DNS Demystified

Global Traffic Management with Amazon Route 53

AWS re:Invent

aws

This Hour of Your Short Life

Theme: Large-Scale DNS

- Lightning Intro to DNS & Core Route 53 Features
- DNS Resolution inside EC2
- What's New in Route 53
- Customer Case Study: MuleSoft
- Route 53 Advanced Traffic Management
- DNS Operational Excellence

Lightning Tour of

DNS & Core Route 53 Features

What Problem Does DNS Solve?

How Does It Work?

How Do You Set It up?

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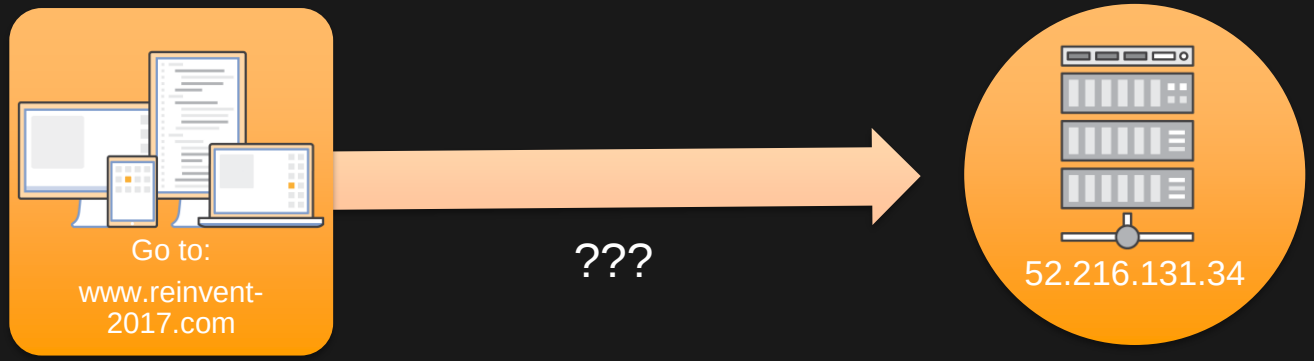
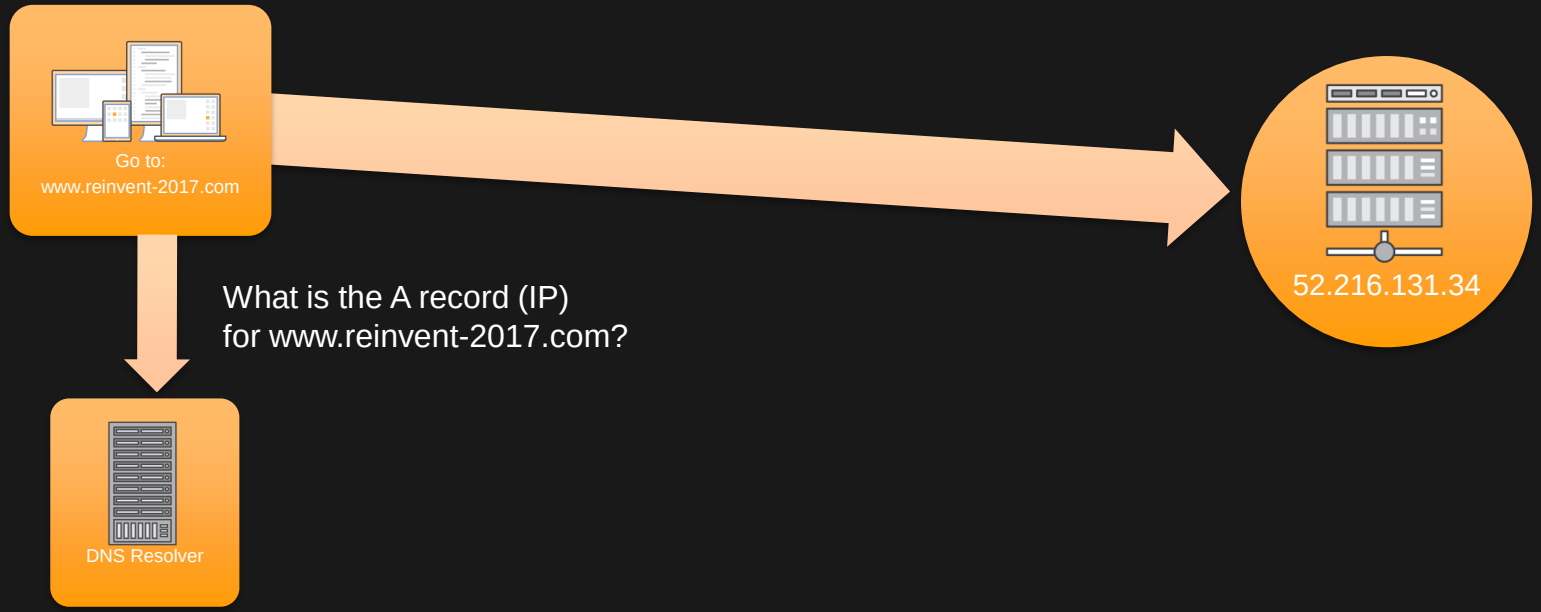
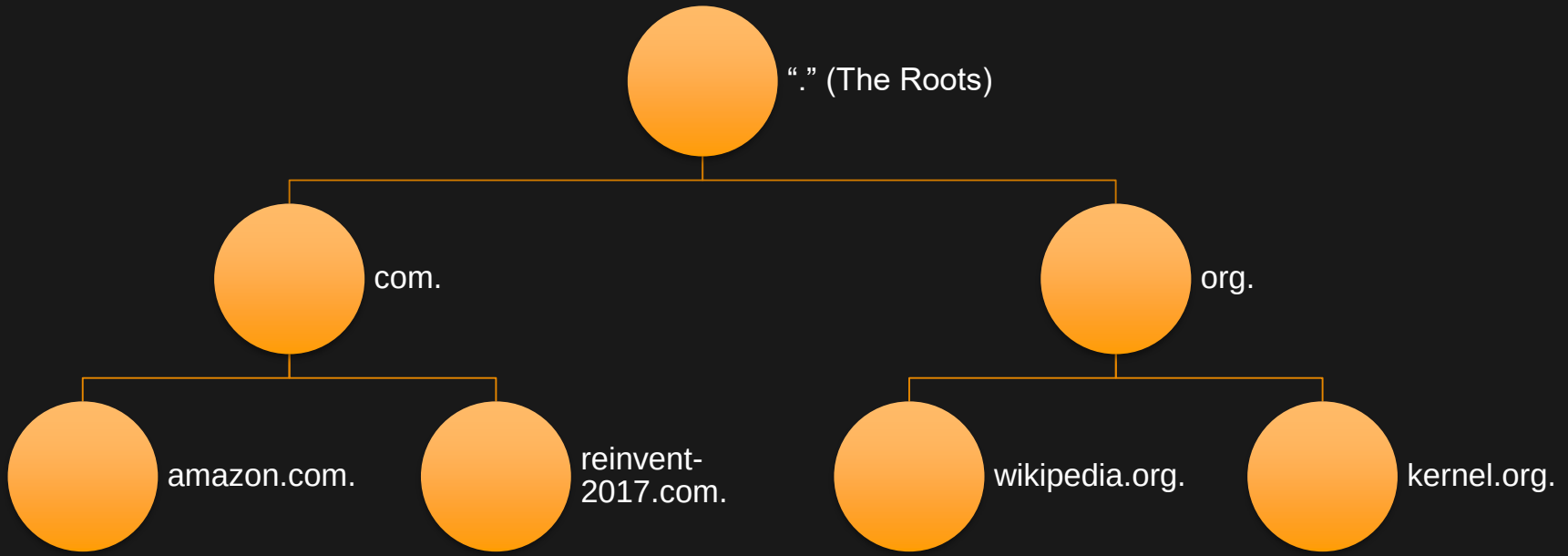
The Problem DNS Solves



The Problem DNS Solves



How Do the Resolvers Know?



How Does a Resolver Work?

root nameservers
(Various)

- A record for www.reinvent-2017.com?
- NS records for com

com nameservers
(Verisign)

- A record for www.reinvent-2017.com?
- NS records for reinvent-2017.com

reinvent-2017.com
Nameservers
(Route 53)

- A record for www.reinvent-2017.com?
- Yes! 52.216.131.34

Recursive Resolution

```
ubuntu@ip-172-31-9-203:~$ dig +trace www.reinvent-2017.com

; <<>> DiG 9.9.5-3ubuntu0.16-Ubuntu <<>> +trace www.reinvent-2017.com
;; global options: +cmd
.                   518400      IN    NS    A.ROOT-SERVERS.NET.
.                   518400      IN    NS    B.ROOT-SERVERS.NET.
.                   518400      IN    NS    C.ROOT-SERVERS.NET.
.                   518400      IN    NS    D.ROOT-SERVERS.NET.
.                   518400      IN    NS    E.ROOT-SERVERS.NET.
.                   518400      IN    NS    F.ROOT-SERVERS.NET.
.                   518400      IN    NS    G.ROOT-SERVERS.NET.
.                   518400      IN    NS    H.ROOT-SERVERS.NET.
.                   518400      IN    NS    I.ROOT-SERVERS.NET.
.                   518400      IN    NS    J.ROOT-SERVERS.NET.
.                   518400      IN    NS    K.ROOT-SERVERS.NET.
.                   518400      IN    NS    L.ROOT-SERVERS.NET.
.                   518400      IN    NS    M.ROOT-SERVERS.NET.
;; Received 239 bytes from 172.31.0.2#53(172.31.0.2) in 192 ms
```

Recursive Resolution

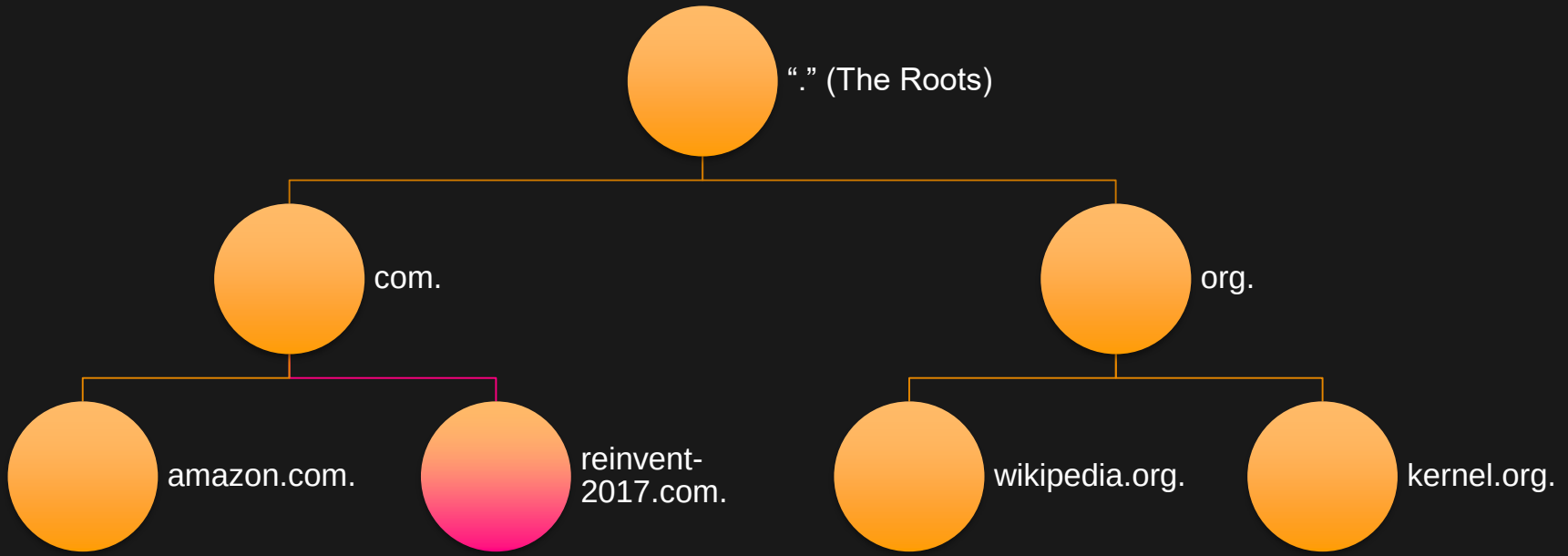
```
com.            172800    IN    NS    b.gtld-servers.net.
com.            172800    IN    NS    e.gtld-servers.net.
com.            172800    IN    NS    j.gtld-servers.net.
com.            172800    IN    NS    i.gtld-servers.net.
com.            172800    IN    NS    l.gtld-servers.net.
com.            172800    IN    NS    k.gtld-servers.net.
com.            172800    IN    NS    g.gtld-servers.net.
com.            172800    IN    NS    f.gtld-servers.net.
com.            172800    IN    NS    m.gtld-servers.net.
com.            172800    IN    NS    h.gtld-servers.net.
com.            172800    IN    NS    a.gtld-servers.net.
com.            172800    IN    NS    d.gtld-servers.net.
com.            172800    IN    NS    c.gtld-servers.net.
;; Received 1181 bytes from 202.12.27.33#53(M.ROOT-SERVERS.NET) in 88 ms
```

Recursive Resolution

```
reinvent-2017.com.  172800    IN   NS   ns-1900.awsdns-45.co.uk.
reinvent-2017.com.  172800    IN   NS   ns-1526.awsdns-62.org.
reinvent-2017.com.  172800    IN   NS   ns-709.awsdns-24.net.
reinvent-2017.com.  172800    IN   NS   ns-250.awsdns-31.com.
;; Received 704 bytes from 192.41.162.30#53(l.gtld-servers.net) in 38 ms
```

```
www.reinvent-2017.com.   60   IN   A    52.216.131.34
reinvent-2017.com.  172800    IN   NS   ns-1900.awsdns-45.co.uk.
reinvent-2017.com.  172800    IN   NS   ns-1526.awsdns-62.org.
reinvent-2017.com.  172800    IN   NS   ns-250.awsdns-31.com.
reinvent-2017.com.  172800    IN   NS   ns-709.awsdns-24.net.
;; Received 203 bytes from 205.251.192.250#53(ns-250.awsdns-31.com) in 9 ms
```

DNS for a Website



What Is Route 53?

- Route 53 Public DNS (zone hosting)
    - 100% availability SLA
    - Currently 76x PoPs worldwide
- Route 53 Registrar
- Route 53 Private DNS (inside EC2)
- Route 53 Health Checking and Traffic Management
- Public APIs and CLIs for automated operation
    - SDK, AWS CLI, CLI53, Boto, Denominator …

DNS for a Website

```
a45e60d6bfe1:~ gavinmc$ aws route53domains check-domain-availability --domain-name reinvent-2017.com
{
    "Availability": "AVAILABLE"
}

a45e60d6bfe1:~ gavinmc$ aws route53domains register-domain --cli-input-json file://route53domains-skeleton.json \
                        --domain-name reinvent-2017.com
{
    "OperationId": "eae4c84c-606c-4453-89d8-e752ff614337"
}

a45e60d6bfe1:~ gavinmc$ aws route53domains list-operations
{
    "Operations": [
        {
            "Status": "IN_PROGRESS",
            "Type": "REGISTER_DOMAIN",
            "SubmittedDate": 1510208466.623,
            "OperationId": "eae4c84c-606c-4453-89d8-e752ff614337"
        }
    ]
}
```

Zone Created Automatically

```
a45e60d6bfe1:~ gavinmc$ aws route53 list-hosted-zones-by-name
{
    "HostedZones": [
        {
            "ResourceRecordSetCount": 2,
            "CallerReference": "RISWorkflow-RD:8498650d-2e08-4b12-b099-8c30e4ff5f61",
            "Config": {
                "Comment": "HostedZone created by Route53 Registrar",
                "PrivateZone": false
            },
            "Id": "/hostedzone/Z2PBIU2YUKVPKA",
            "Name": "reinvent-2017.com."
        }
    ],
    "IsTruncated": false,
    "MaxItems": "100"
}
```

Create Records

```
a45e60d6bfe1:~ gavinmc$ aws route53 change-resource-record-sets --cli-input-json file://change-rrset.json \
                            --hosted-zone-id Z2PBIU2YUKVPKA
{
    "ChangeInfo": {
        "Status": "PENDING",
        "Comment": "Creating_a_first_record",
        "SubmittedAt": "2017-11-09T06:43:01.339Z",
        "Id": "/change/C23K4GSRVZTUAG"
    }
}

a45e60d6bfe1:~ gavinmc$ aws route53 get-change --id C23K4GSRVZTUAG
{
    "ChangeInfo": {
        "Status": "INSYNC",
        "Comment": "Creating_a_first_record",
        "SubmittedAt": "2017-11-09T06:43:01.339Z",
        "Id": "/change/C23K4GSRVZTUAG"
    }
}
```

What Was in the JSON Doc?

```
{
    "ChangeBatch": {
        "Comment": "Creating a first record",
        "Changes": [
            {
                "Action": ”CREATE",
                "ResourceRecordSet": {
                    "Name": "www.reinvent-2017.com",
                    "Type": "A",
                    "SetIdentifier": "1",
                    "Weight": 0,
                    "TTL": 900,
                    "ResourceRecords": [
                        {
                            "Value": ”52.216.131.34"
                        }
                    ]
                }
```

DNS inside EC2

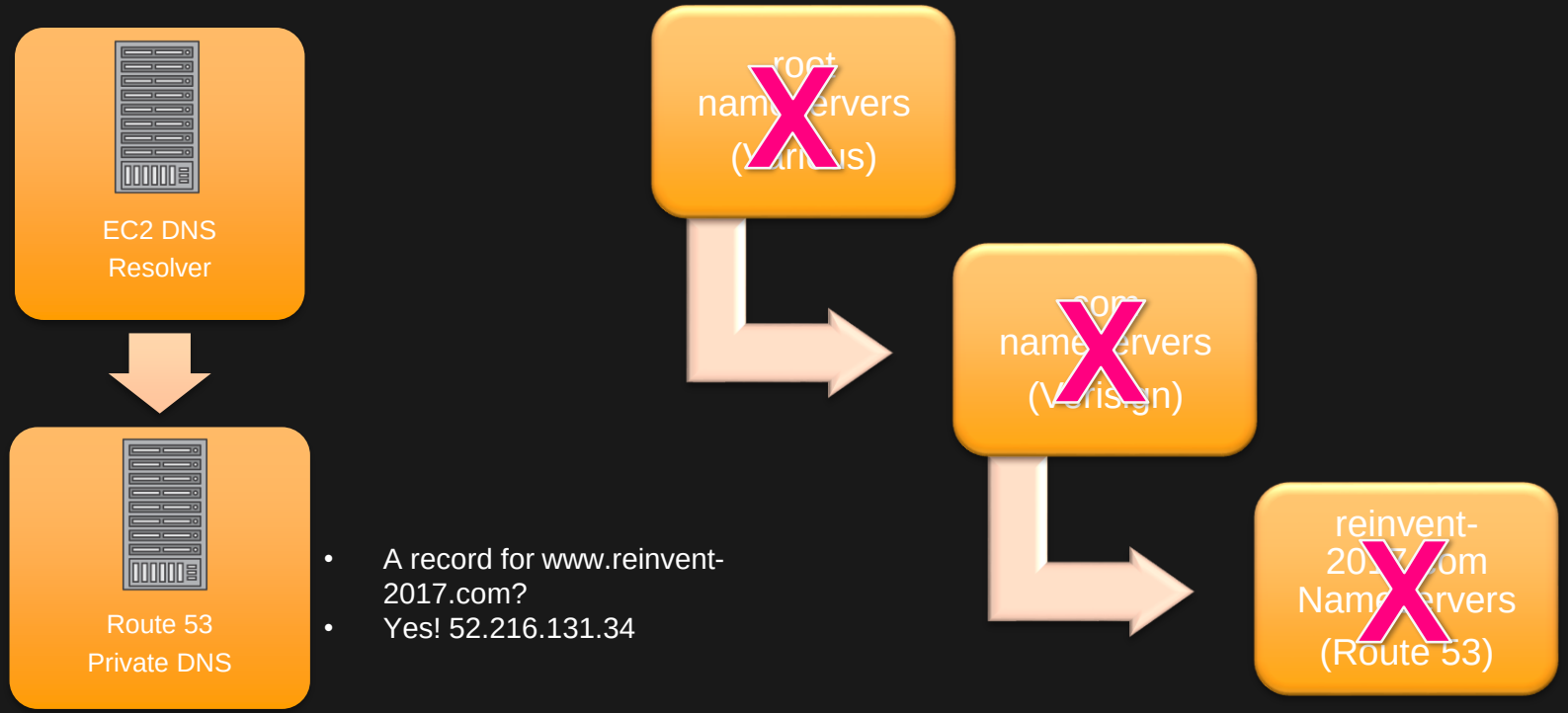
Amazon-Provided DNS

Route53 Private DNS

DNS Resolution in VPCs

- “Amazon-Provided DNS” in EC2
    - Public DNS resolver
    - Internal instance hostnames
- Route 53 Private DNS
    - Create/Associate Private DNS zone
    - Cross-region, cross-account zones

How Does Private DNS Work?

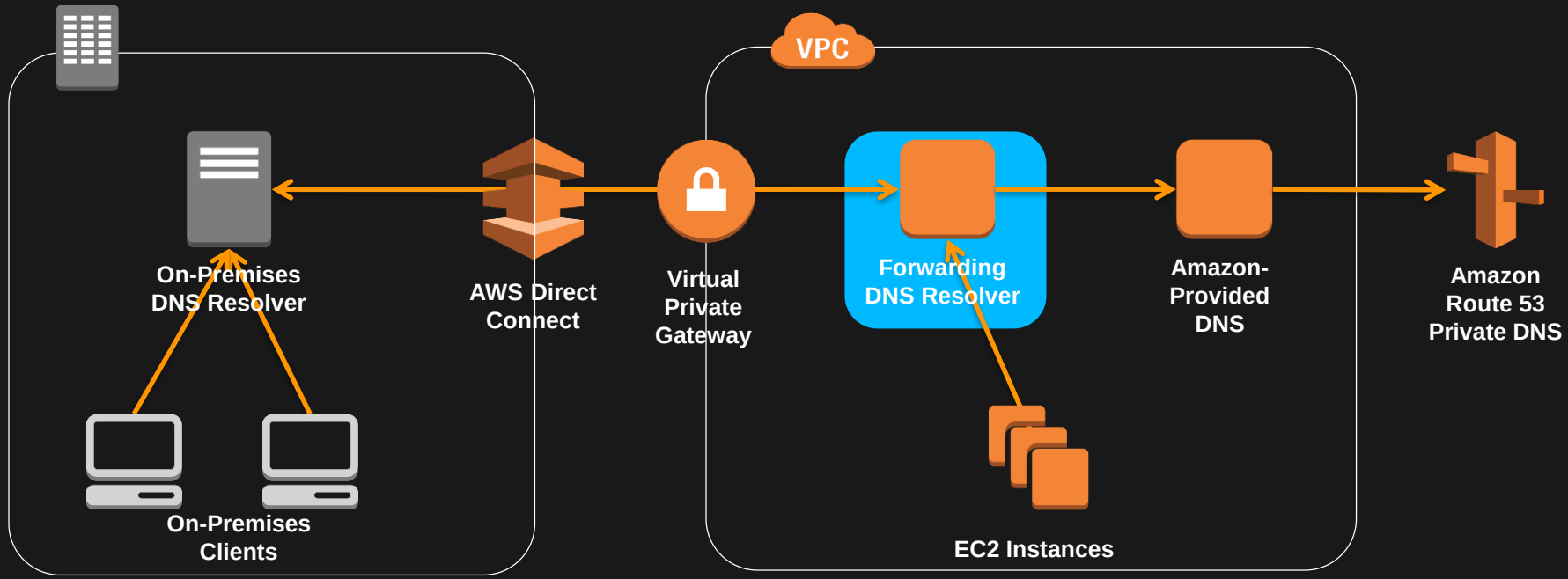


- A record for www.reinvent-2017.com?
- Yes! 52.216.131.34

DNS In "Hybrid" Clouds

- DirectConnect or VPN between data center and VPC
- A single view of DNS for data center hosts and VPC instances
- Solutions
    - Forwarding Resolver instances, e.g., Unbound, DNSMasq, Simple AD
    - Lambda-based sync from DC into Route53 Private DNS
    - Per-instance conditional forwarding, e.g., Unbound
- Whitepaper
    - *Hybrid Cloud DNS Solutions For Amazon VPC* (October 2017)

Hybrid Cloud – Forwarding Instances



What's New in Route 53?

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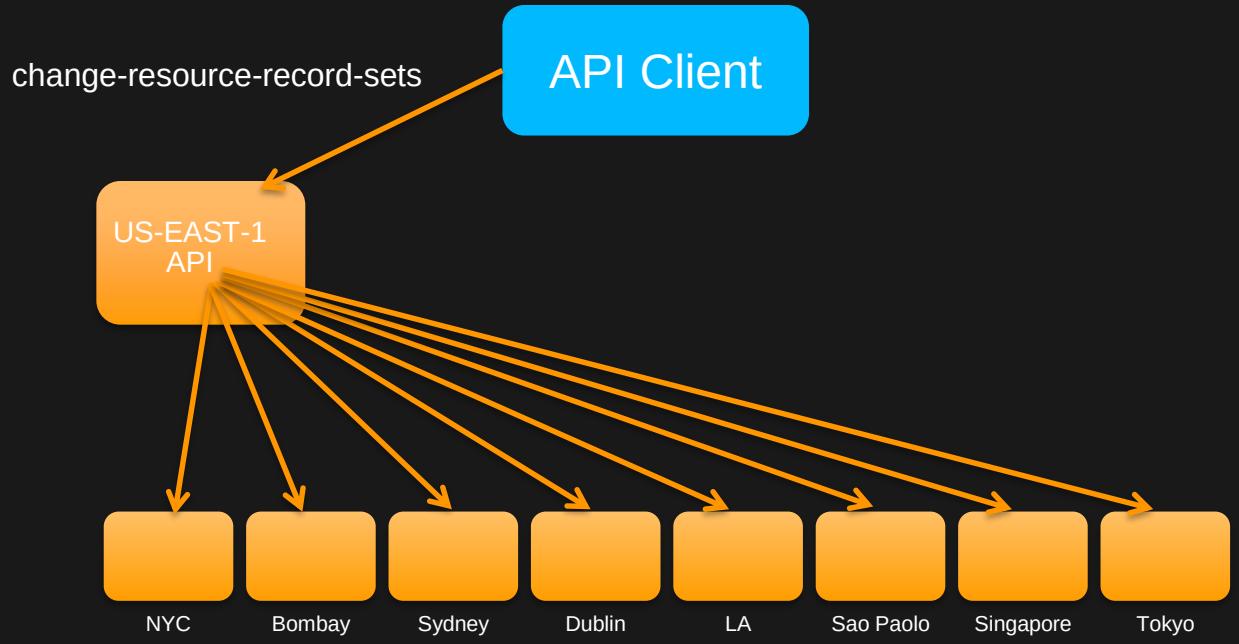
What's New?

- Geo-Proximity Routing Type
- Public Route 53 Query Logs
- Registrar Bulk (100x) Domain Transfer
- Multi-Response Answers for Weighted Round Robin
- CAA Record Support
- Service Limits API

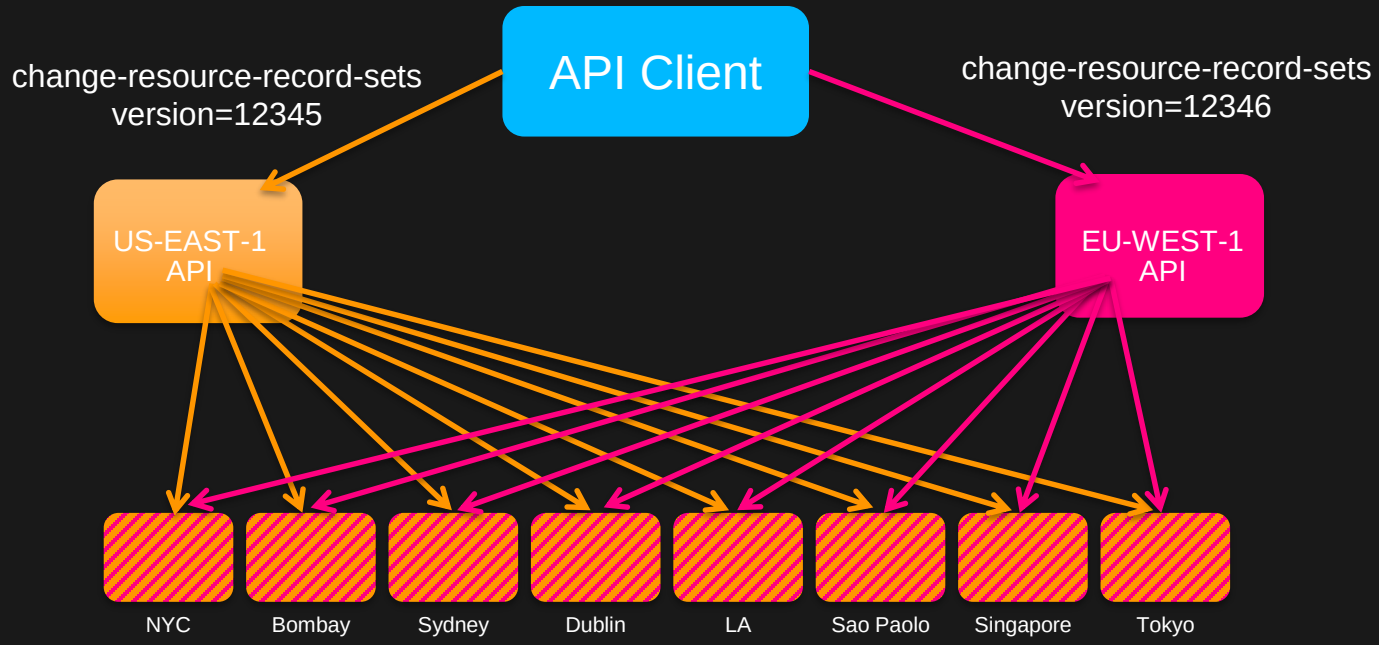
API and Change Propagation

- Route 53 100% SLA on DNS Queries
- Making DNS record changes: standard API in US-EAST-1
- Optional: second Route 53 API endpoint available in EU-WEST-1
- Tradeoffs in using standard versus multi-region API
- Customer use case: MuleSoft

Route 53 Multi-Region API



Route 53 Multi-Region API



MuleSoft's Propagation-Sensitive Use Case

About MuleSoft

Company overview

- Help organizations change and innovate faster by making it easy to connect the world's applications, data, and devices
- Founded in 2006, HQ: San Francisco
- 1,000+ employees worldwide

Business momentum

- IPO in March 2017
- Over 1,000 customers in approximately 60 countries
- Global presence: offices in five continents
- Global footprint: sales, services, support

MuleSoft's Anypoint Platform

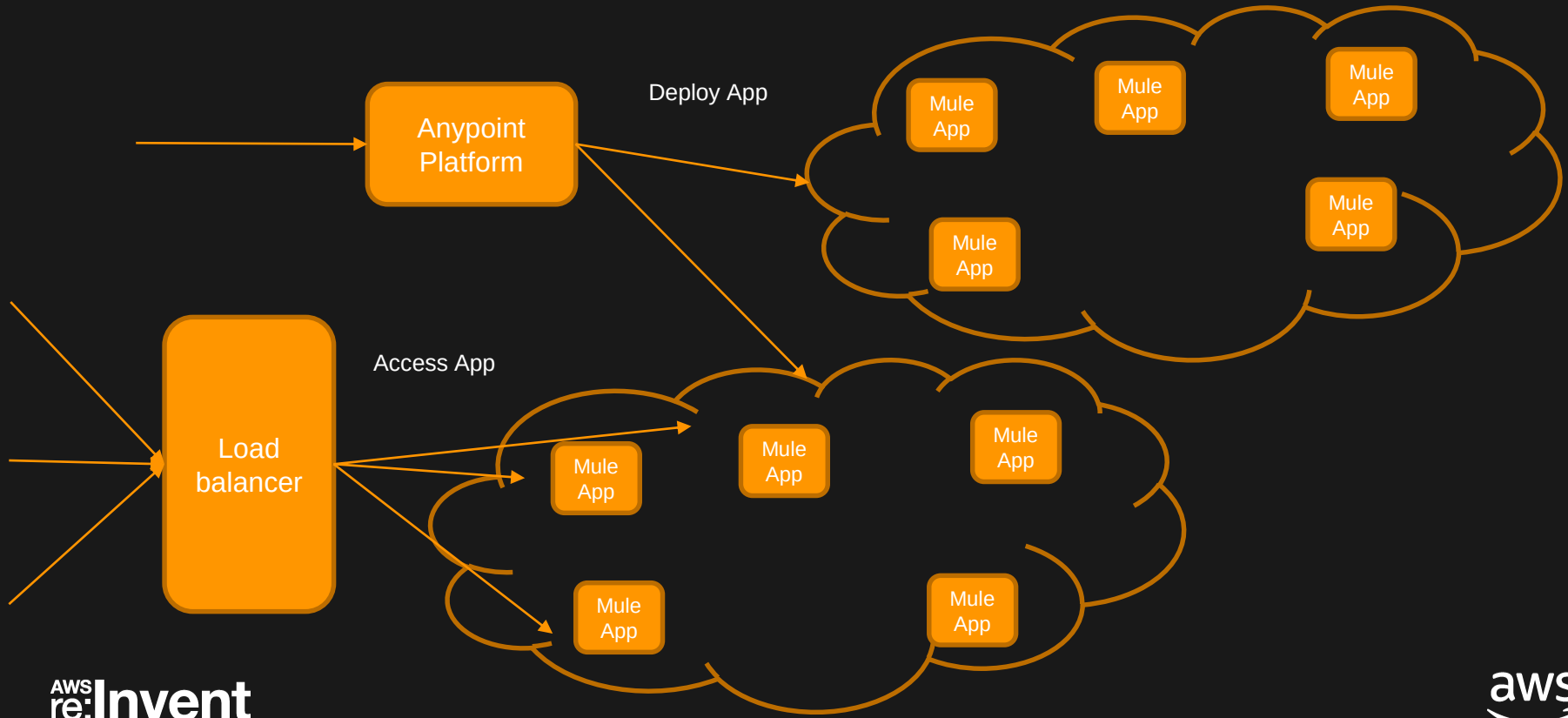
- Multi-tenant hybrid integration platform for APIs and integration
- iPaaS:
    - 99.99% uptime
    - One-click multi-DC HA
    - One-click scalability
    - Zero down-time upgrades
    - Smart healing
    - Built-in security

MuleSoft's Anypoint Platform in AWS

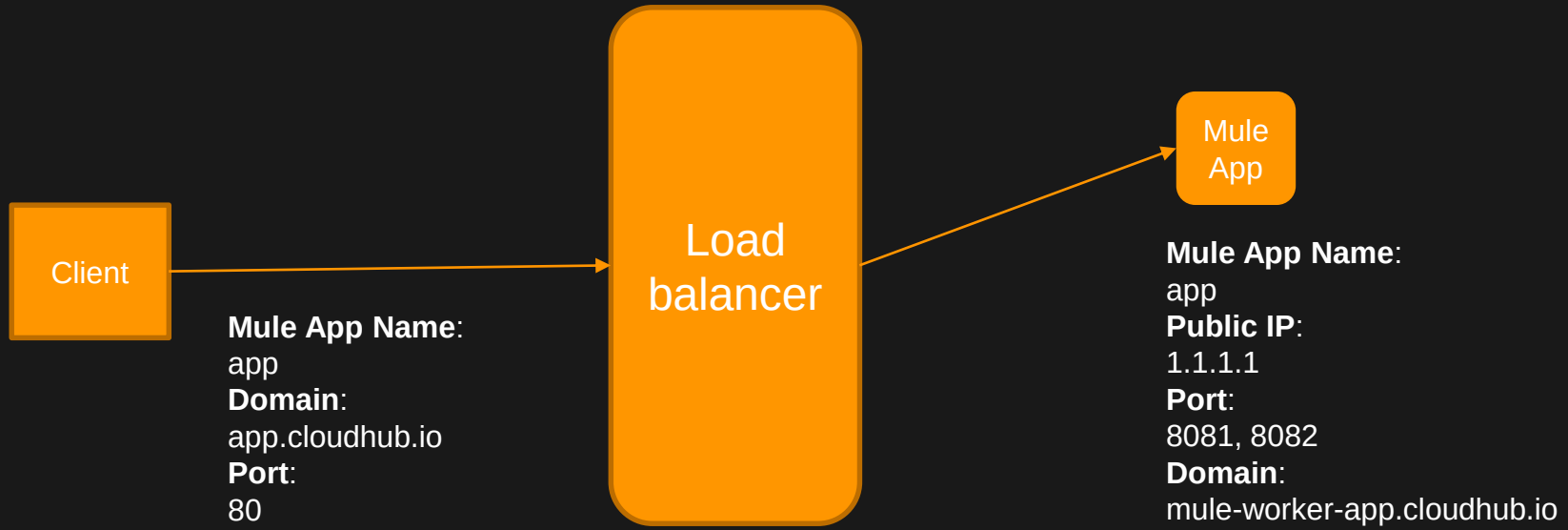
- Build on top of EC2, CloudWatch, SQS, S3, Route 53, etc.
- Run instances in 12 regions
- Active instances over 25,000
- CloudWatch Alarms over 30,000

- Daily application deployment over 9,000
    - EC2 Instance Provisions: 4,500
    - EC2 Instance Shutdown: 4,000
- **Daily Route 53 DNS Record Operations**
    - **Insert Resource Records: 5,000**
    - **Delete Resource Records: 4,000**

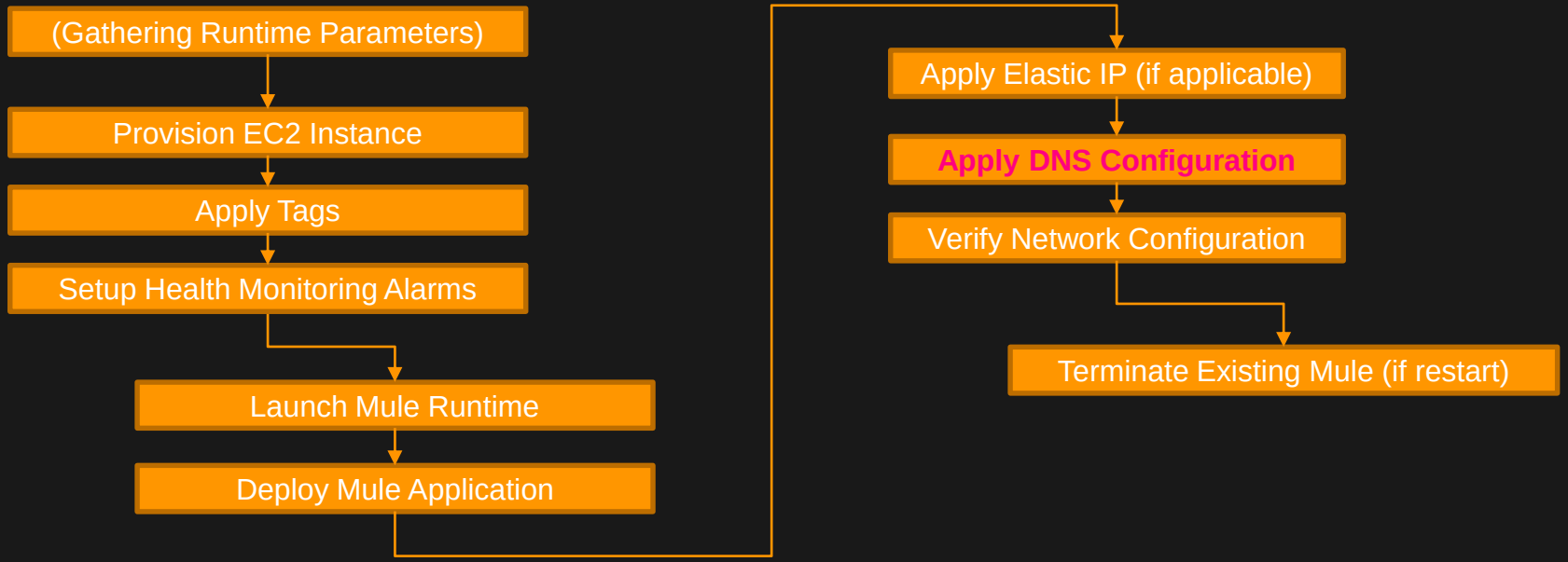
MuleSoft's Anypoint Platform in AWS



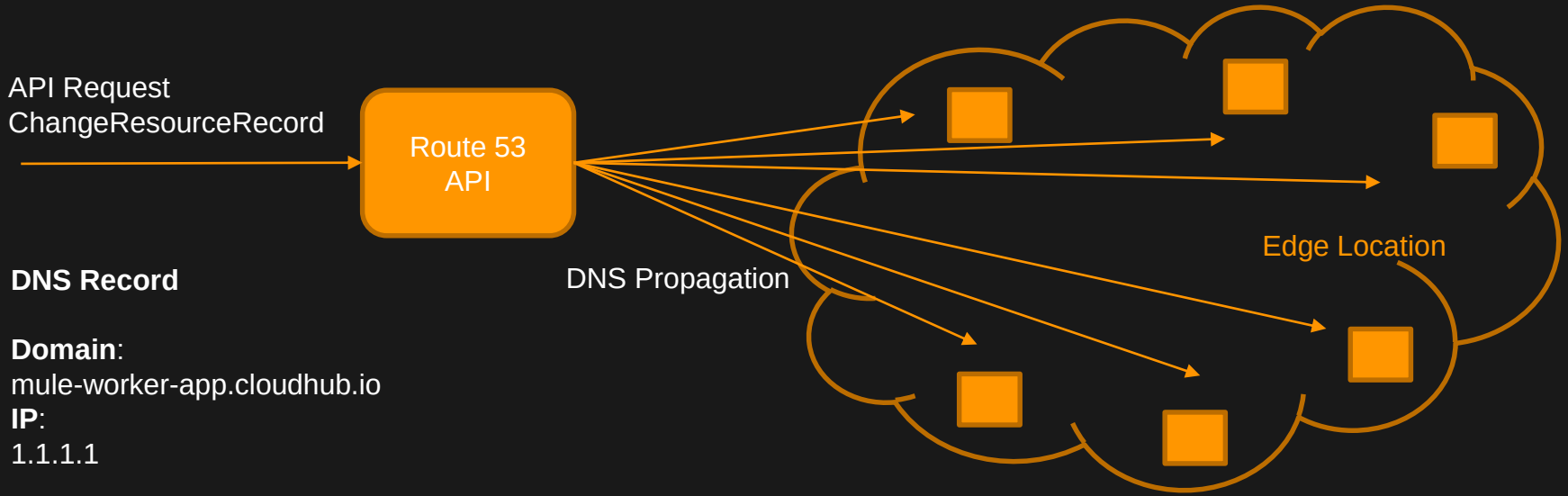
MuleSoft's Anypoint Platform in AWS



Mule App Deployment



Mule App Deployment—Route 53



DNS Record

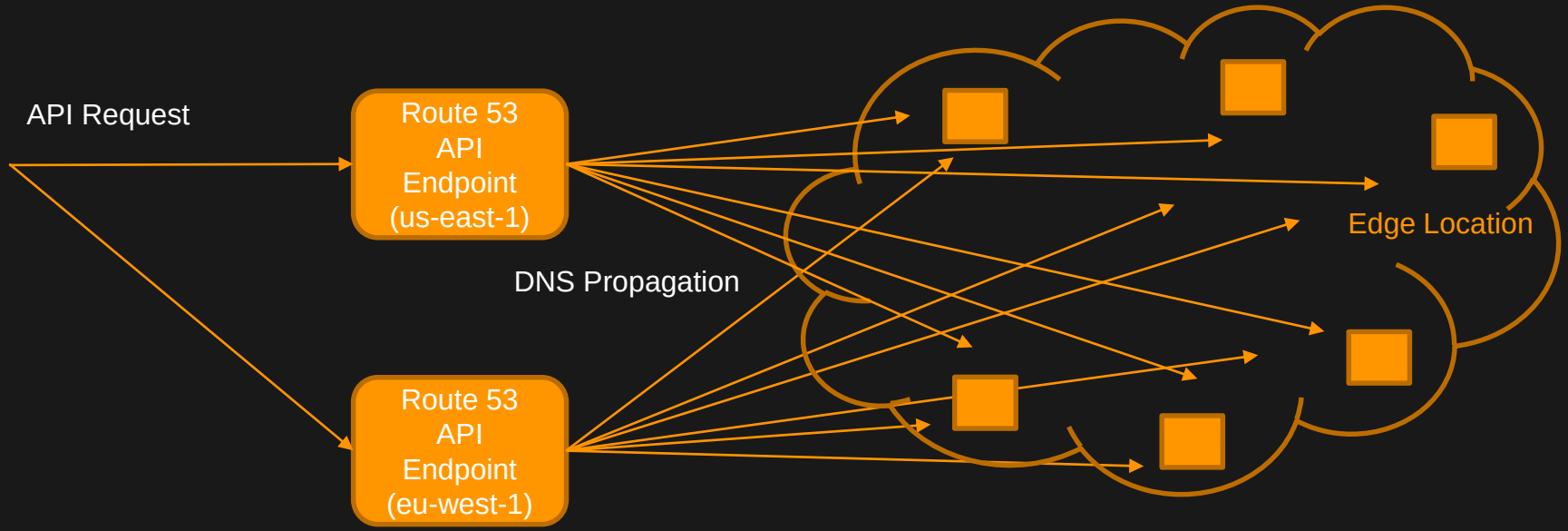
Domain:
mule-worker-app.cloudhub.io
IP:
1.1.1.1

Importance of Route 53

- Potential failure mode of Route 53
    - Unreachable API
    - Slow DNS records propagation

- Impact on MuleSoft's Anypoint Platform
    - Mule application deployment failures
    - Unresolvable Mule applications

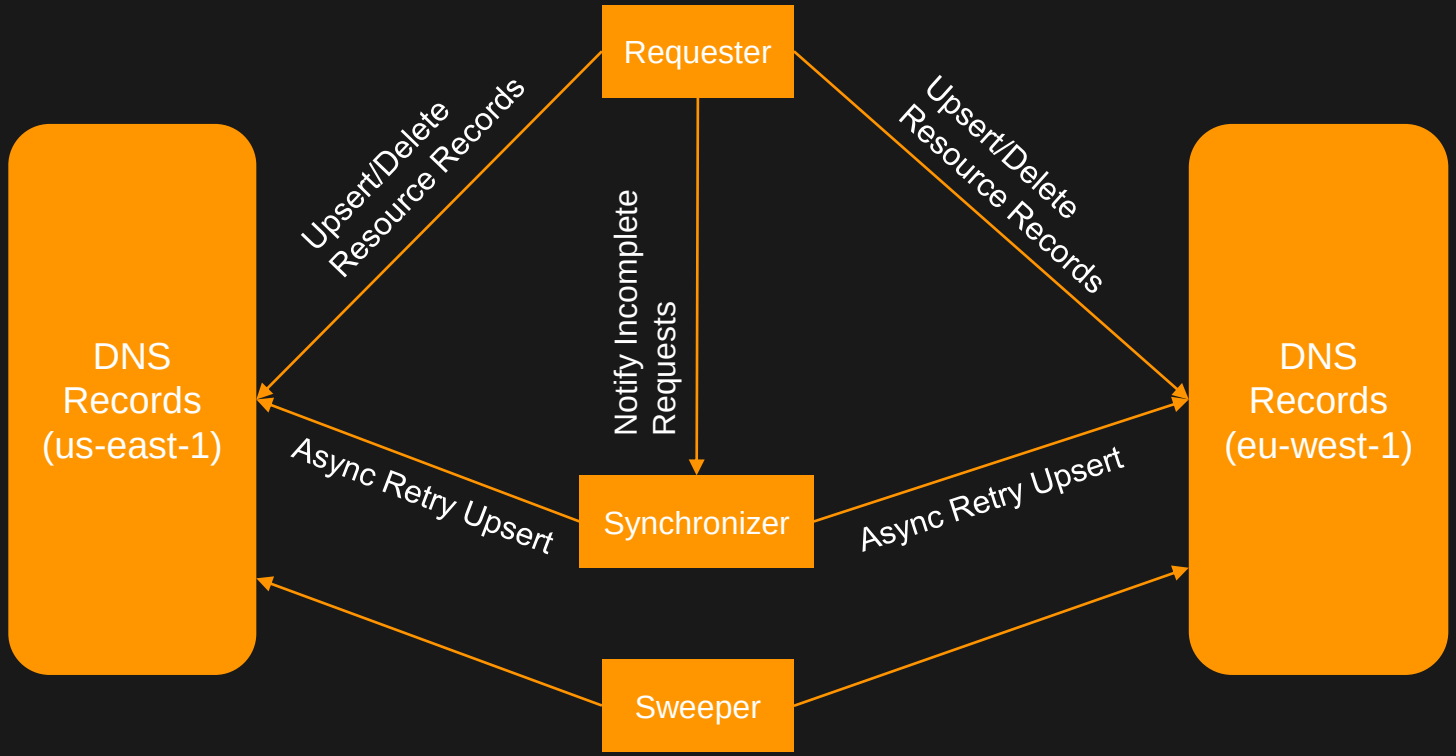
Extra Resilience of Route 53 Services



Options on Multi-Region Route 53

- How it works
  - Two independent Route 53 API endpoints in two regions
  - Operate separately and propagate two sets of versioned DNS records
  - DNS query gets the higher-versioned record
- Options
  - Failover (not recommended)
    - Use the secondary one only if the primary doesn't respond
      - Distinguish various types of failures
      - Deal with two sets of DNS records
  - Redundancy
    - Goal is to keep records in both API regions

Utilization Multi-Region Route 53 Services



Iterate and remove garbage records (infrequently)

Implementation Limitations and Concerns

- Independence of multi-region Route 53 servers
    - High availability and redundancy
    - Additional synchronization for consistency between the two regions

- Migration from current Route 53 services to multi-region Route 53
    - Backwards compatible
    - Complicated rollback procedures in case of problems

- Rare theoretical case of delayed DNS update
    - The Route 53 services in two regions experience problems in reachability and propagation respectively in turn

Conclusion

- Increased uptime and resilience for MuleSoft's Anypoint Platform
- Real-time alert on Route 53 DNS status
- 100% success rate on application DNS resolve so far

Multi-Region API Recap

- Twin APIs provide redundant paths to provision records
- Best practice is to write all changes to all zones (constant work)
- Not currently released. Private beta only.
- Complexity trade-offs are only appropriate for customers with very sensitive, synchronous workflows

Advanced Traffic Management

DNS for High Availability

DNS for Failover

DNS for Global Least Latency

DNS for Regional Content

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Traffic Management

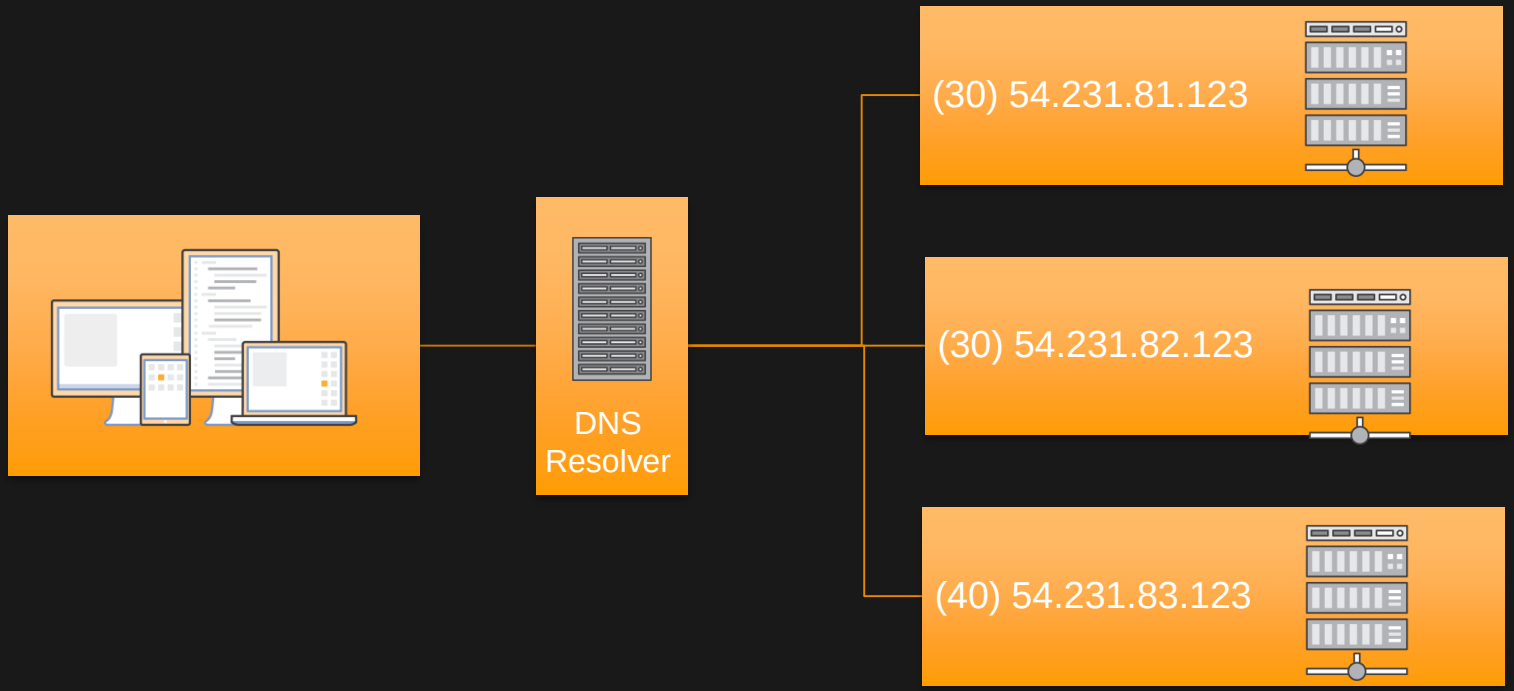
- DNS is an abstraction layer
- Smart answers to manage traffic
- Let’s look at some customer use cases

DNS for Load Balancing

- *Customer: I run an online bookshop and I want to be able to run my service active-active across multiple redundant data centers.*

- *Feature: Weighted Round Robin records will return each endpoint IP in the ratio you determine.*

DNS for Load Balancing

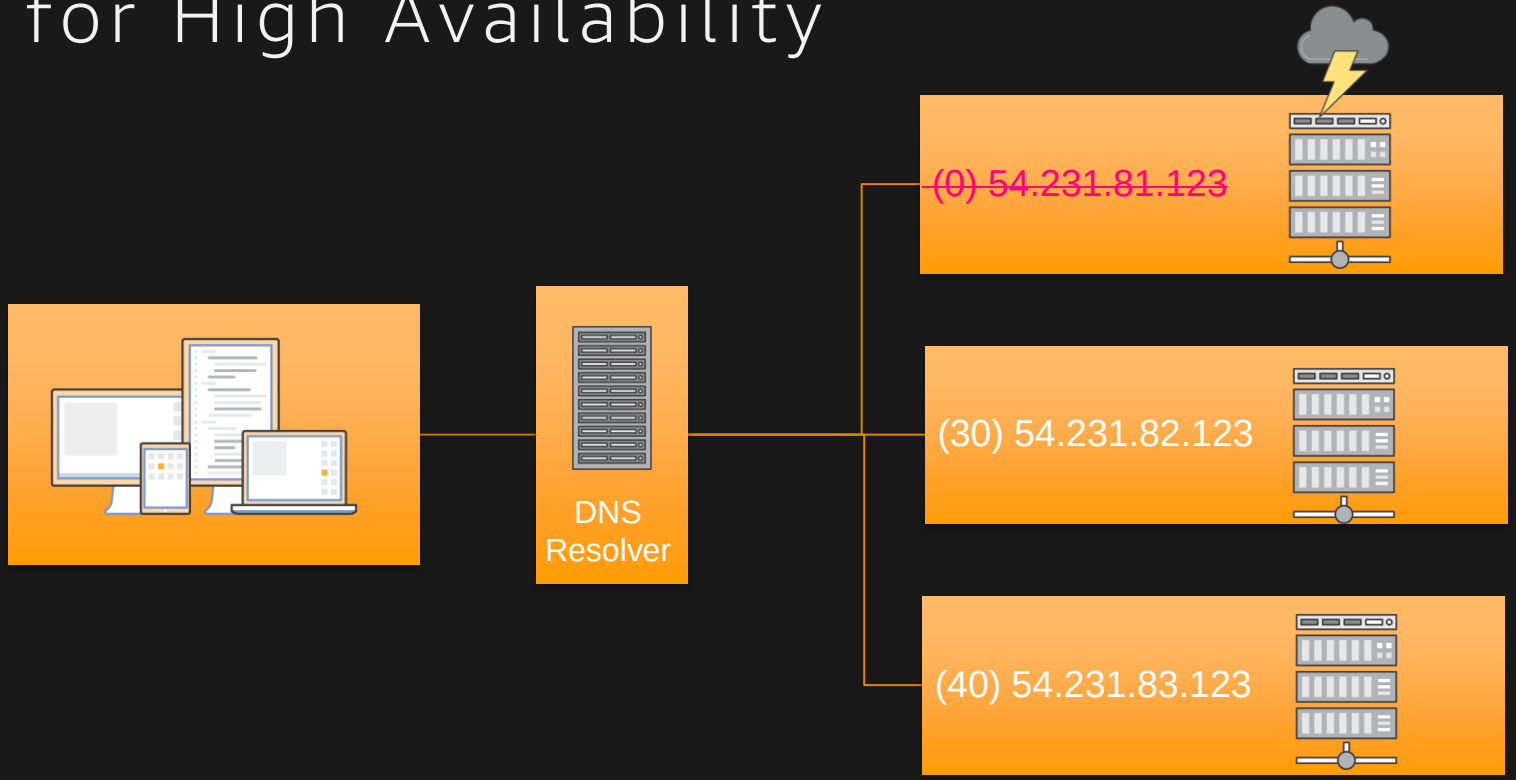


DNS for High Availability

- *Customer: Now, how do I recover automatically when one of my endpoints or data centers fails?*

- *Feature: Route 53 Health Checks will poll each configured endpoint regularly, establish which ones are healthy and only return those.*

DNS for High Availability

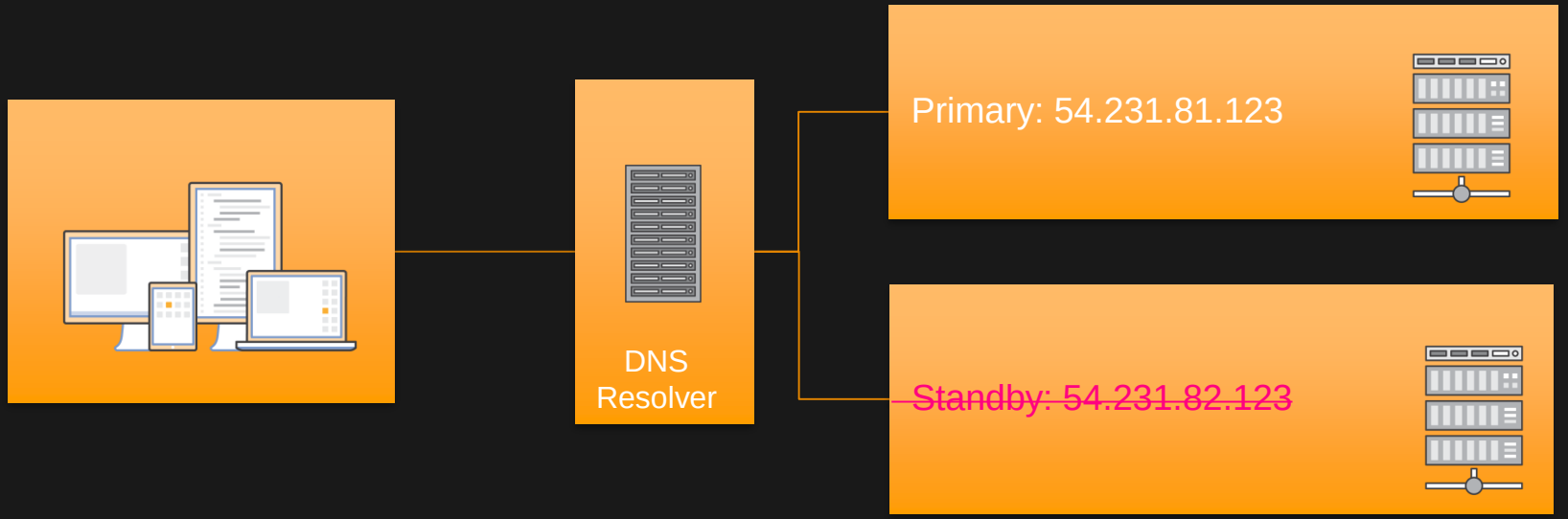


DNS for Failover

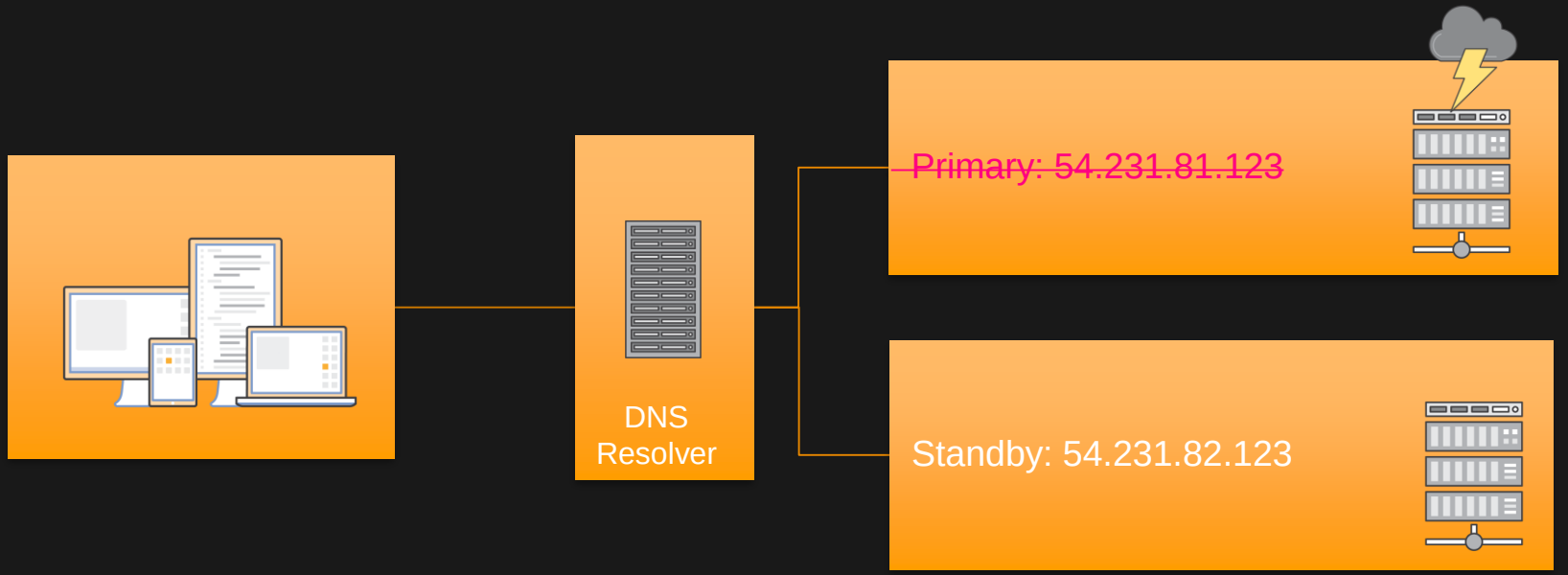
- *Customer: I'm running a web service. If it fails, I need to fail over to a second standby system (for example, a second stack, an S3 bucket website).*

- *Feature: Route 53 Failover routing type with health checks.*

DNS for Failover



DNS for Failover



DNS for Low Latency

- *Customer: I built my web service out in multiple EC2 Regions. Responsiveness is critical. How do I route customers to the lowest latency EC2 region?*

- *Feature: Route 53 Latency-Based Routing (LBR) Policy determines the IP address of the client and always returns the endpoints in the lowest latency (healthy) region for that client IP.*

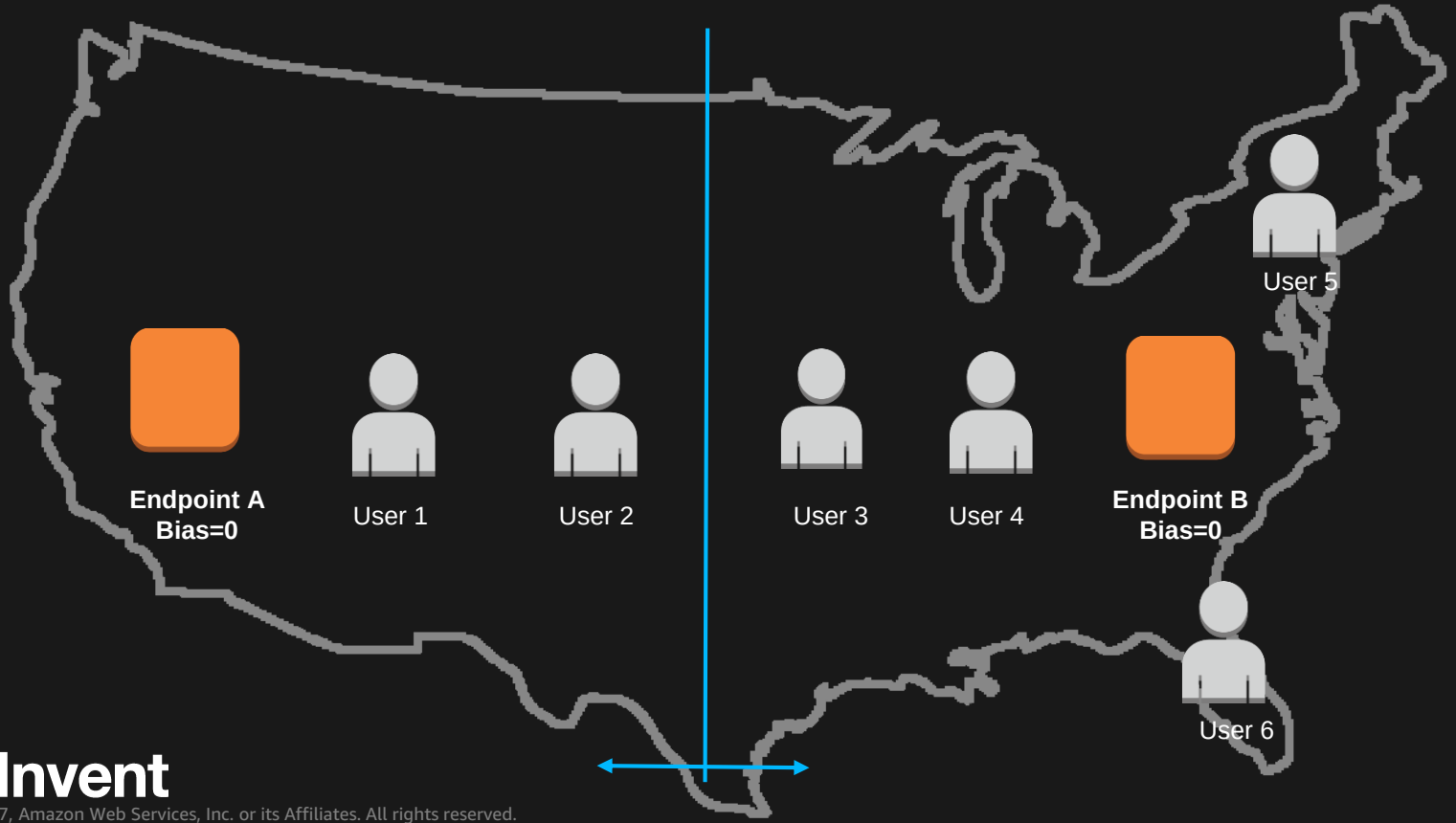
DNS for Low Latency (LBR)

DNS for Low Latency (Geoproximity)

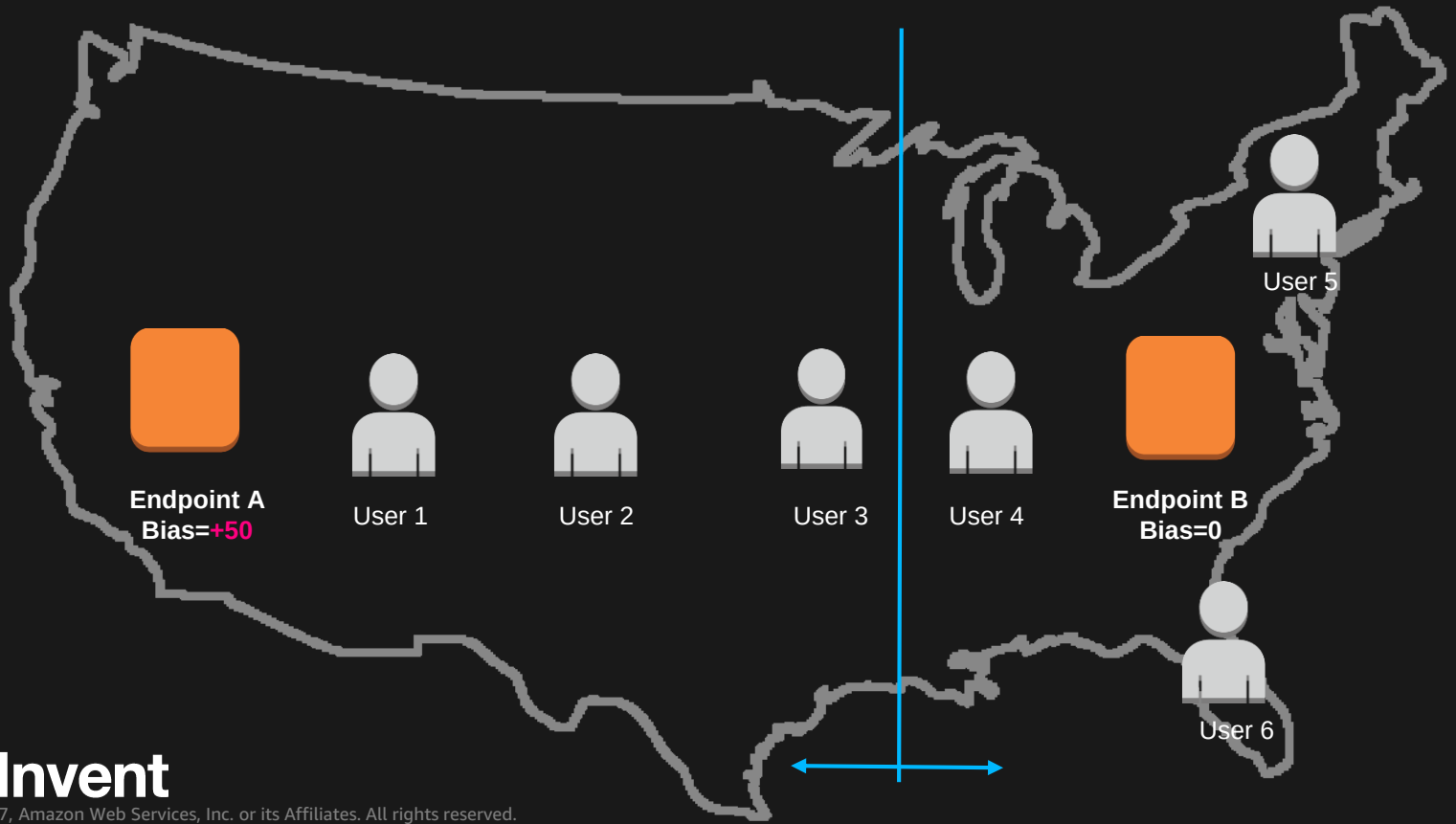
- *Customer: What if my endpoints are not inside EC2 Regions? What if I want to shift traffic between regions while preferring least latency?*

- *Feature: Route 53 Geo-Proximity estimates the map location of the client and returns endpoints which are at the minimal distance from the client.*

DNS for Low Latency (Geoproximity)



DNS for Low Latency (GeoProximity)

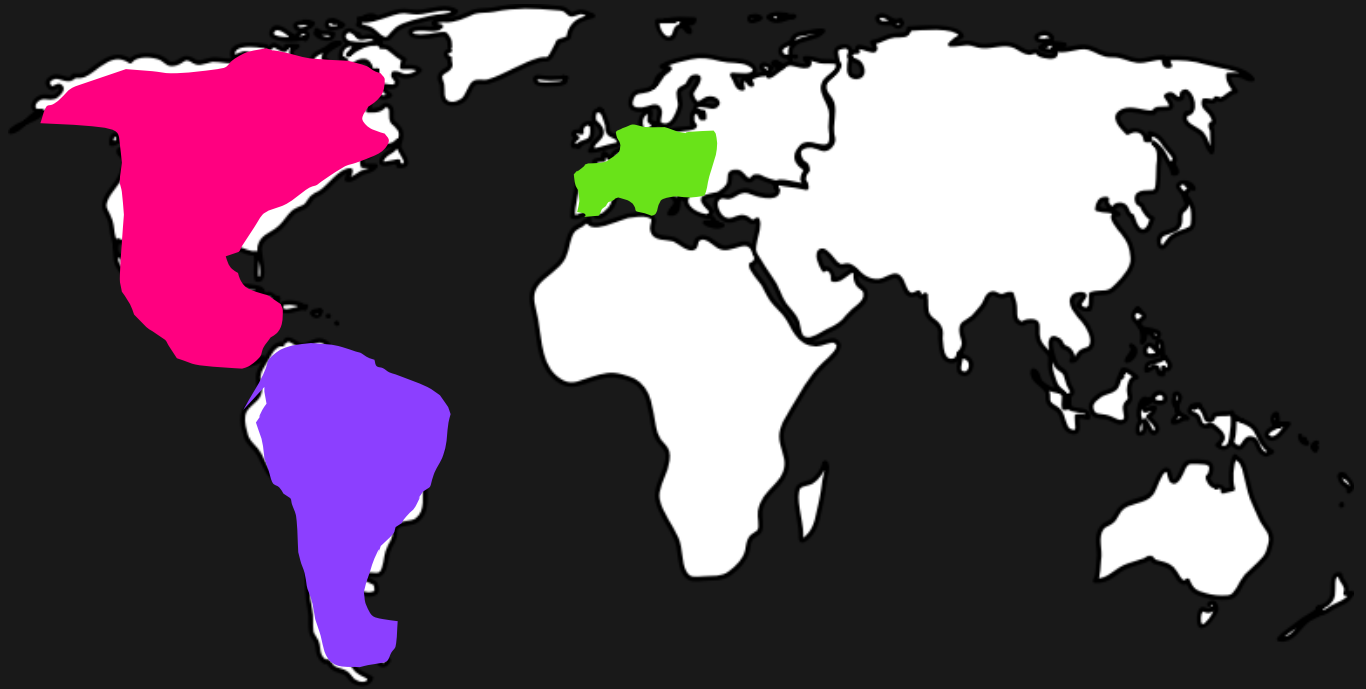


DNS for Regional Content

- *Customer: I need to offer different content based on the location of the client.*

- *Feature: Route 53 Geolocation determines the continent, country, and state (in USA) of the client. Customers can choose which locations go to which endpoints.*

DNS for Regional Content

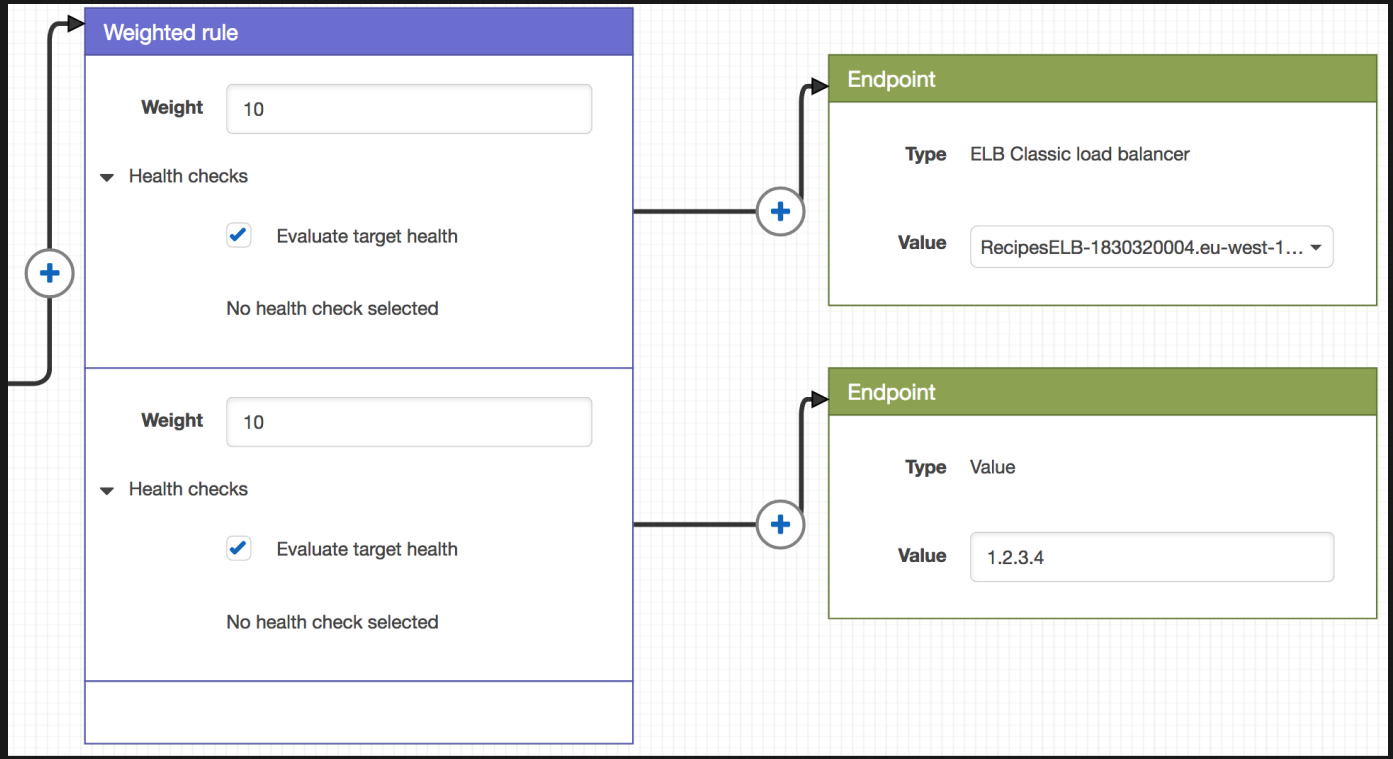


Route 53 Traffic Flow

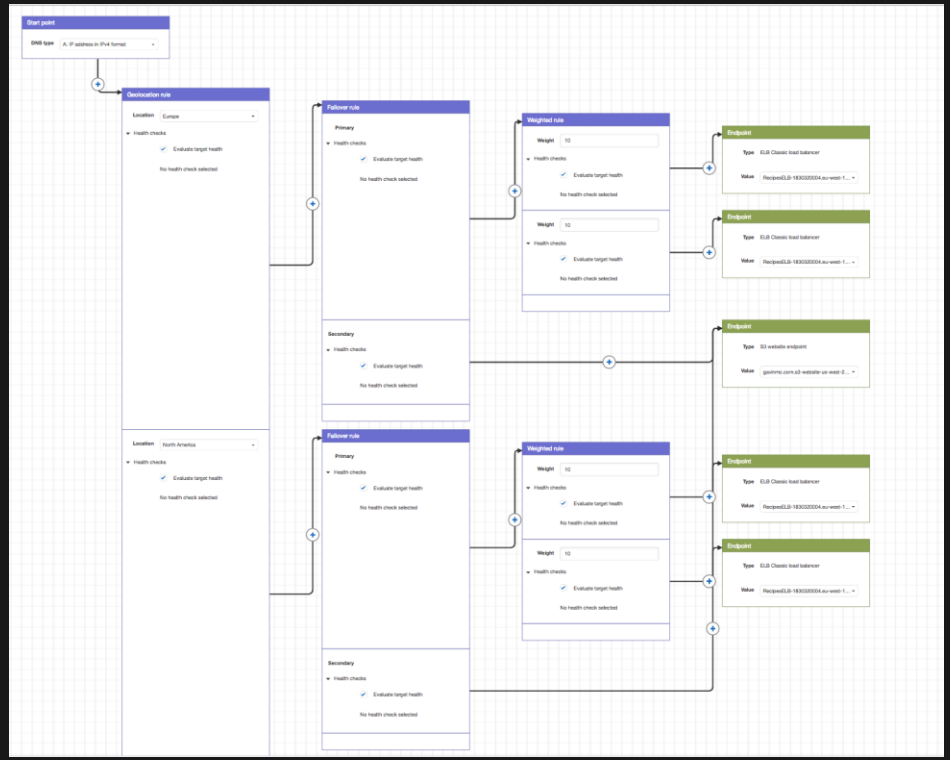
- *Customer: My routing policy combines Health Checks, Weighting, LBR, and Failover records. I need a way to visualise the flow.*
- *Customer: I need to be able to make multiple, atomic changes to my routing policy.*
- *Customer: I need to be able to rollback my routing policy.*

- *Feature: Route 53 Traffic Flow UI and API.*

Route53 Traffic Flow



Route53 Traffic Flow



Traffic Flow Policy as Code

```
{
    "AWSPolicyFormatVersion":"2015-10-01",
    "RecordType":"A",
    "Endpoints":{
        "endpoint-weighted-blue":{
            "Type":"value",
            "Value":"1.2.3.4"
        },
        "endpoint-weighted-green":{
            "Type":"value",
            "Value":"3.4.5.6"
        }
    },
    "Rules":{
        "weighted-start-purple":{
            "RuleType":"weighted",
            "Items":[
                {"Weight":"10", "EndpointReference":"endpoint-weighted-blue", "EvaluateTargetHealth":true},
                {"Weight":"10", "EndpointReference":"endpoint-weighted-green","EvaluateTargetHealth":true}
            ]
        }
    },
    "StartRule":"weighted-start-purple"
}
```

Creating a Policy

```
a45e60d6bfe1:~ gavinmc$ aws route53 create-traffic-policy --name reinvent-2017.com-policy \
                                --document file://policy.json
{
    "TrafficPolicy": {
        "Document": "{……}",
        "Version": 2,
        "Type": "A",
        "Id": "fd936505-74a3-4f58-8ebb-be270b426460",
        "Name": "reinvent-2017.com-policy"
    },
    "Location": "https://route53.amazonaws.com/2013-04-01/trafficpolicy/fd936505-74a3-4f58-8ebb-
be270b426460/1"
}
```

Apply the Policy

```
a45e60d6bfe1:~ gavinmc$ aws route53 update-traffic-policy-instance \
    --traffic-policy-version 2  --ttl 60 \
    --id=3a91fc71-76b6-4e8e-b7ad-a7b3eaa8b6ca \
    --traffic-policy-id fd936505-74a3-4f58-8ebb-be270b426460
{
    "TrafficPolicyInstance": {
        "Name": "www.route53-2017.com.",
        "TrafficPolicyVersion": 2,
        "TrafficPolicyType": "A",
        "State": "Updating",
        "TrafficPolicyId": "fd936505-74a3-4f58-8ebb-be270b426460",
        "TTL": 60,
        "HostedZoneId": "Z2DICVFGUDZI8F",
        "Id": "3a91fc71-76b6-4e8e-b7ad-a7b3eaa8b6ca"
    }
}
```

Rolling Back a Policy

```
a45e60d6bfe1:~ gavinmc$ aws route53 update-traffic-policy-instance \
     --traffic-policy-version 1  --ttl 60 \
     --id=3a91fc71-76b6-4e8e-b7ad-a7b3eaa8b6ca \
     --traffic-policy-id fd936505-74a3-4f58-8ebb-be270b426460
{
    "TrafficPolicyInstance": {
        "Name": "www.route53-2017.com.",
        "TrafficPolicyVersion": 1,
        "TrafficPolicyType": "A",
        "State": "Updating",
        "TrafficPolicyId": "fd936505-74a3-4f58-8ebb-be270b426460",
        "TTL": 60,
        "HostedZoneId": "Z2DICVFGUDZI8F",
        "Id": "3a91fc71-76b6-4e8e-b7ad-a7b3eaa8b6ca"
    }
}
```

DNS Operational Excellence Tips

Safely Switching Providers

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TTLs Are Important!

- As a DNS operator, the TTL is your friend!
- Short TTL = fast traffic shifts and rollbacks
- Long TTL = better customer experience, lower query volume ($)
- For critical changes, lower the TTL temporarily
    - Faster rollback

Switching DNS Providers

- We want to move a production DNS zone to Route 53
- Simplest solution:
    1. Export the zone data
    2. Create a zone in Route 53 and import data
    3. Update registrar with new nameservers
- If you have a problem, roll back takes two days ☹

Safely Switching DNS Providers

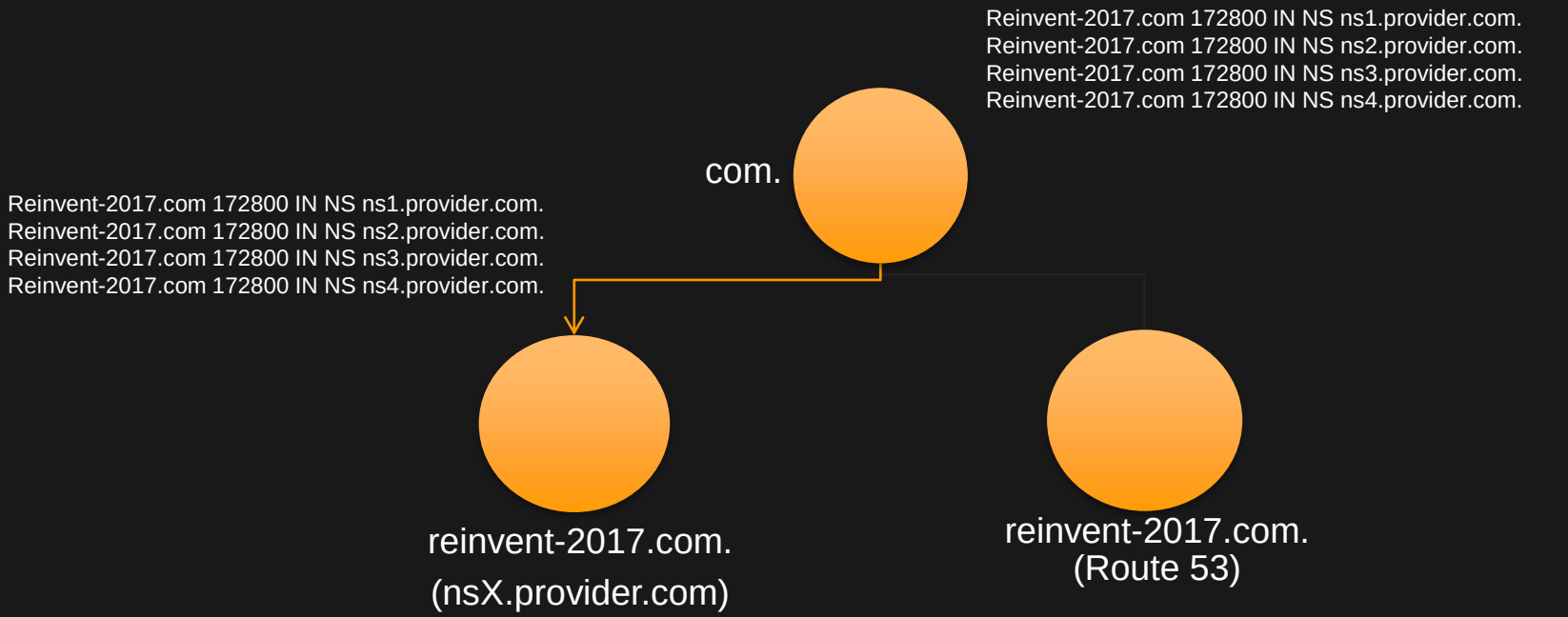
- Good change management always includes quick rollback steps
- Rollback of registrar: two days!
    - TTL on TLD NS records is 172800 sec
- There is a way to make it safer
    - Two copies of NS records
    - Most resolvers cache the in-zone copy

Recall: Recursive Resolution

```
reinvent-2017.com.  172800    IN   NS   ns-1526.awsdns-62.org.
reinvent-2017.com.  172800    IN   NS   ns-1900.awsdns-45.co.uk.
reinvent-2017.com.  172800    IN   NS   ns-709.awsdns-24.net.
reinvent-2017.com.  172800    IN   NS   ns-250.awsdns-31.com.
;; Received 704 bytes from 192.41.162.30#53(l.gtld-servers.net) in 38 ms

www.reinvent-2017.com.   60   IN   A    52.216.131.34
reinvent-2017.com.  172800    IN   NS   ns-1526.awsdns-62.org.
reinvent-2017.com.  172800    IN   NS   ns-1900.awsdns-45.co.uk.
reinvent-2017.com.  172800    IN   NS   ns-250.awsdns-31.com.
reinvent-2017.com.  172800    IN   NS   ns-709.awsdns-24.net.
;; Received 203 bytes from 205.251.192.250#53(ns-250.awsdns-31.com) in 9 ms
```

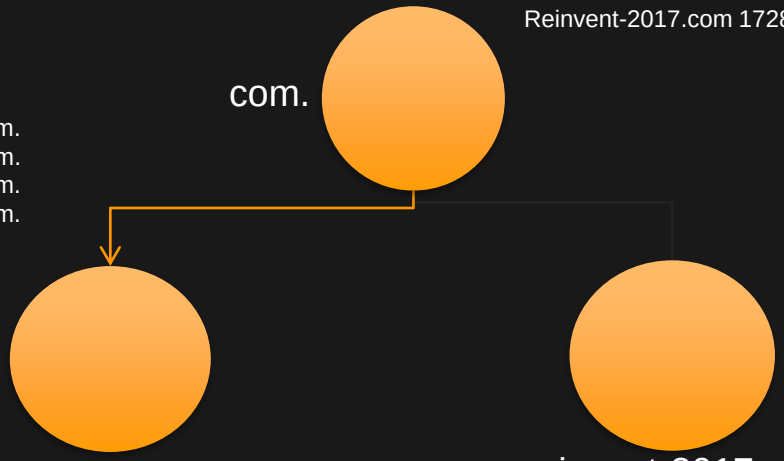
Starting Point



Step 1—Lower TTLs (t=0)

Reinvent-2017.com 172800 IN NS ns1.provider.com.
Reinvent-2017.com 172800 IN NS ns2.provider.com.
Reinvent-2017.com 172800 IN NS ns3.provider.com.
Reinvent-2017.com 172800 IN NS ns4.provider.com.

Reinvent-2017.com 600 IN NS ns1.provider.com.
Reinvent-2017.com 600 IN NS ns2.provider.com.
Reinvent-2017.com 600 IN NS ns3.provider.com.
Reinvent-2017.com 600 IN NS ns4.provider.com.

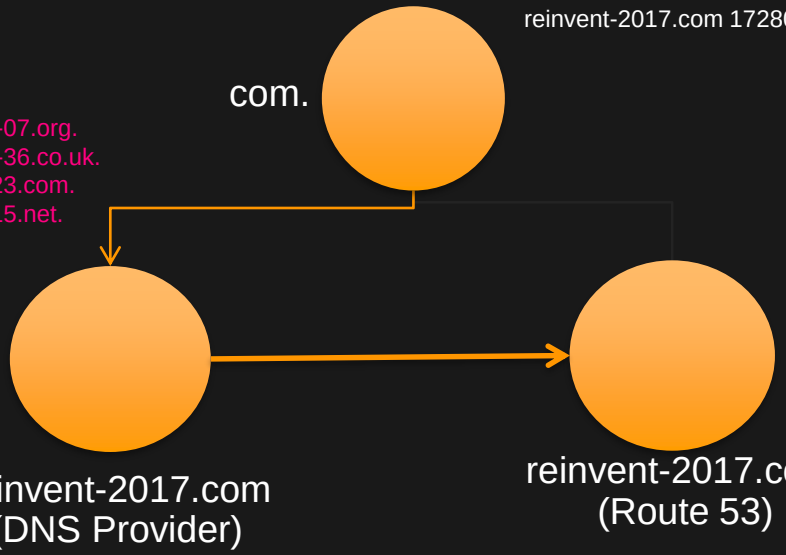


Reinvent-2017.com 600 IN NS ns-1084.awsdns-07.org.
Reinvent-2017.com 600 IN NS ns-1831.awsdns-36.co.uk.
Reinvent-2017.com 600 IN NS ns-190.awsdns-23.com.
Reinvent-2017.com 600 IN NS ns-634.awsdns-15.net.

Step 2—Alter NS In-Zone (t = 2 Days)

reinvent-2017.com 172800 IN NS ns1.provider.com.
reinvent-2017.com 172800 IN NS ns2.provider.com.
reinvent-2017.com 172800 IN NS ns3.provider.com.
reinvent-2017.com 172800 IN NS ns4.provider.com.

reinvent-2017.com 600 IN NS ns-1084.awsdns-07.org.
reinvent-2017.com 600 IN NS ns-1831.awsdns-36.co.uk.
reinvent-2017.com 600 IN NS ns-190.awsdns-23.com.
reinvent-2017.com 600 IN NS ns-634.awsdns-15.net.

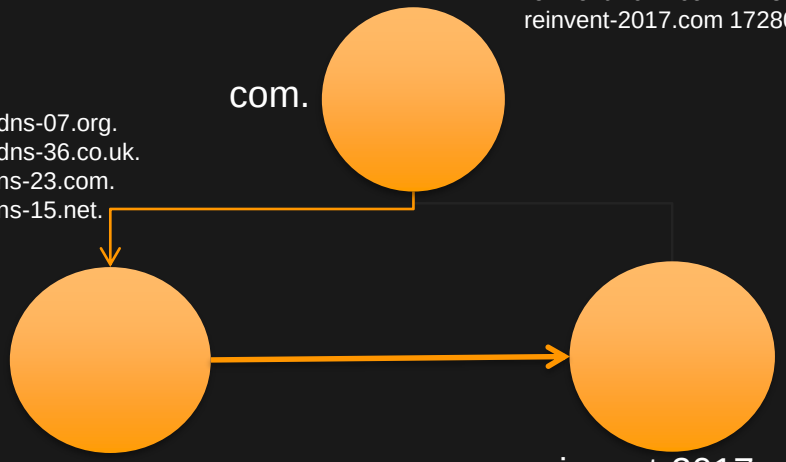


reinvent-2017.com 600 IN NS ns-1084.awsdns-07.org.
reinvent-2017.com 600 IN NS ns-1831.awsdns-36.co.uk.
reinvent-2017.com 600 IN NS ns-190.awsdns-23.com.
reinvent-2017.com 600 IN NS ns-634.awsdns-15.net.

Step 3—Raise TTLs (t = 3 Days)

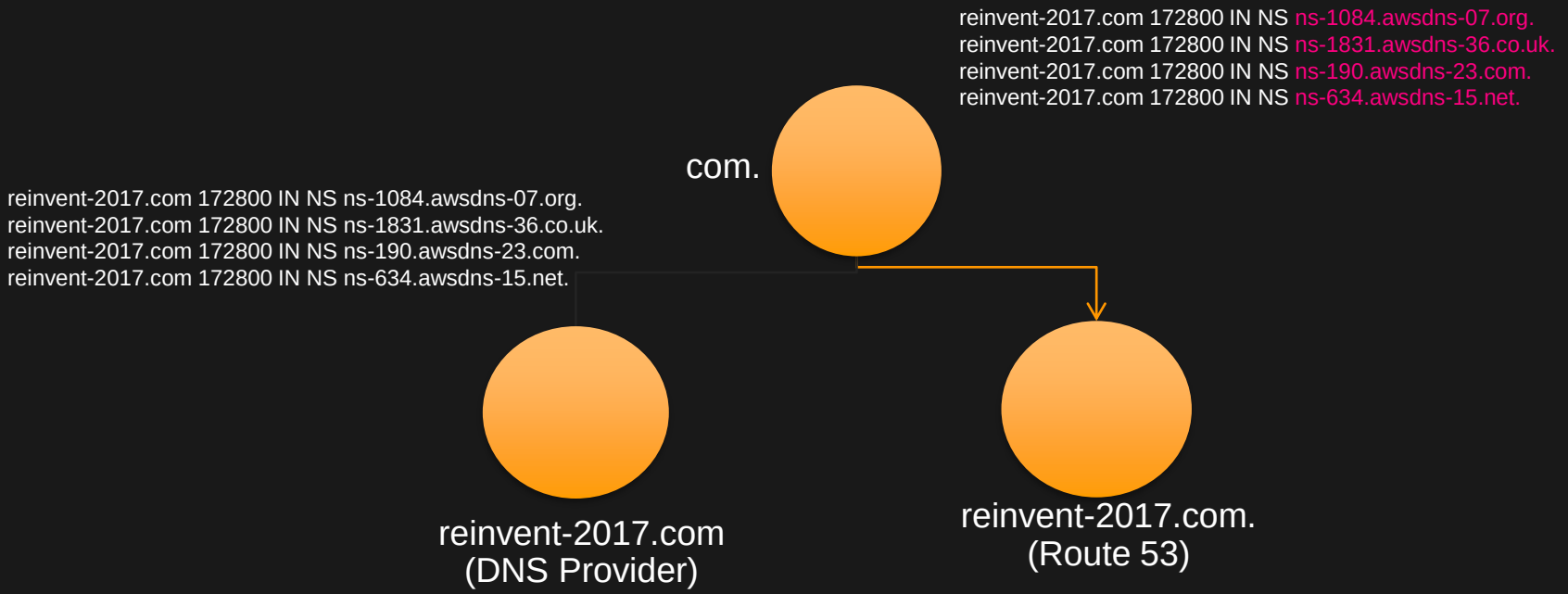
reinvent-2017.com 172800 IN NS ns1.provider.com.
reinvent-2017.com 172800 IN NS ns2.provider.com.
reinvent-2017.com 172800 IN NS ns3.provider.com.
reinvent-2017.com 172800 IN NS ns4.provider.com.

reinvent-2017.com 172800 IN NS ns-1084.awsdns-07.org.
reinvent-2017.com 172800 IN NS ns-1831.awsdns-36.co.uk.
reinvent-2017.com 172800 IN NS ns-190.awsdns-23.com.
reinvent-2017.com 172800 IN NS ns-634.awsdns-15.net.



reinvent-2017.com 172800 IN NS ns-1084.awsdns-07.org.
reinvent-2017.com 172800 IN NS ns-1831.awsdns-36.co.uk.
reinvent-2017.com 172800 IN NS ns-190.awsdns-23.com.
reinvent-2017.com 172800 IN NS ns-634.awsdns-15.net.

Step 4—Change the Registrar (t = 4 Days)



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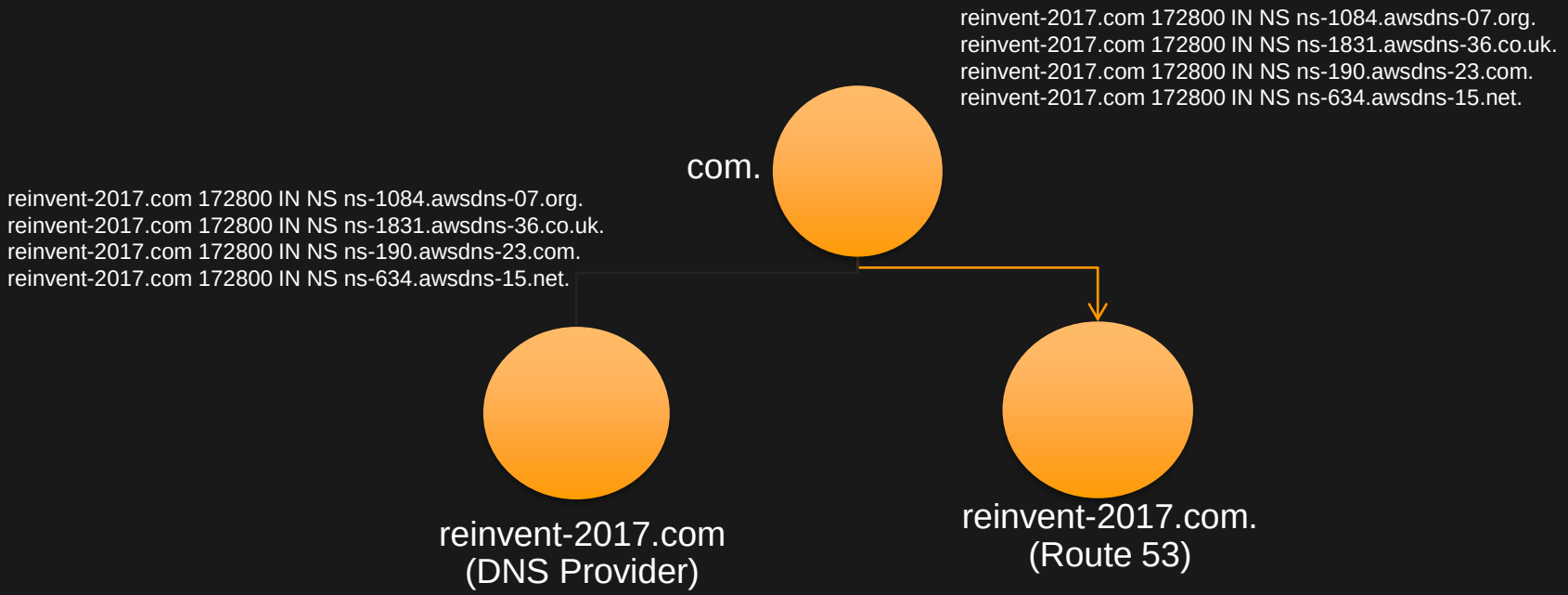
Step 5—Wait for Traffic to Drain



Summarizing

- Route 53: Low Cost, High Availability DNS services
- Flexible Traffic Management
- Fully Automatable
- MuleSoft—Time-Sensitive DNS Changes
- Operational Excellence

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Thank you!