunctionalTests.sh
          timeout: 3600
    ValidateService:
        - location: Scripts/MonitorService.sh
          timeout: 3600
          runas: codedeployuse
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CodeDeploy AppSec example

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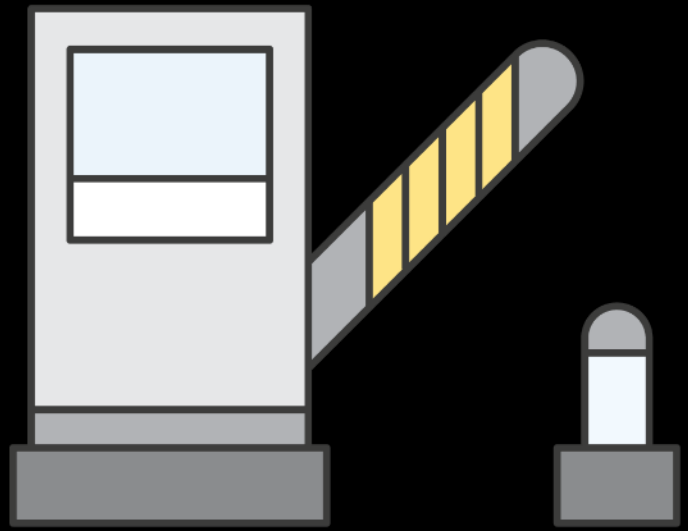
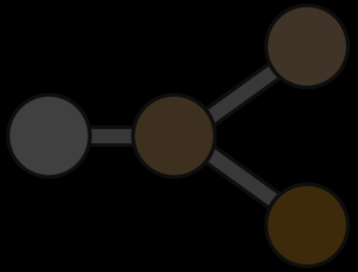
Food Tasting in AWS

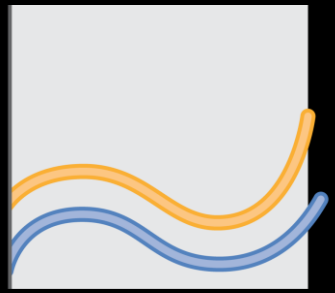


- Acts as a quality gate
- Roll-back can be automatic
- Verification never affects user facing traffic

Design pattern 2: Flash Crowds



Maximizing availability with Food Tasting

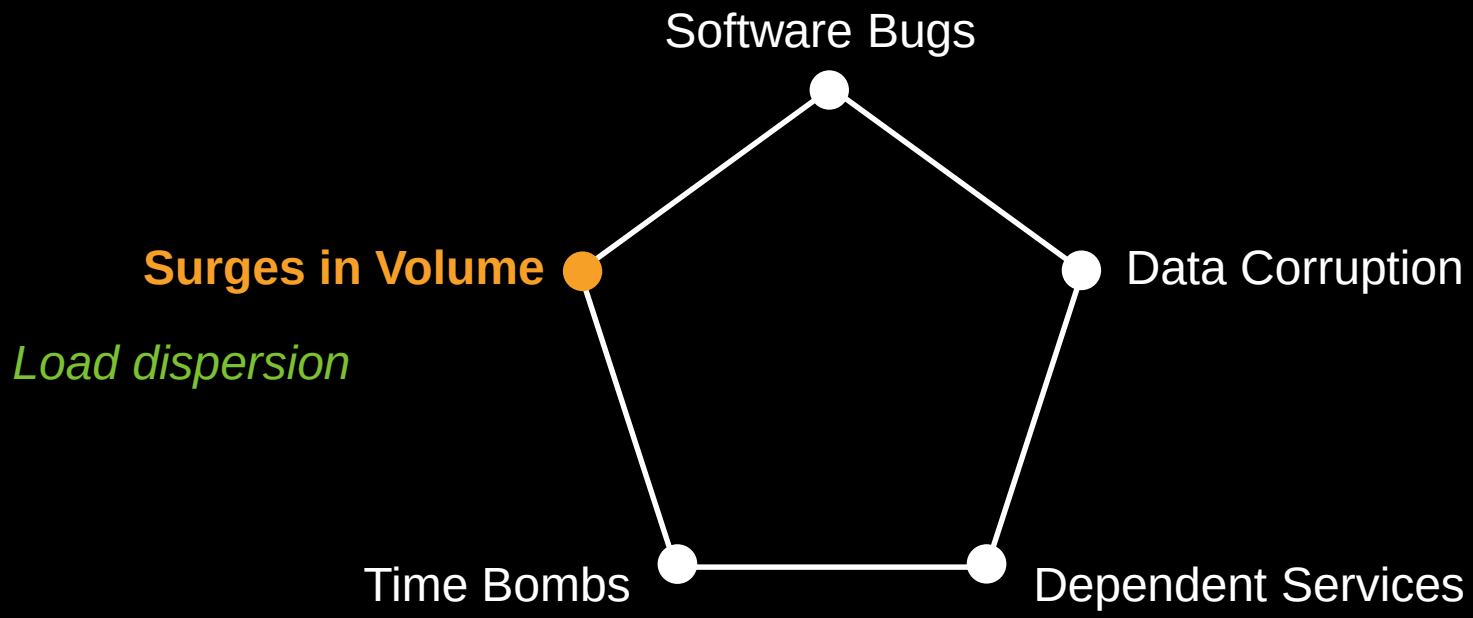


Flash Crowds without scaling for the peak

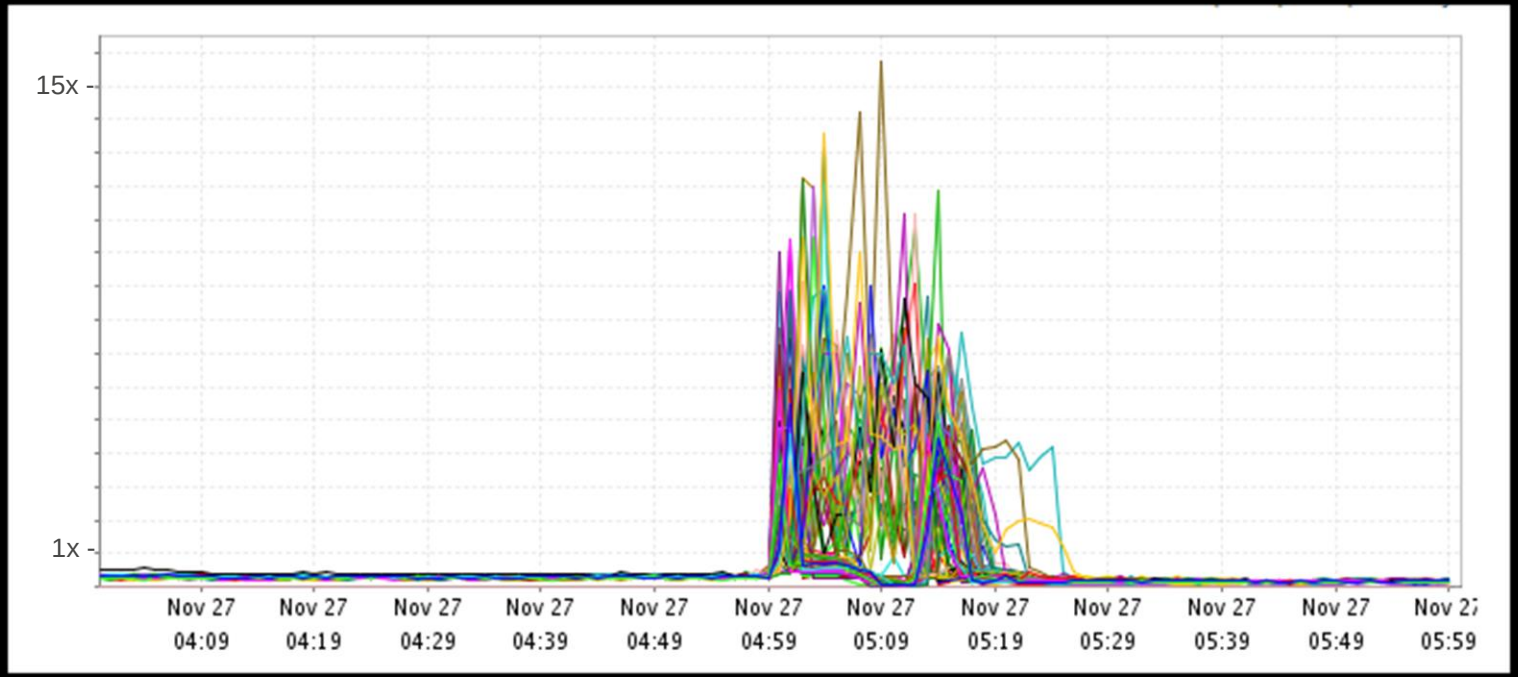
Defense in Depth Strategies

Time Bomb Jitter Protection

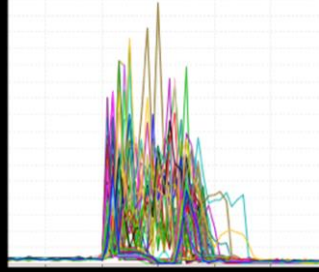
Risks to availability



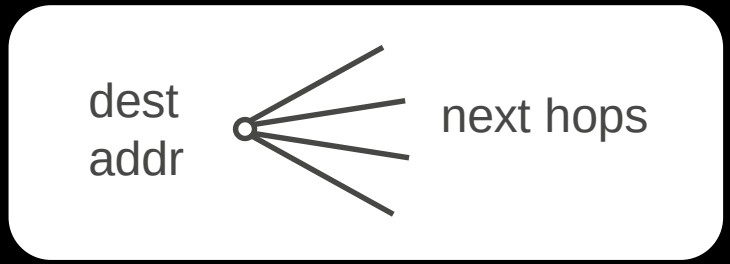
HTTP Flash Crowds



Static & Dynamic Strategies

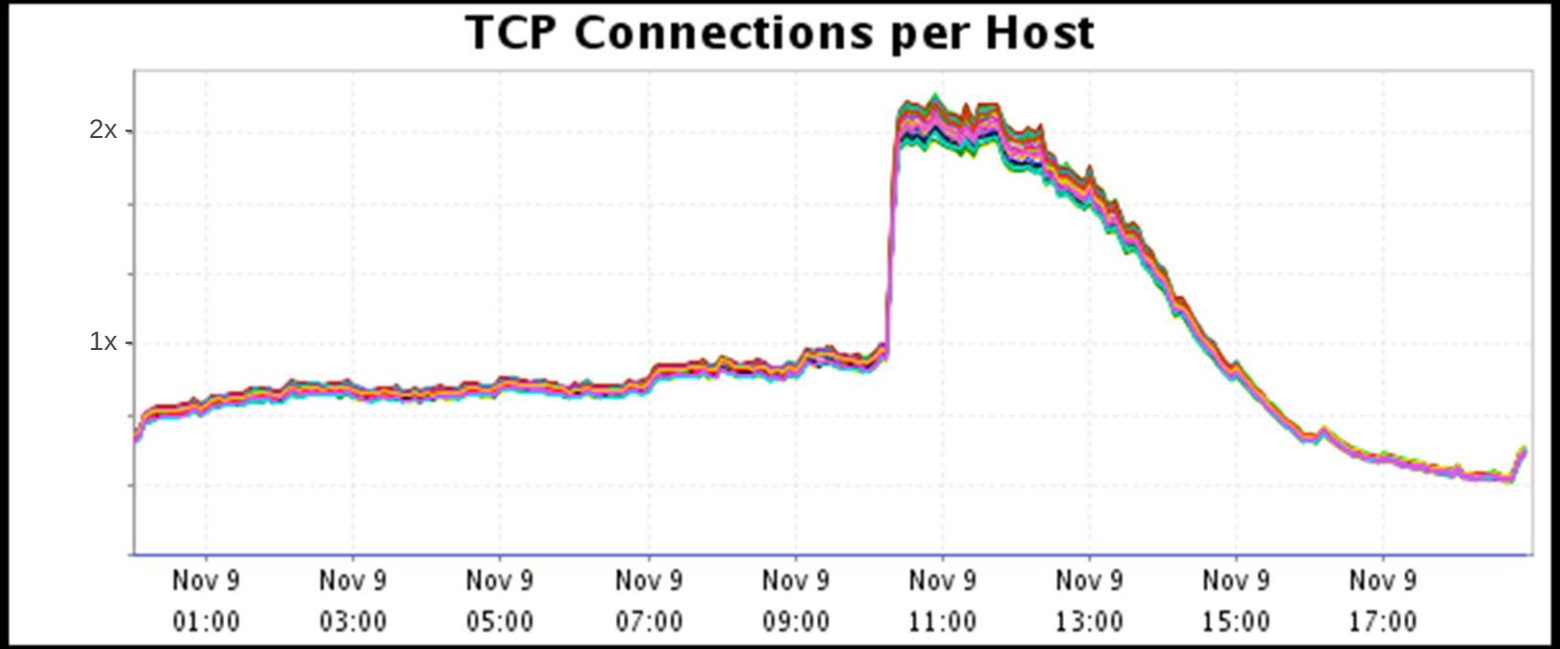


Packet-flow config



Feedback loop

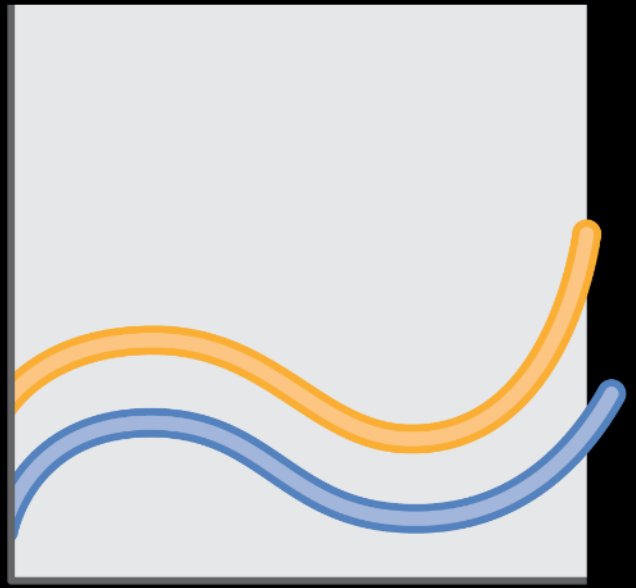
Load Dispersal

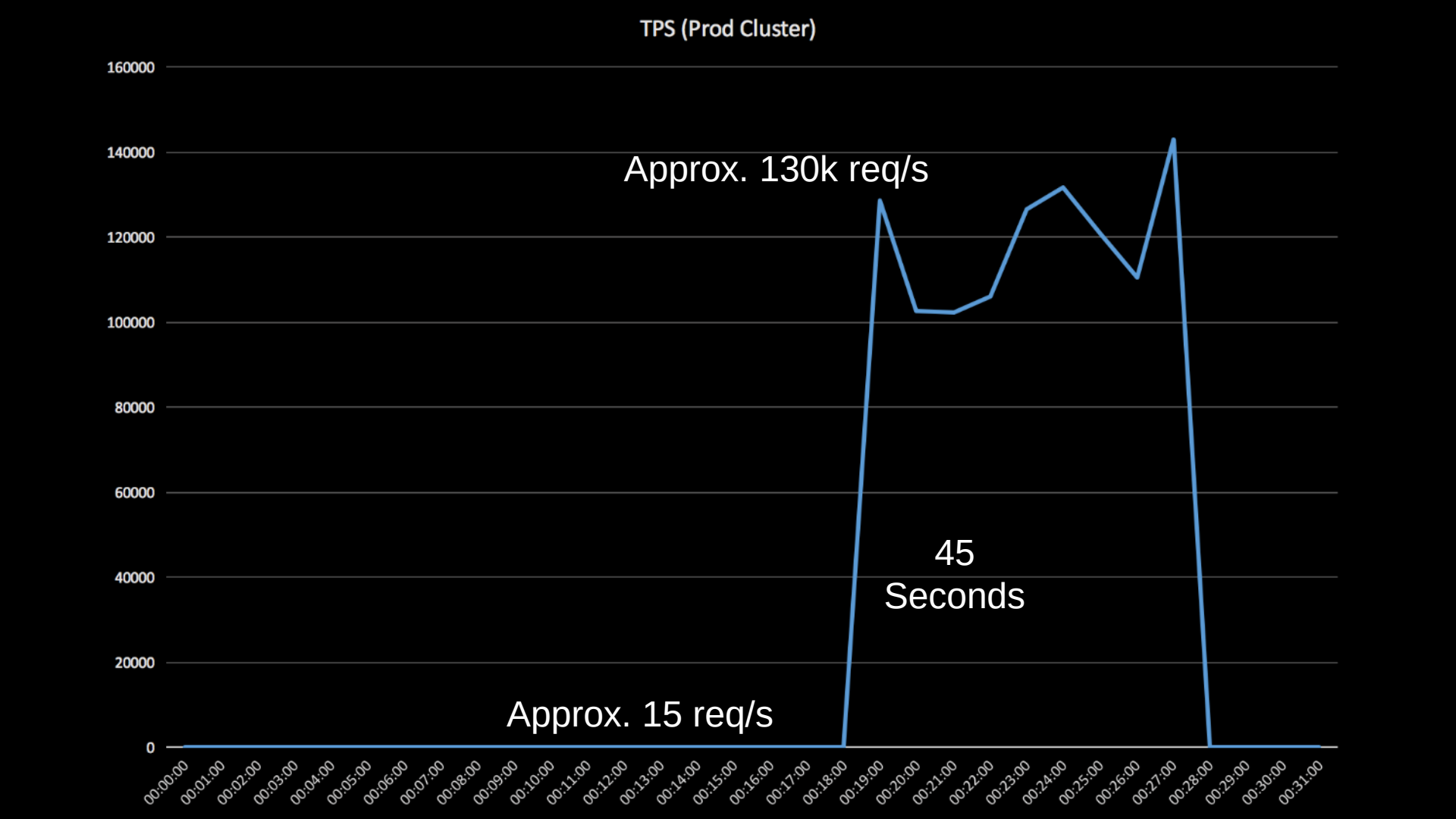


Flash Crowds within AWS

Auto Scaling works really well

But.




TPS (Prod Cluster)
160000
140000
120000
100000
80000
60000
40000
20000
0
Approx. 130k req/s
45
Seconds
Approx. 15 req/s
00:00:00
00:01:00
00:02:00
00:03:00
00:04:00
00:05:00
00:06:00
00:07:00
00:08:00
00:09:00
00:10:00
00:11:00
00:12:00
00:13:00
00:14:00
00:15:00
00:16:00
00:17:00
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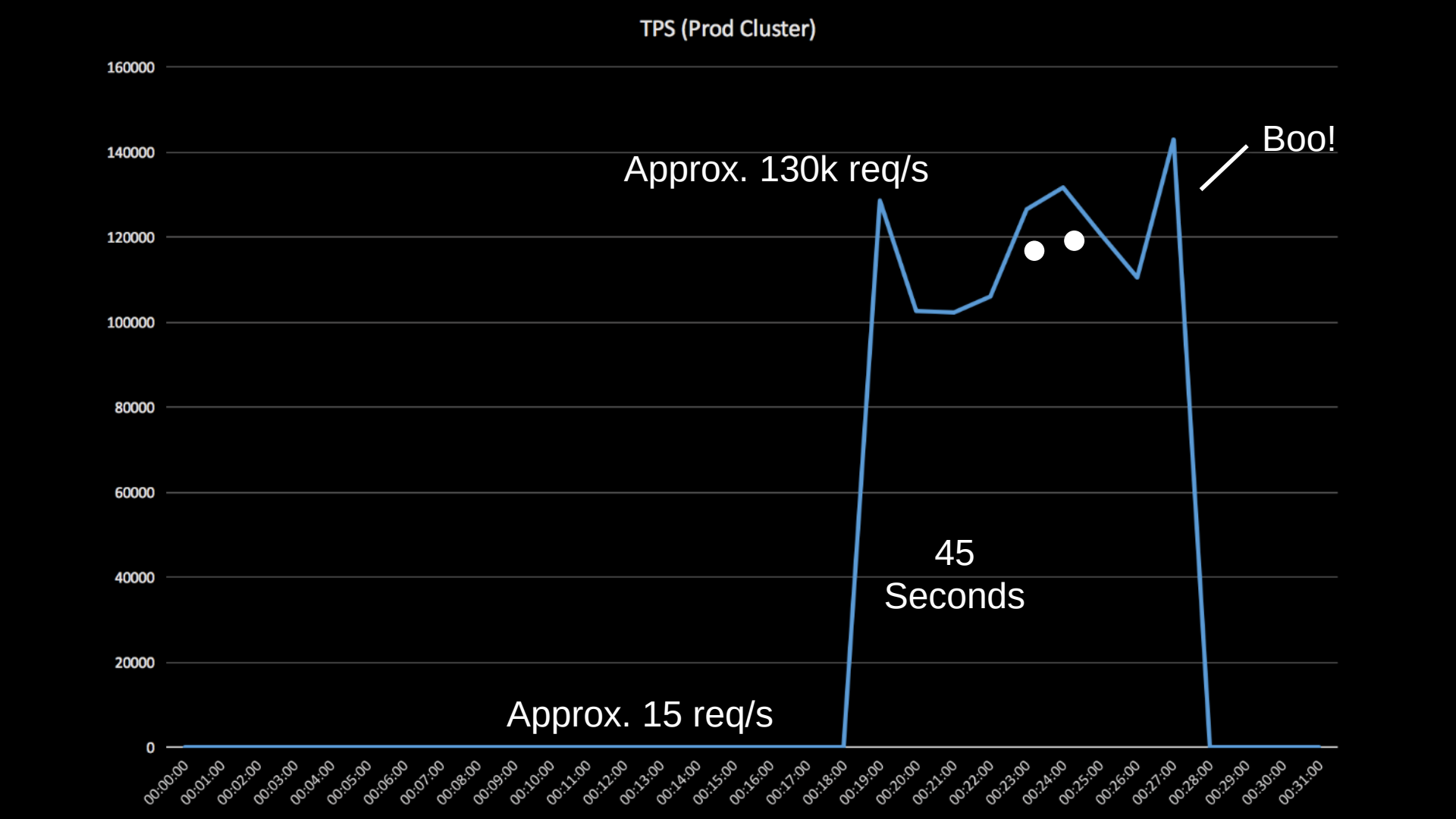
TPS (Prod Cluster)
160000
140000
120000
100000
80000
60000
40000
20000
0
Approx. 130k req/s
Boo!
45
Seconds
Approx. 15 req/s
00:00:00
00:01:00
00:02:00
00:03:00
00:04:00
00:05:00
00:06:00
00:07:00
00:08:00
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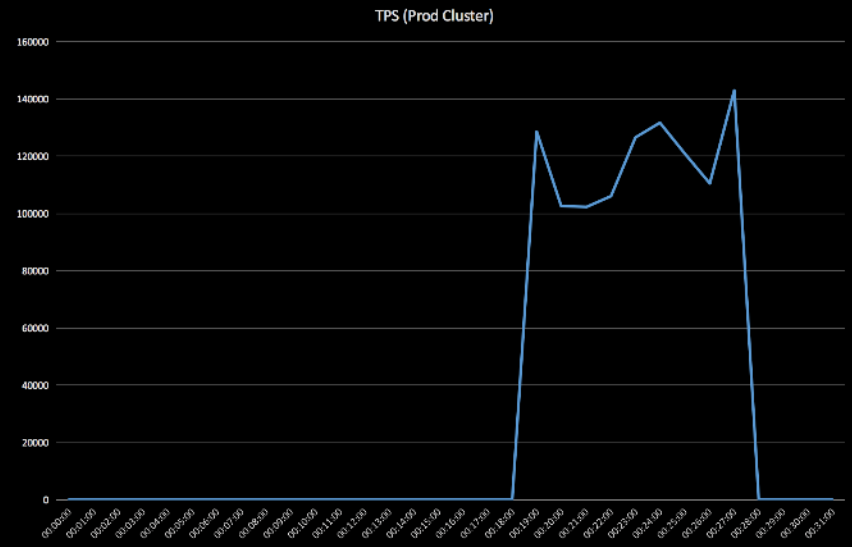
00:23:00
00:24:00
00:25:00
00:26:00
00:27:00
00:28:00
00:29:00
00:30:00
00:31:00

Problem: Flash Crowds

Auto Scaling works really well

But.

Sometimes, 60s is too long.



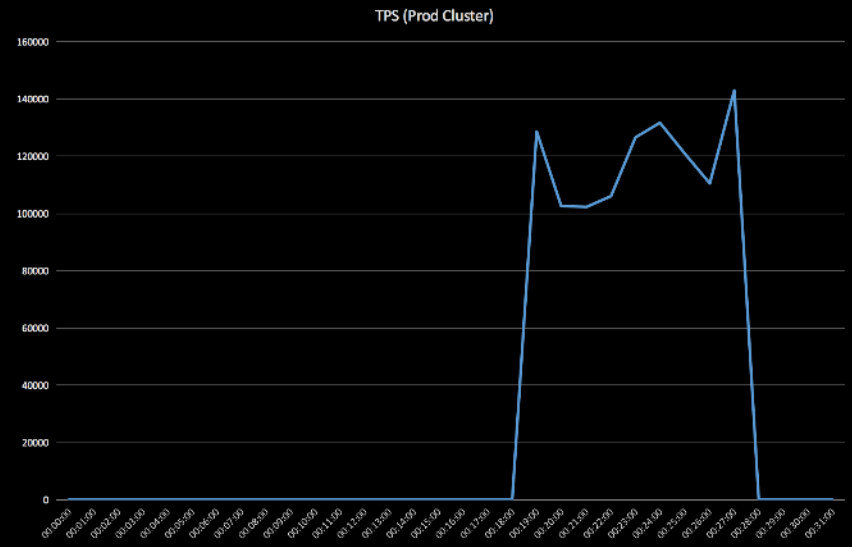
AWS solutions

- **Plan Ahead**

Planning ahead

Typical examples:

- TV programs
- Live events (sports)
- Game releases
- Established traffic patterns



Planning ahead

Typical examples:

- TV programs
- Live events (sports)
- Game releases
- Established traffic patterns

AWS Solutions:


Infrastructure Event Management


Scheduled Auto Scaling Group


Auto Scaling Integration

Schedules and the Big Red Button

- Integration of **program scheduling** and Auto Scaling
- Program scheduling includes expected online audience parameters
- Big red button

Schedules and the Big Red Button

- Integration of program scheduling and Auto Scaling
- Program scheduling includes expected online audience parameters
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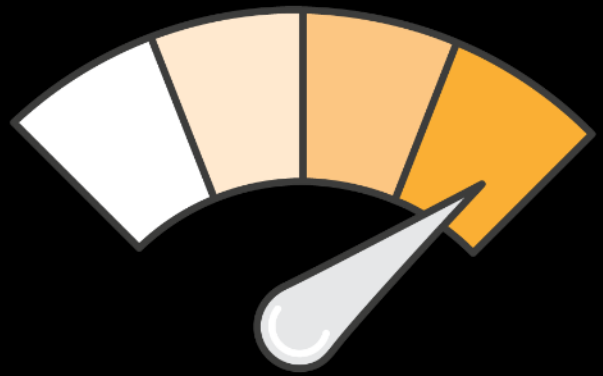
AWS solutions

- Plan Ahead
- **Cache Things**



Cache things

Cache things

I can’t!

My website is…

Cache things

I can’t!

My website is…

DYNAMIC!

Cache things

- What's really dynamic?
  - Newspapers
  - Voting sites
  - Forum sites

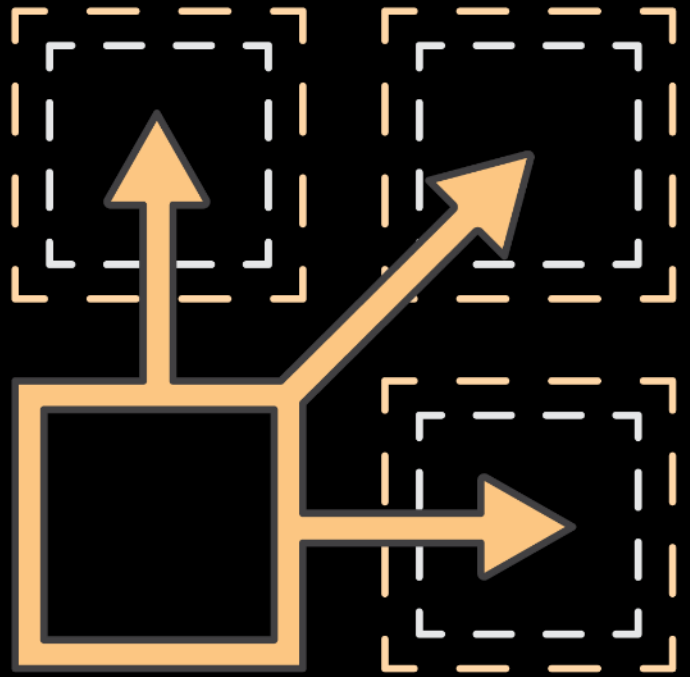
- Updates don't need to be more than once a second

Cache things (even for a second)

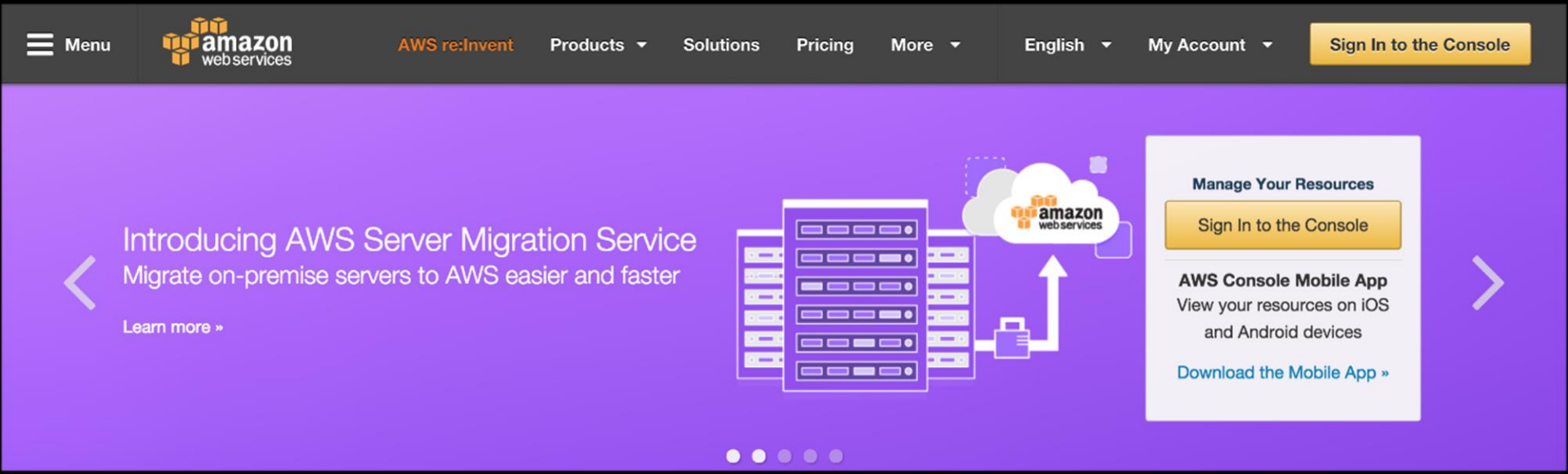
- 10000s req/s
- Assuming every Amazon CloudFront POP
- 10000s req/s -> ~ 10s req/s

AWS solutions

- Plan Ahead
- Cache Things
- **Serve only what you have to**



Serve only what you have to



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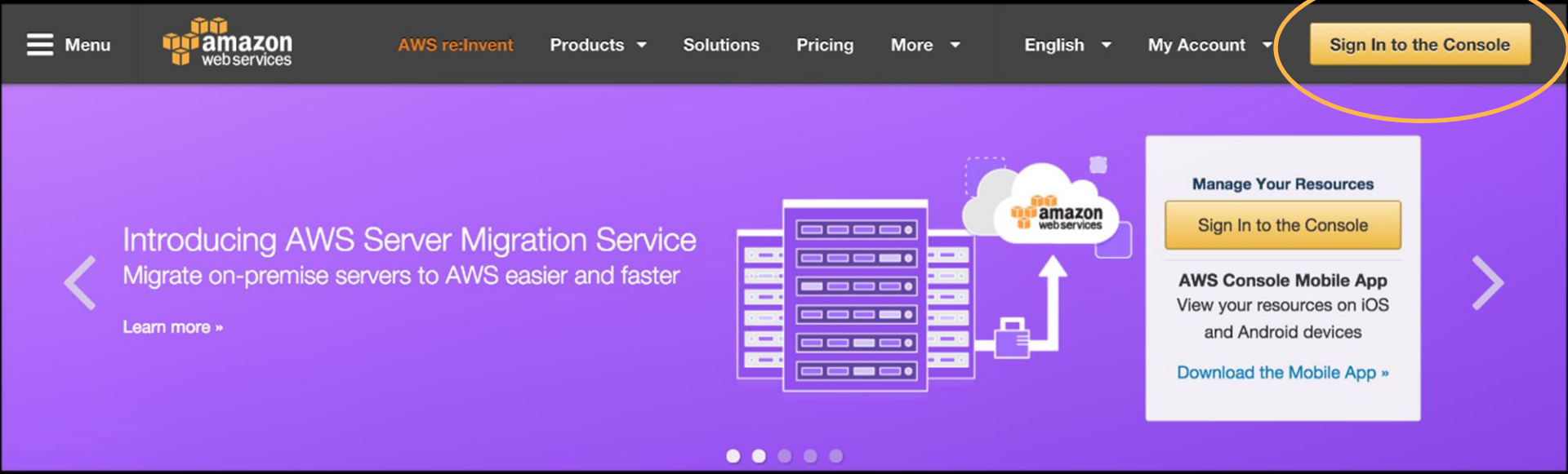

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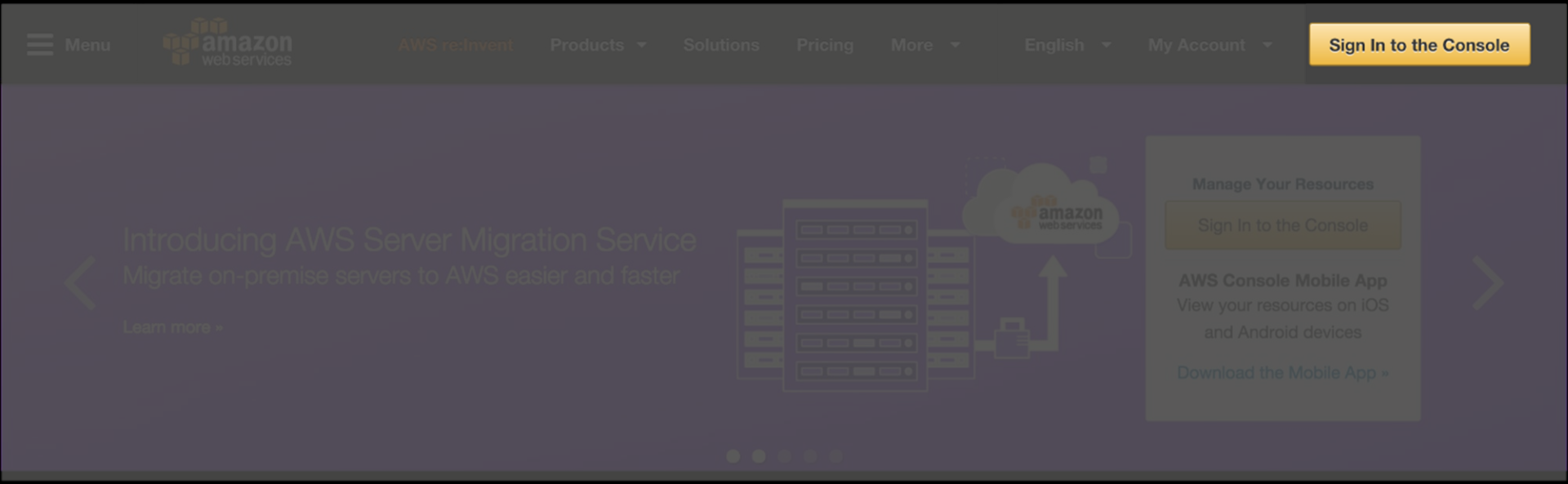
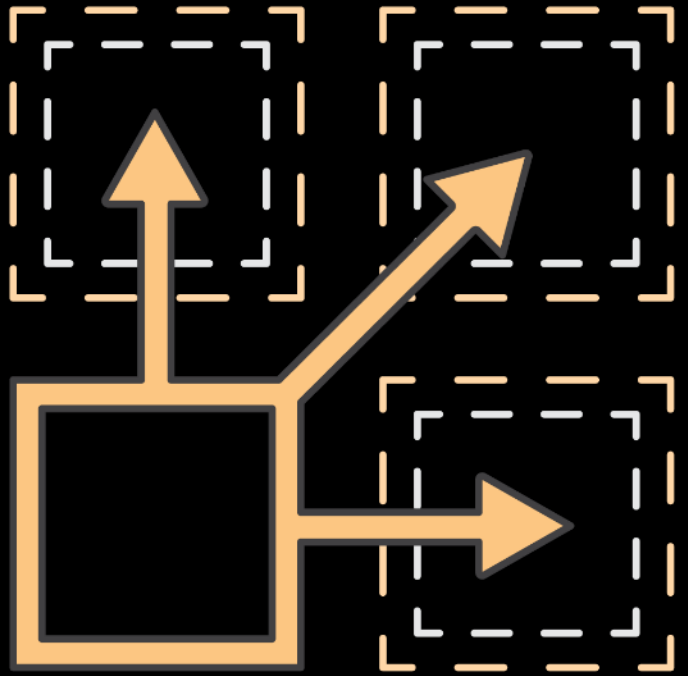


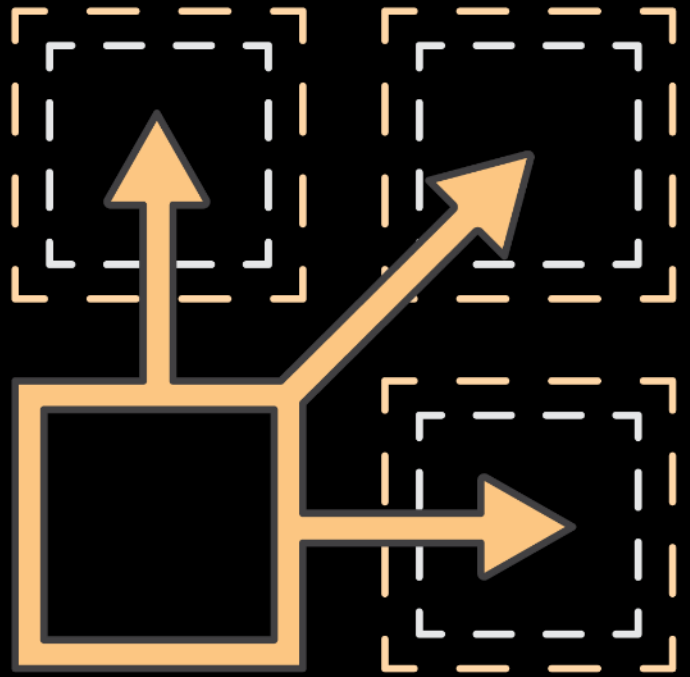
Serve only what you have to

- AJAX Includes

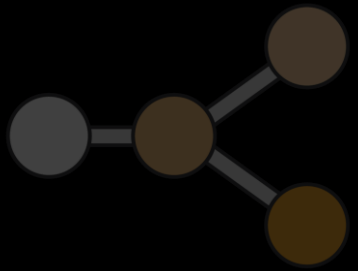


Serve only what you have to

- AJAX Includes
- CloudFront Cache Keys



Design pattern 3: Defense in Depth



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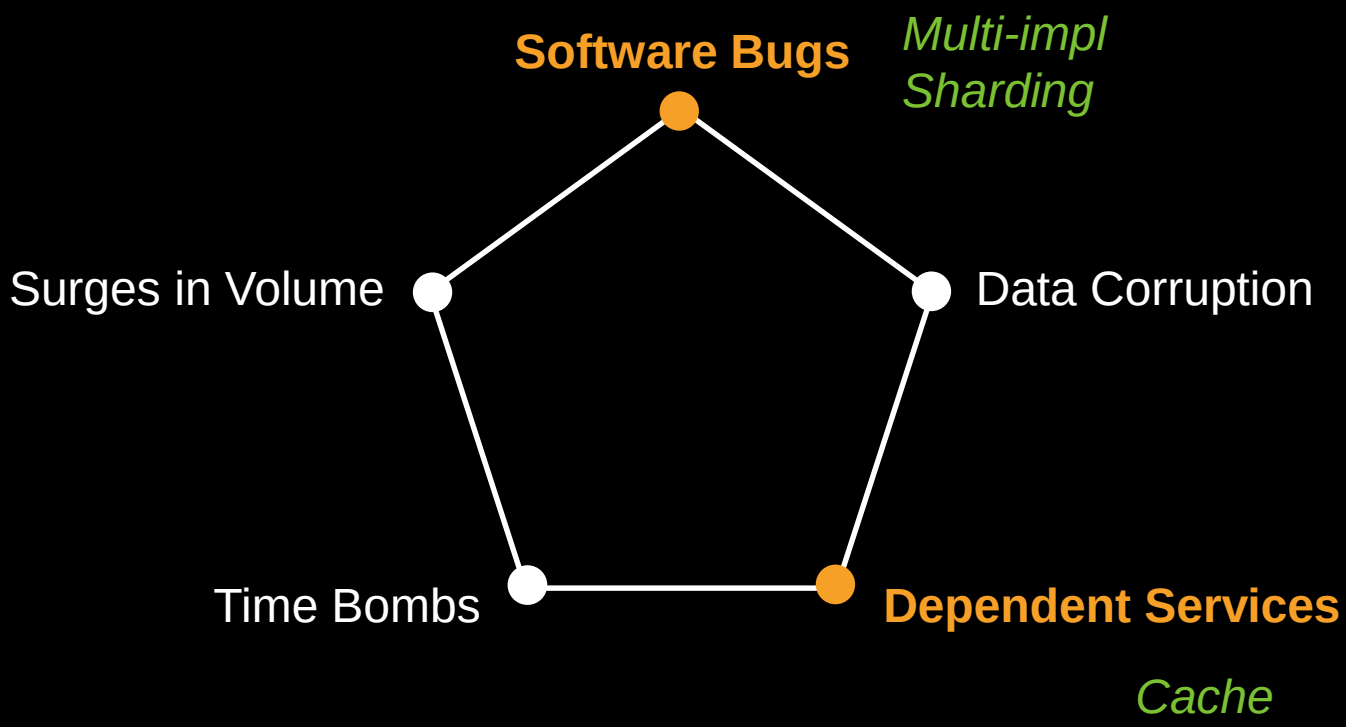
Flash Crowds without scaling for the peak

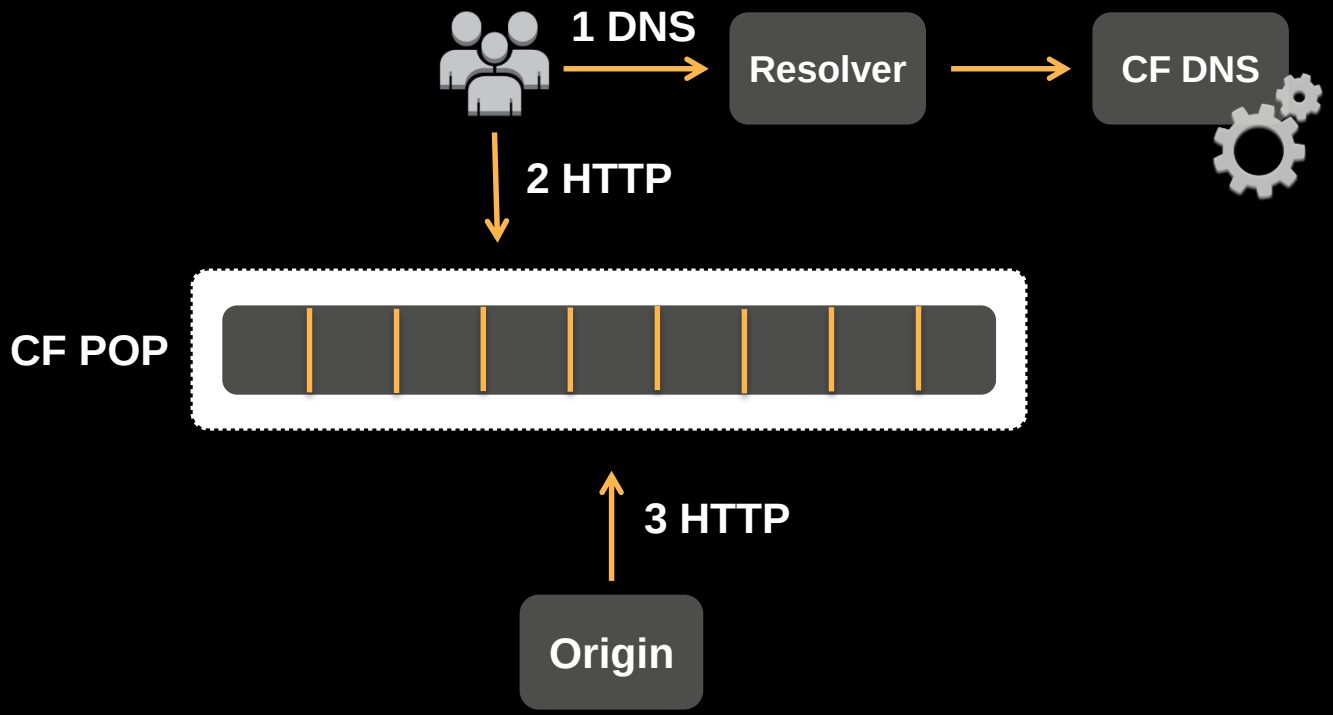
Defense in Depth Strategies

Time Bomb Jitter Protection

Risks to availability



Potential causes of application failure



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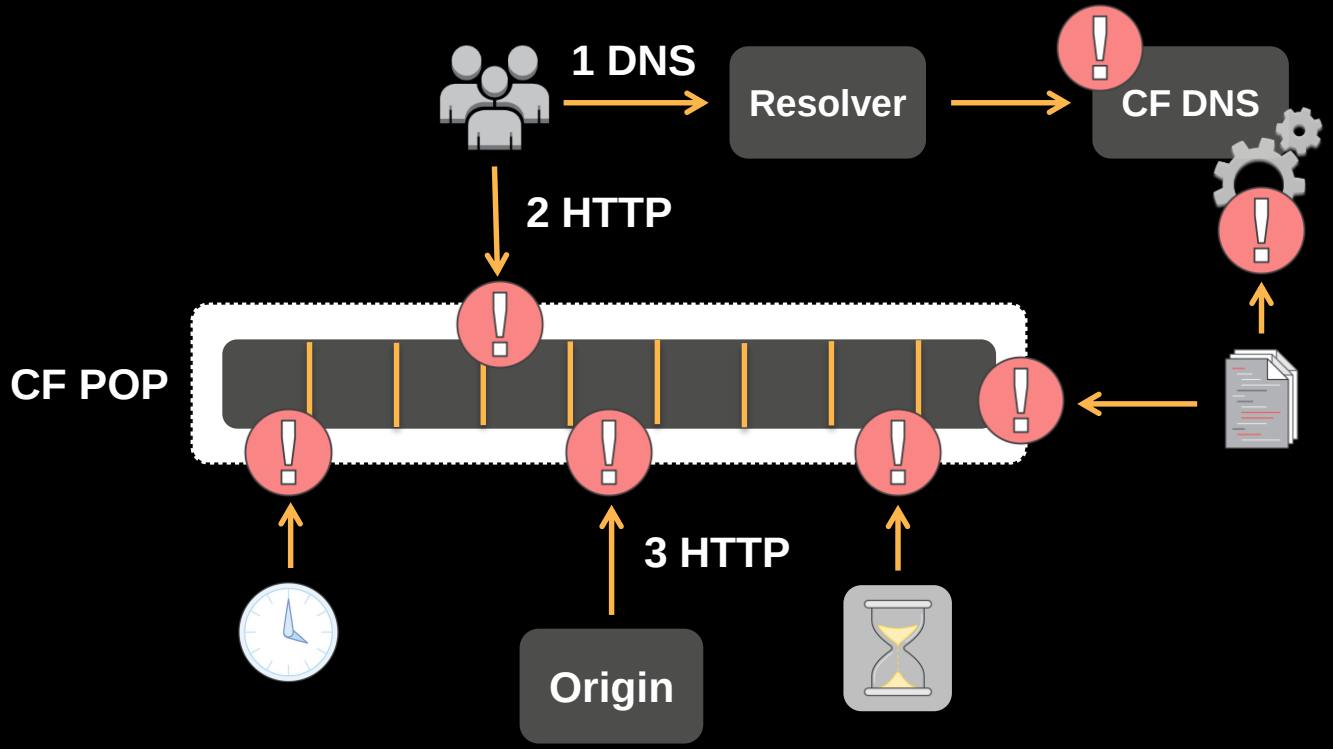

Ideas to avoid crashing

- Comprehensive test coverage
- Simplify systems

Failures are going to happen.

How can we survive them when they do?

Ideas to survive crashing

- Reduce blast radius

- Reject input that previously made you crash

Ideas to survive crashing

- Reduce blast radius
    - shard customers to separate processes

- Reject input that previously made you crash

Ideas to survive crashing

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  - recover quickly

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Ideas to survive crashing

- Reduce blast radius
  - shard customers to separate processes
  - recover quickly
  - multiple implementations
- Reject input that previously made you crash

DNS Multi-Impl

Should this be a fallback system?

Place it in front of every DNS name server?

DNS Multi-Impl

Should this be a fallback system?

- We want to know it always works

Place it in front of every DNS name server?

DNS Multi-Impl

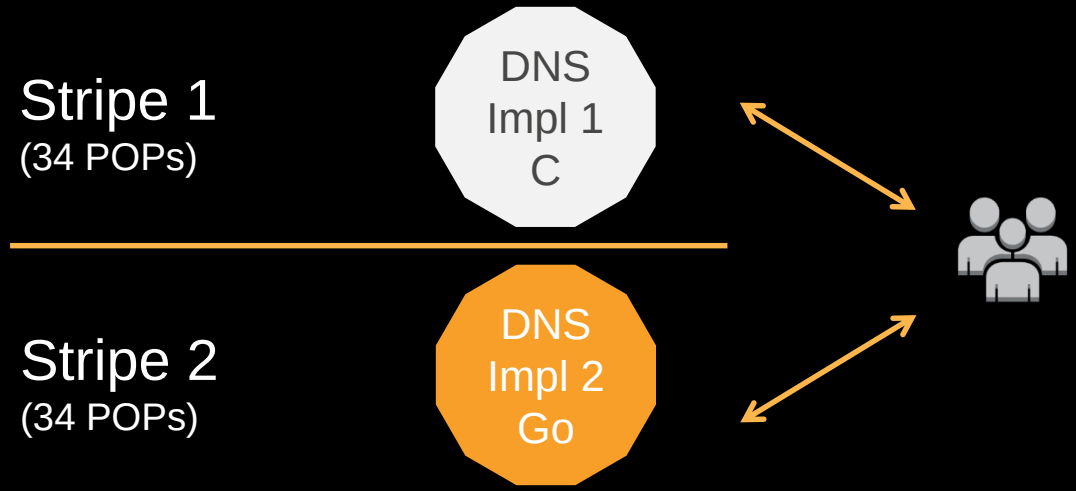
Should this be a fallback system?

- We want to know it always works

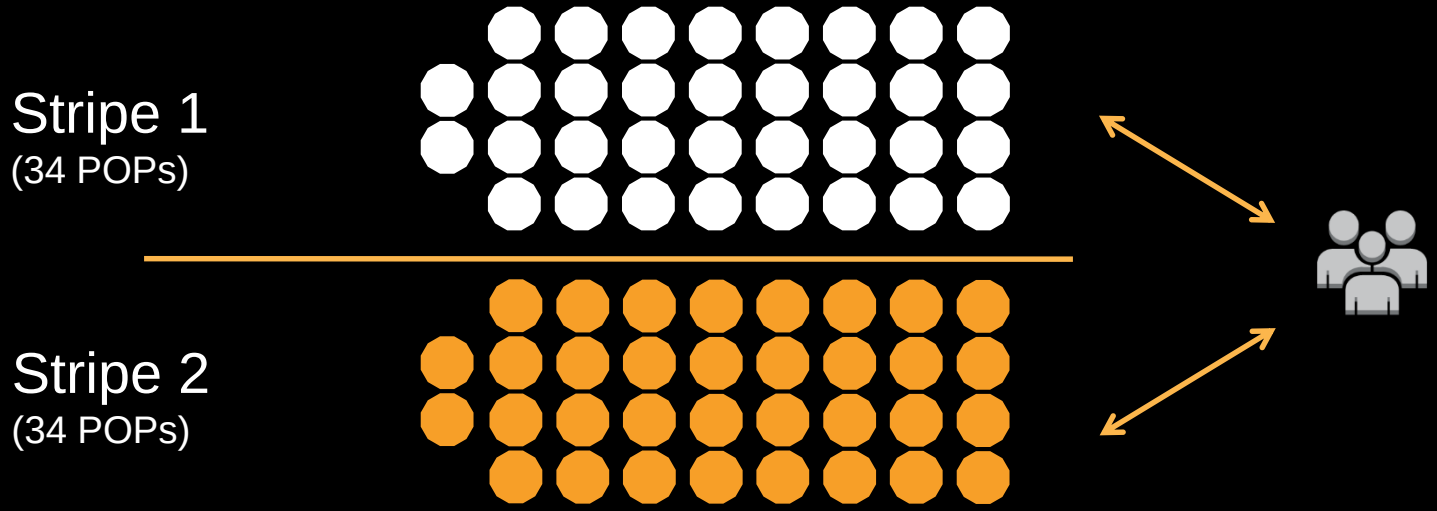
Place it in front of every DNS name server?

- Would trade point of failure one for another

DNS Stripes



DNS Stripes



CloudFront case study

Math.abs() on the lowest 32-bit signed integer, -2^31, yields a negative number.
Leading to invalid DNS configuration.

```
Two's complement: flip bits and add 1.

Math.abs(Integer.MIN_VALUE):
       -2^31 = 10000000 00000000 00000000 00000000
bits flipped = 01111111 11111111 11111111 11111111
          +1 = 10000000 00000000 00000000 00000000  <= -2^31!
```

CloudFront case study

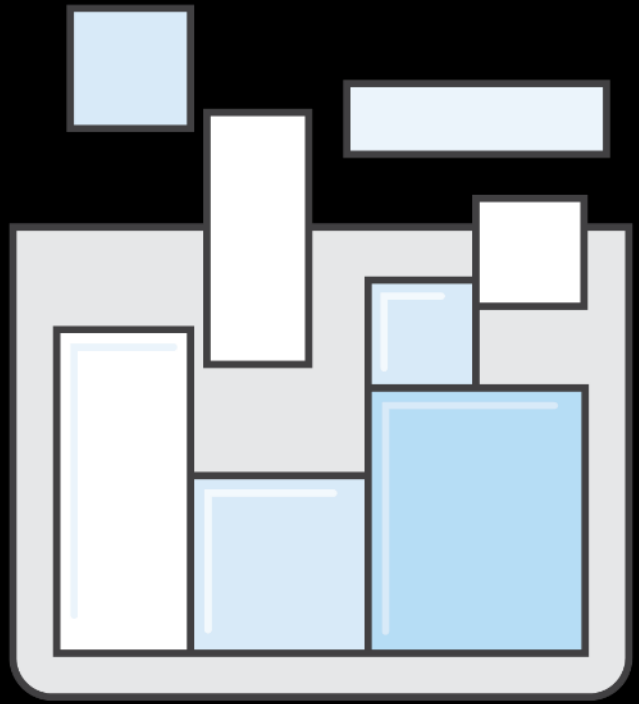
Protections in place:

1. Config process crashing in a loop
2. DNS name server defensively ignores an invalid index
3. FoodTaster crashes protect King DNS name server
4. DNS stripes reduce common failure paths

AWS solution

We can use a Load Balancer with Layer-7 awareness

So we can have multiple backend types across a fleet

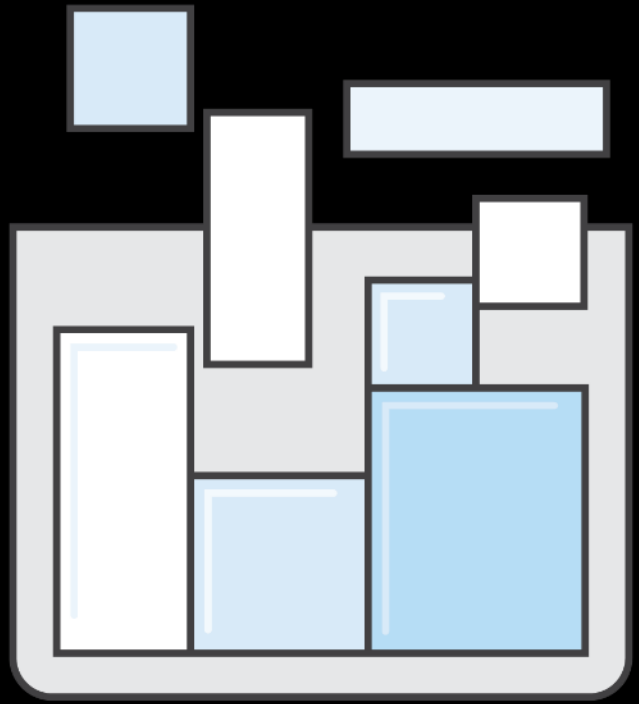


AWS solution

Enabled through microservices

Reimplementing the entire stack multiple times is a difficult cost / efficiency question

Specific high-risk services are easier



AWS solution

Example: **2FA Platform**

API (HTTP) front-end to a back-end authentication platform

Reasonably few SLOC

If it fails – no access to platform

AWS solution

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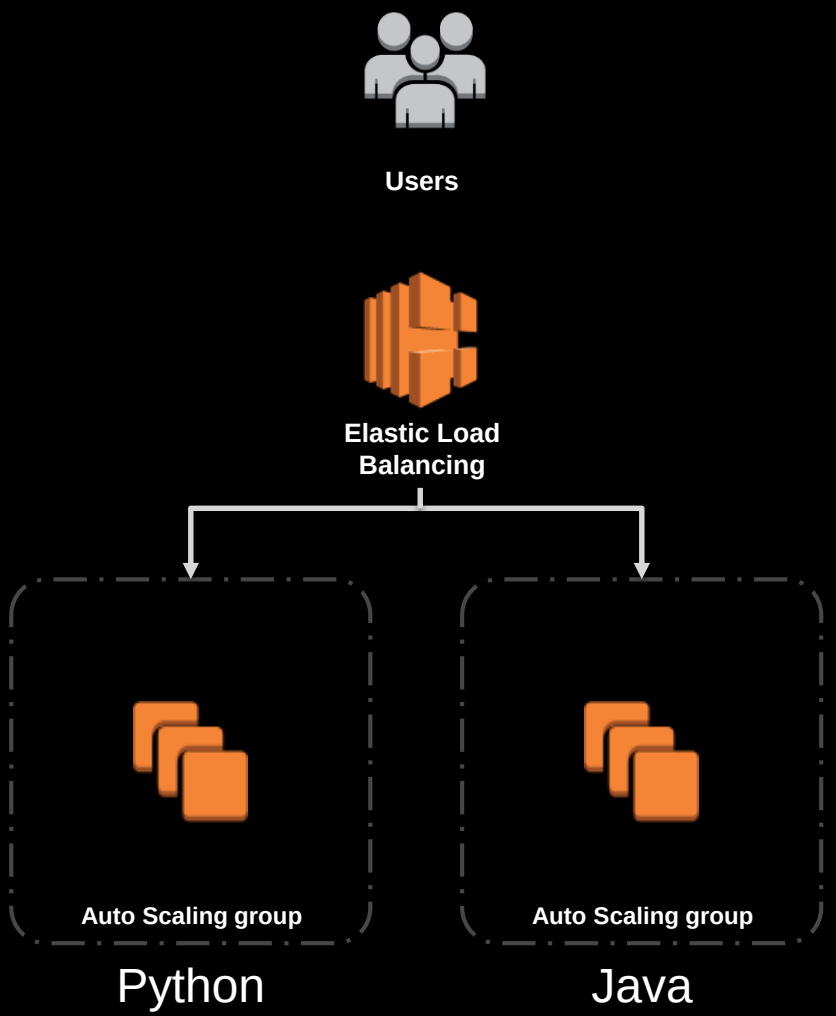
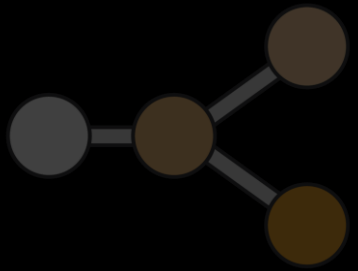


Design Pattern 4: Time Bomb Jitter Protection



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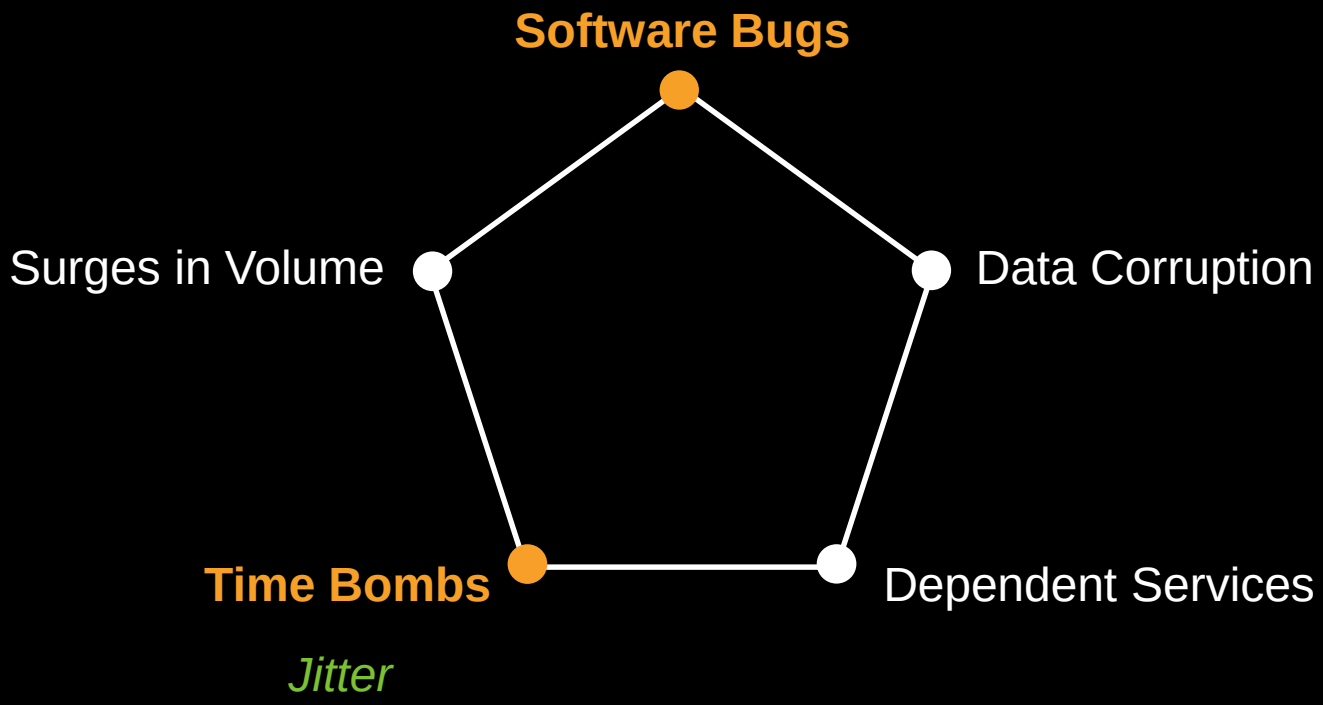
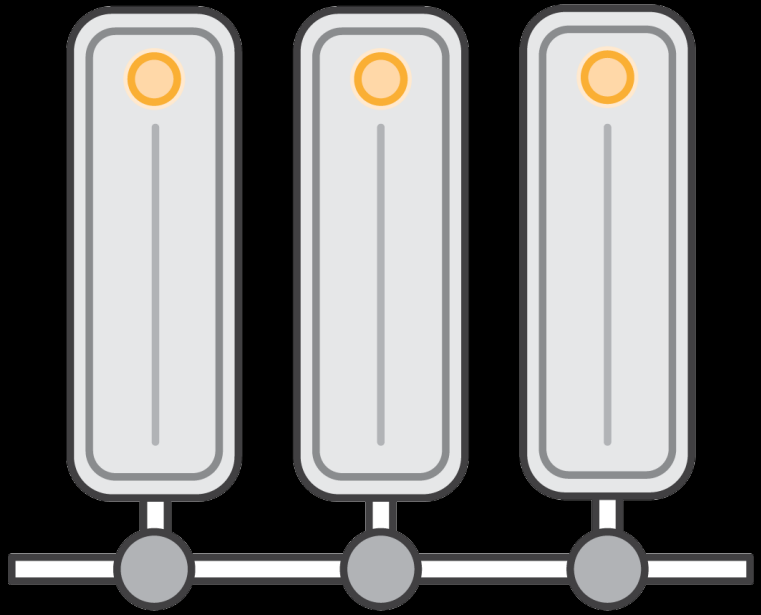
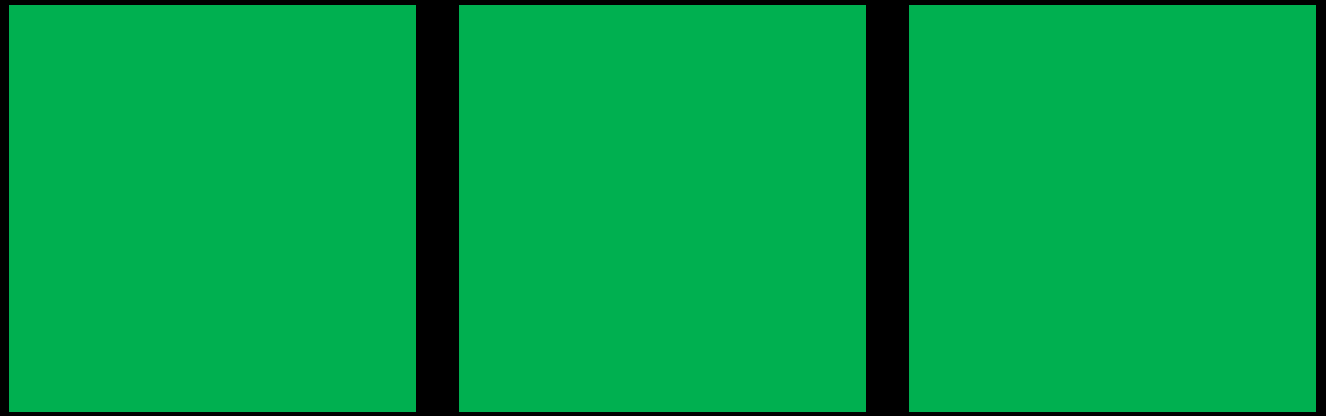


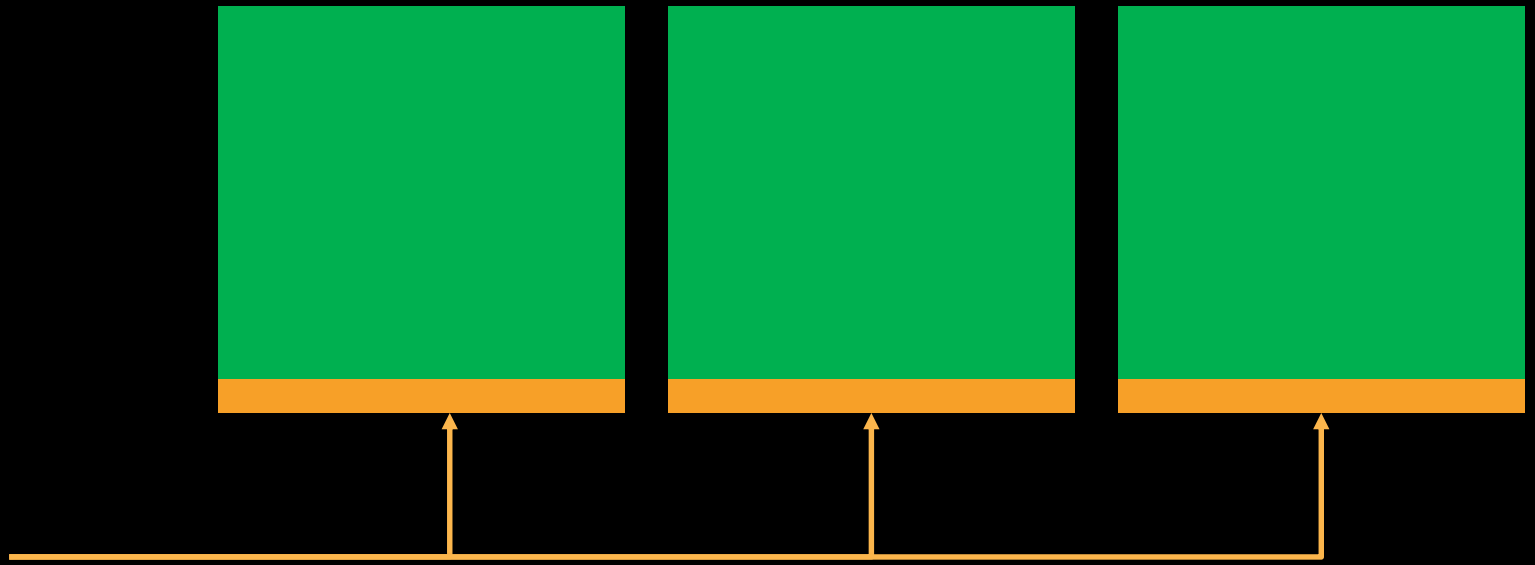
Problem: homogeneous platforms



The problem



The problem

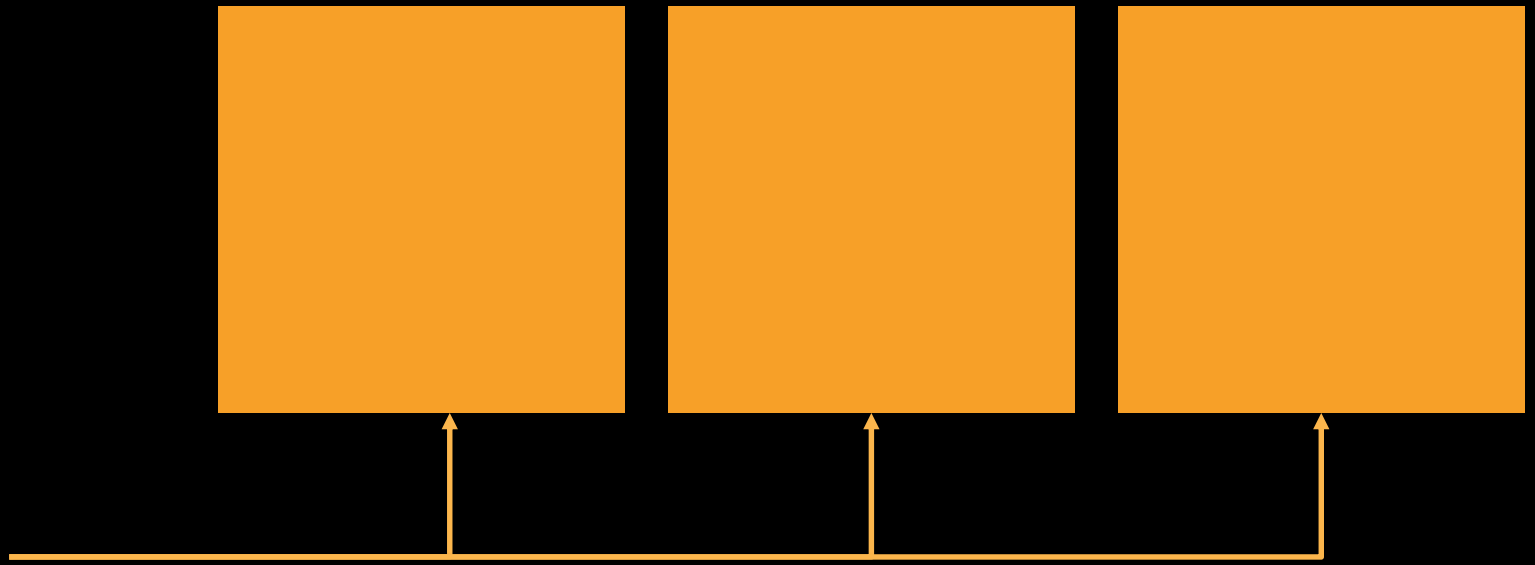


Configuration Updates

The problem

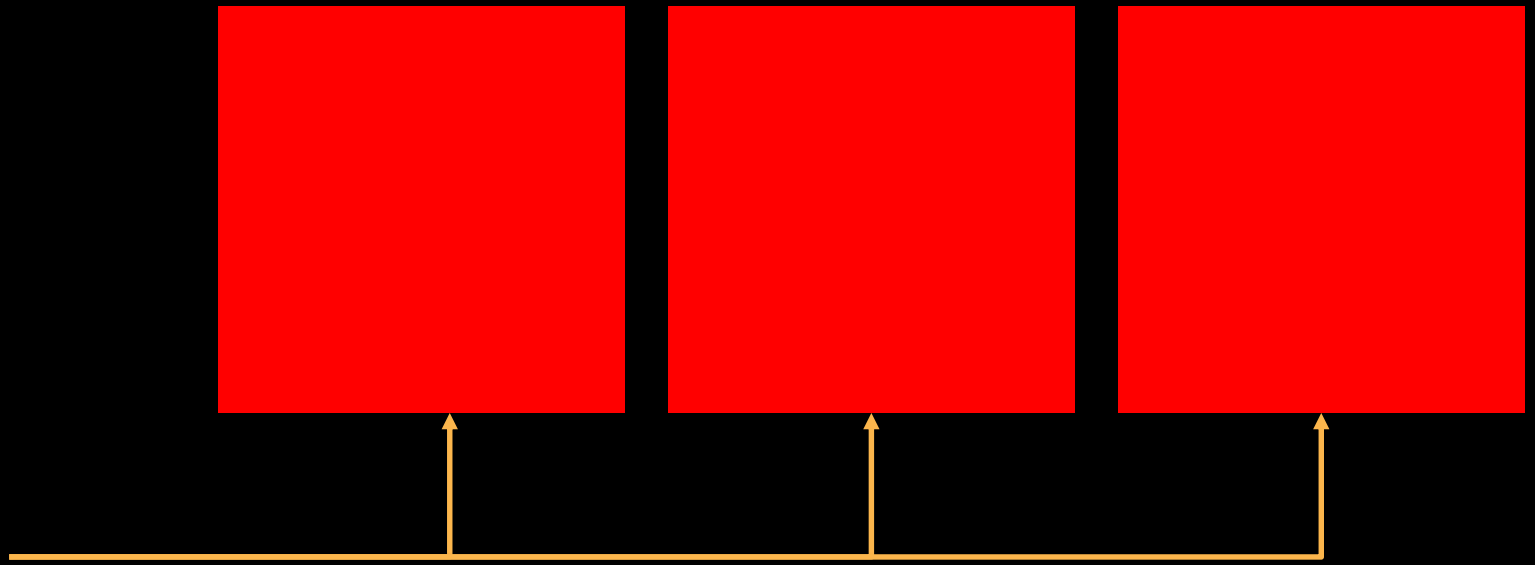
Binary Patches

The problem



Pictures of Cats

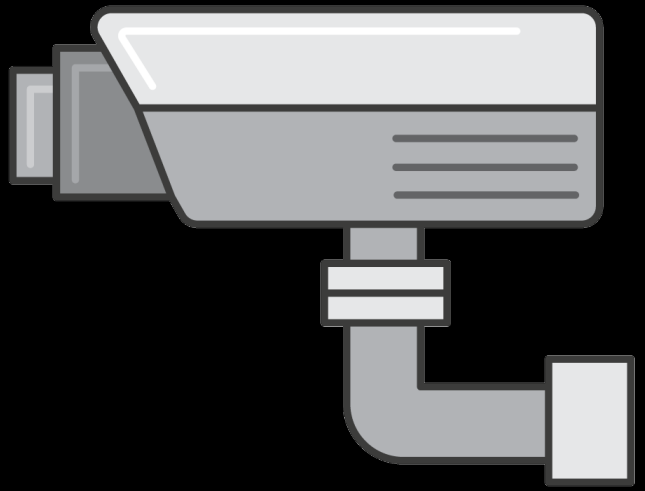
The problem



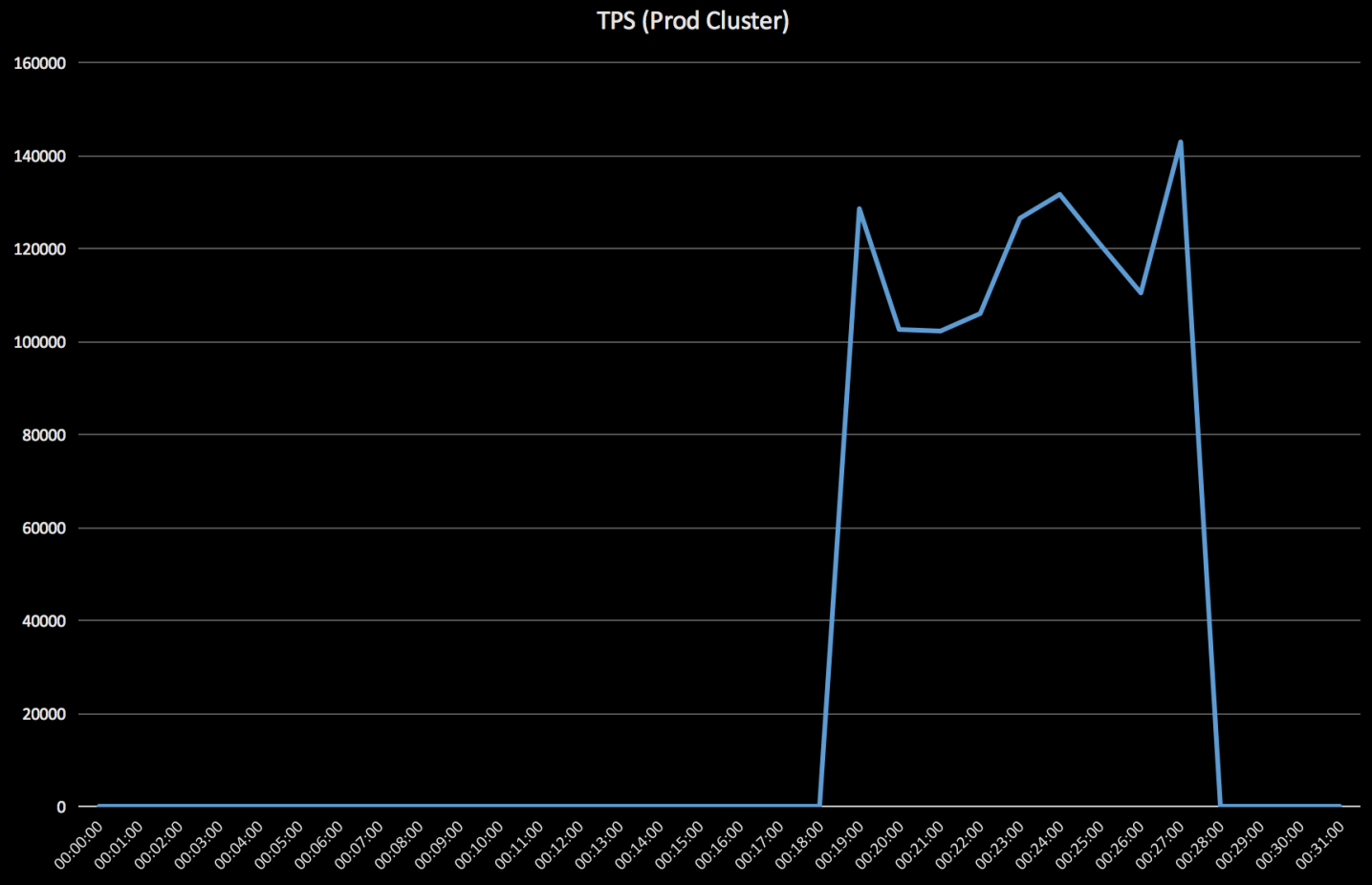
Pictures of Cats

Traditionally..

- Instance level monitoring system with alerts
- Human response
- Monitor both percentage fill, and the fill rate



High availability matters

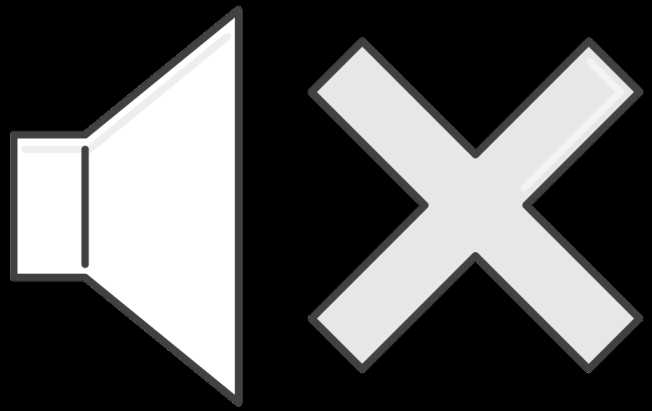


High availability matters

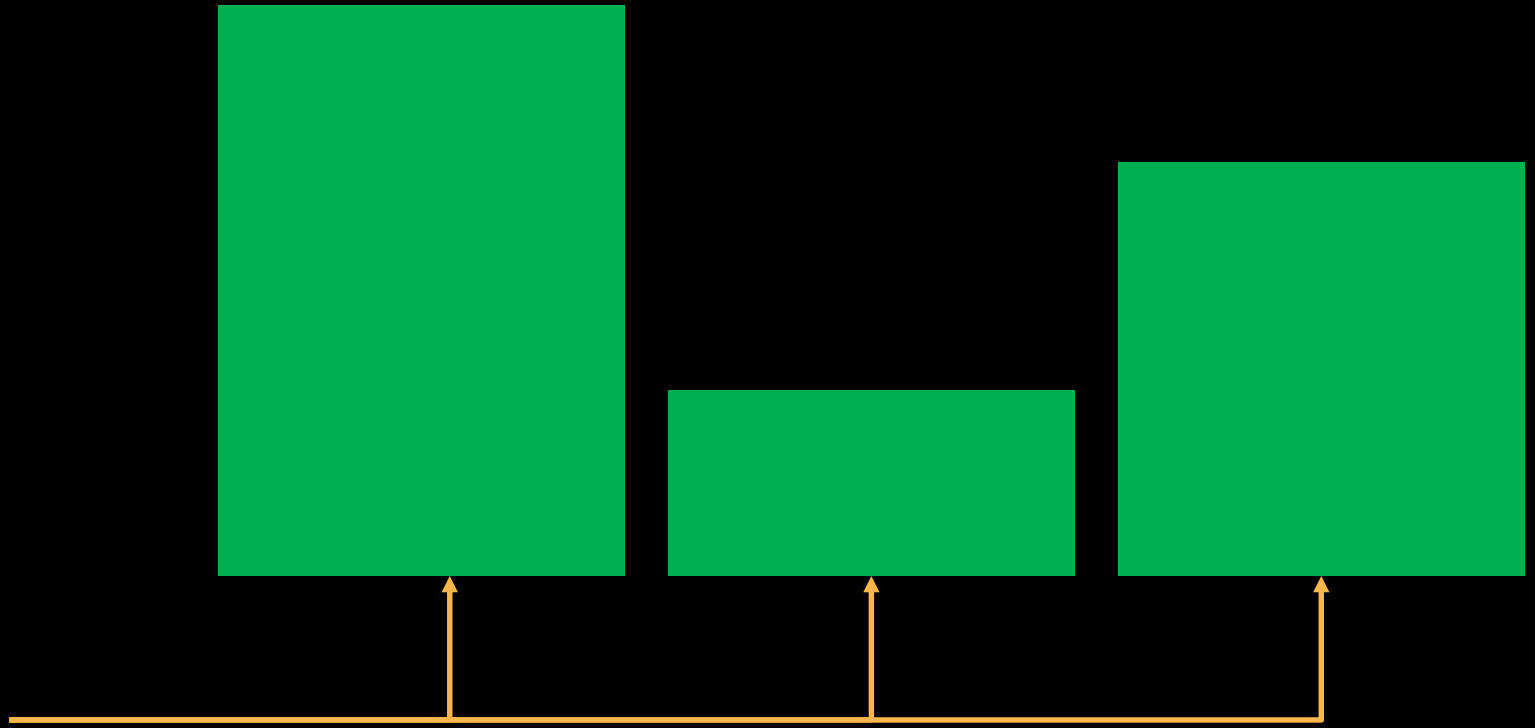
Recycling old instances is **unnecessary cost**

Automated cleanups may be **too slow**

Human operators **almost certainly** too slow



The solution



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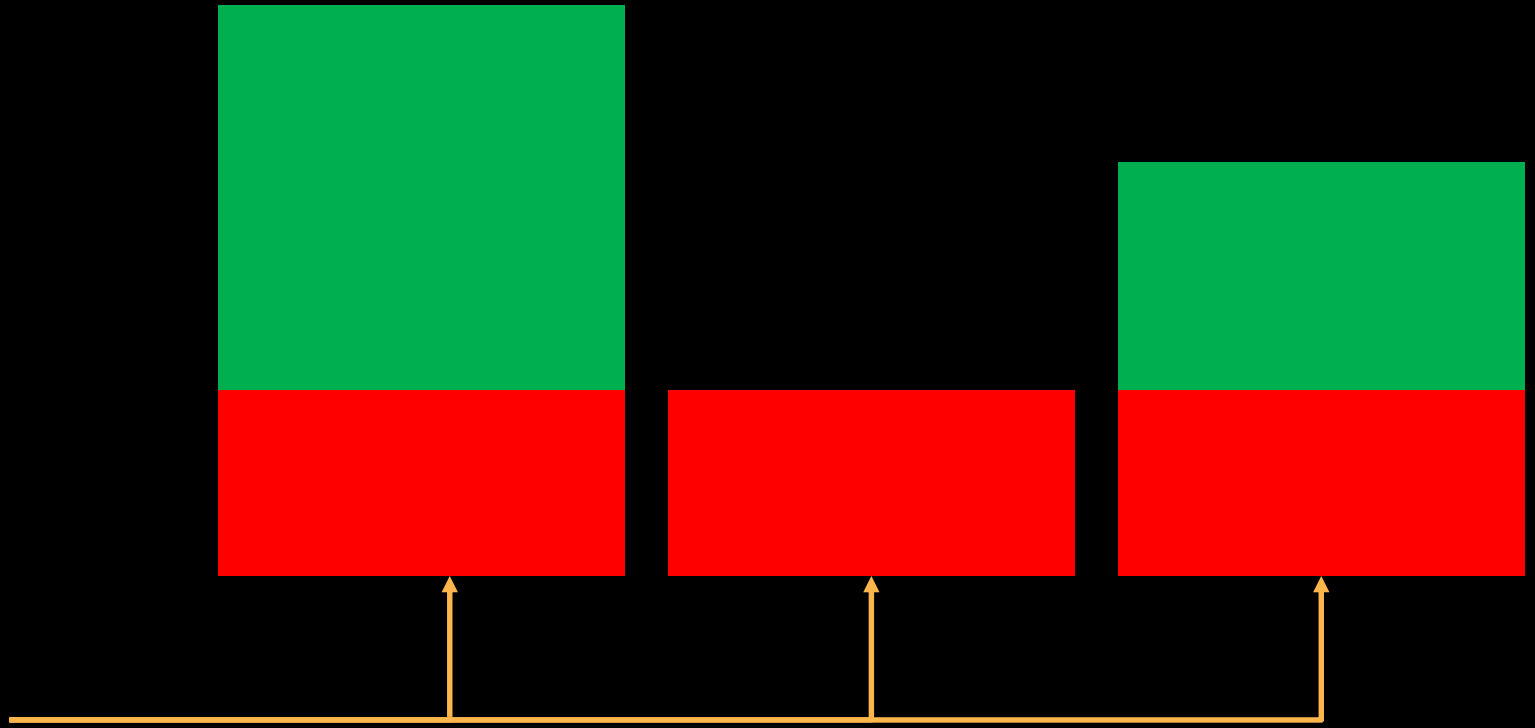
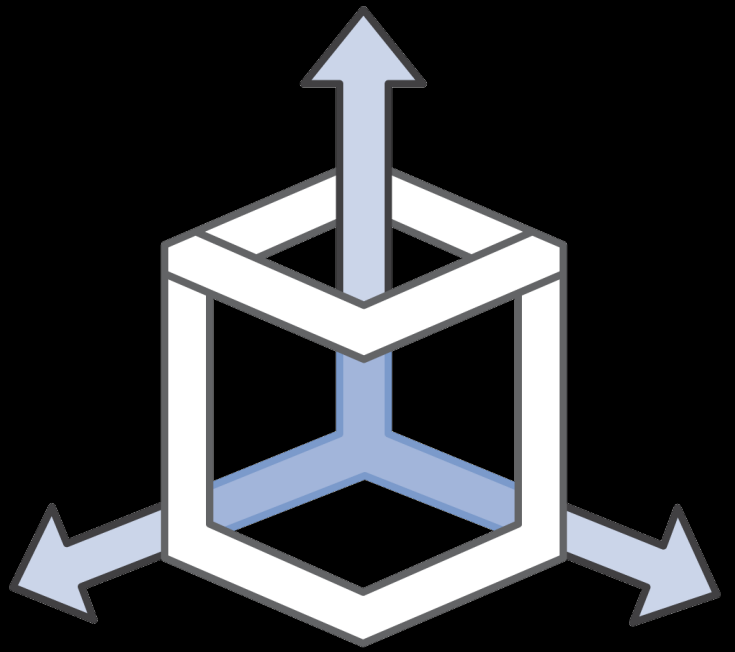


AWS solution – within an Auto Scaling group

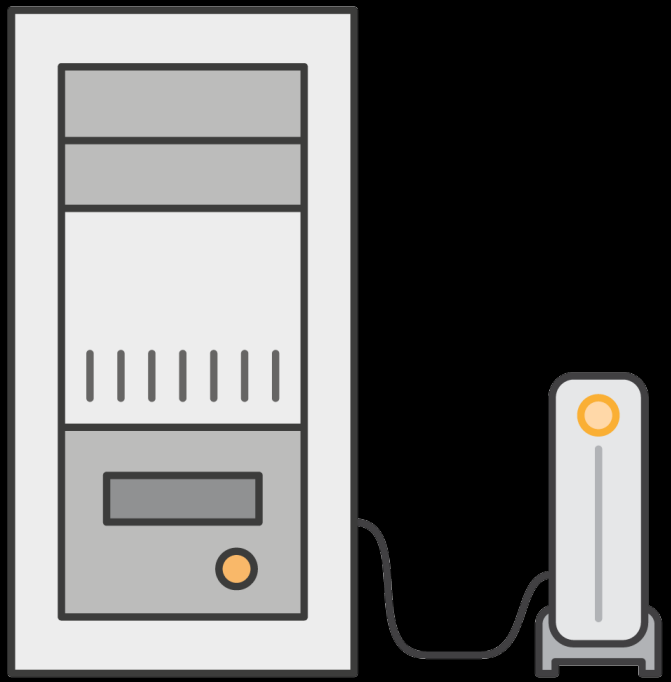
Amazon Linux AMI has /var/run (and /var/tmp) on root

Ubuntu AMI uses tmpfs (10% of RAM)

Jittering **root volume size** is tricky within an ASG



AWS solution – within Auto Scaling



Consciously segregate your files to a specified directory – on a **separate volume** – with jittering

Code will follow (check SlideShare!)

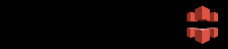
Adds <10s to system startup

What else?

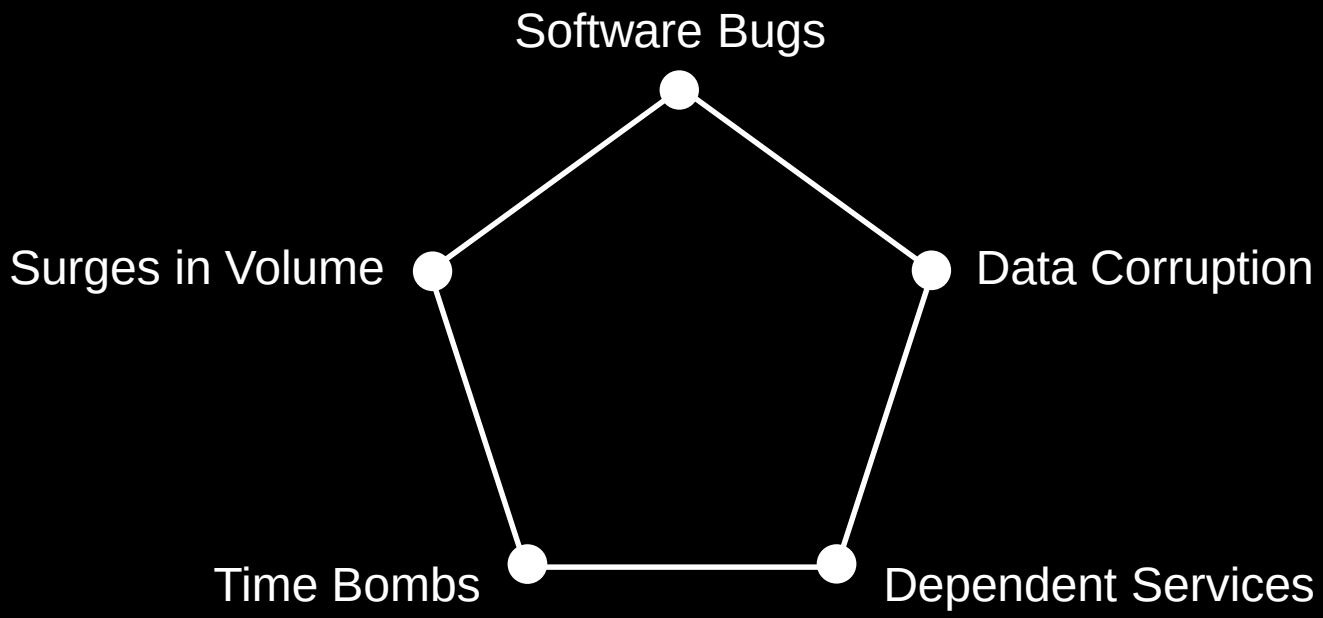
Time

- SSL Certificates
- Domain name registrations
- Deployment Schedules
- ???

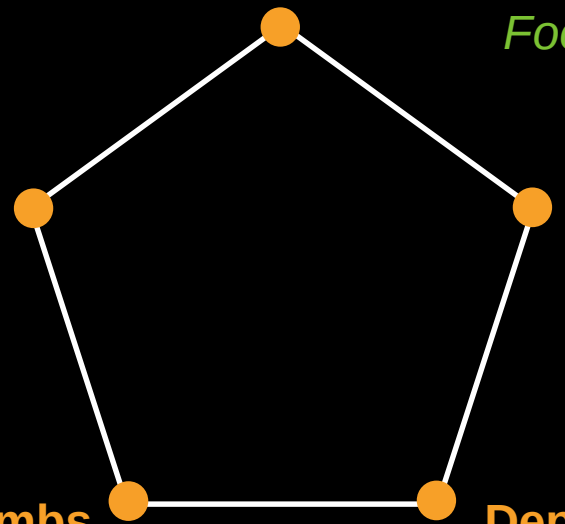
Wrap up:
Lessons learned



Risks to availability



Risks & Common Patterns



Software Bugs

Multi-impl
Sharding
FoodTaster

Surges in Volume

Load dispersion

Data Corruption

FoodTaster

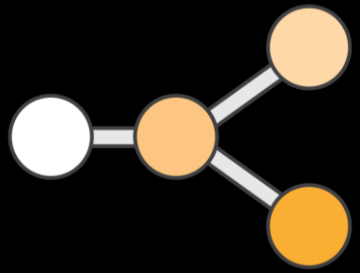
Time Bombs

Jitter

Dependent Services

Cache
Redundancies

Lessons learned



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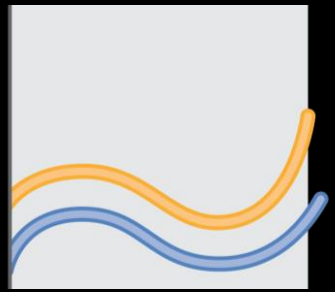
Don’t rely on validation in your main application



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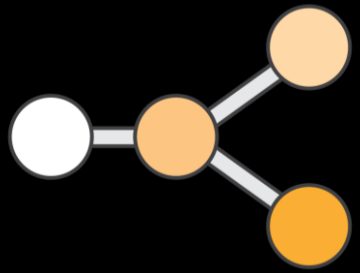

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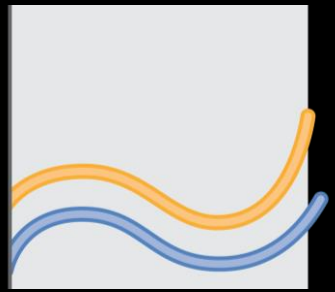

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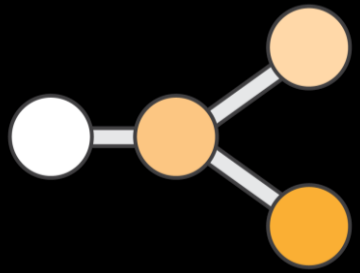

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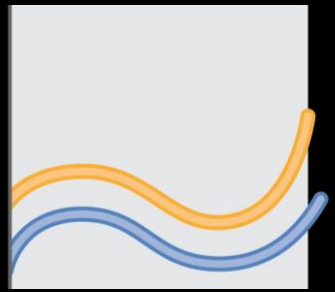

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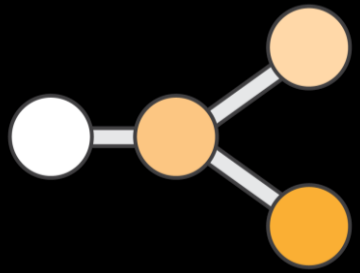

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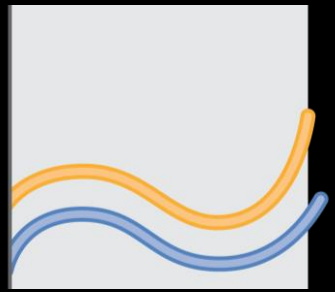

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Thank you!

Remember to complete your evaluations!

Related Sessions

ARC309

Moving Mission Critical Apps from One Region to Multi-Region active/active

ARC204

From Resilience to Ubiquity - #NetflixEverywhere Global Architecture