AWS SOLUTION ARCHITECT

Client report

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1 | Analysis

1.1 Overview

The current implementation cannot be accessed from external networks. Here we will go through the current setup, look at the issues that are preventing successful access by customers, and provide minimum changes to return the site to working health.

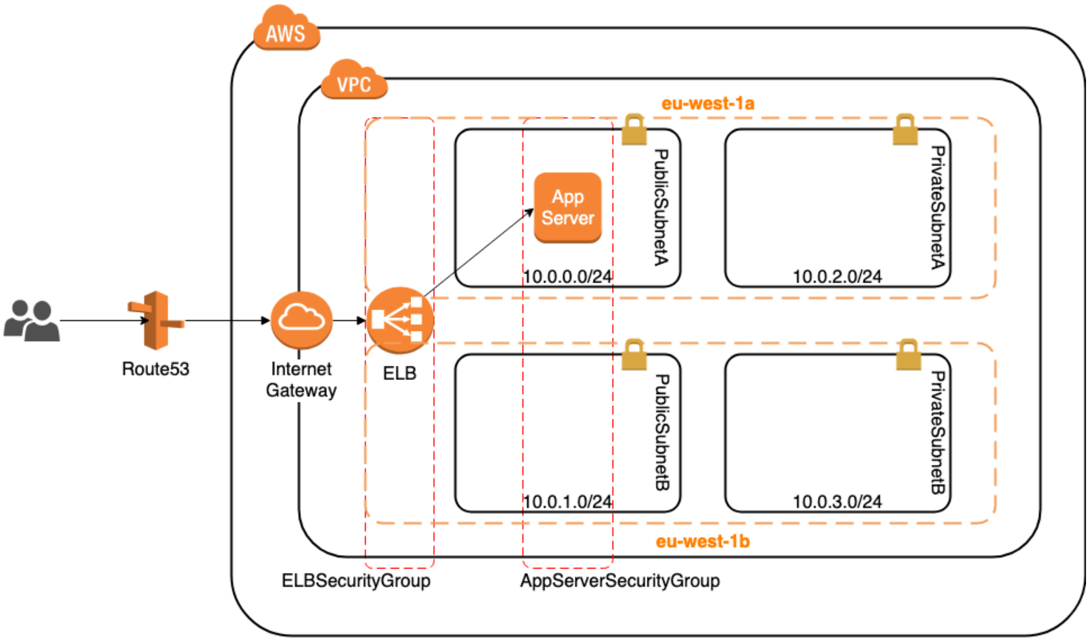


Figure 1.1: Architecture diagram of the current site

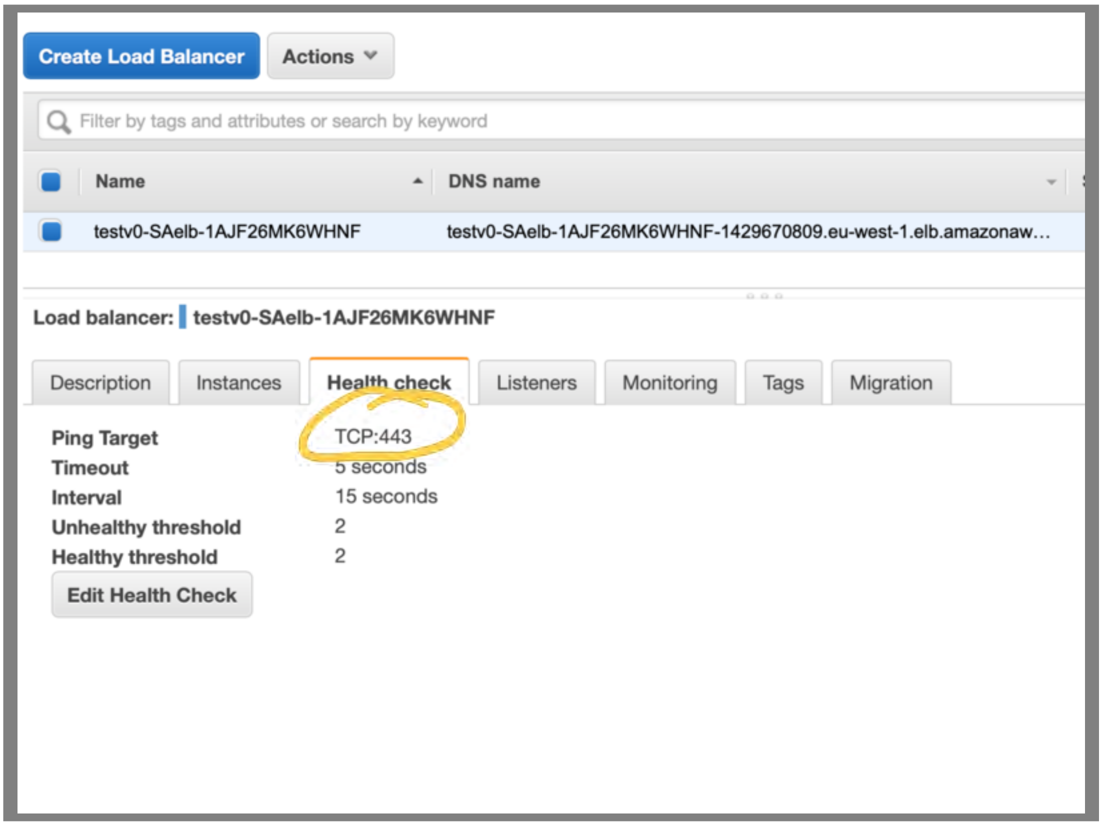
Summary of the setup of the initial solution (Figure 1.1)

(A) Networking is a VPC with CIDR 10.0.0.0/16 with 2 public subnets 10.0.0.0/24 and 10.0.1.0/24 in eu-west-1b and eu-west-1b respectively, as well as 2 private subnets 10.0.2.0/24, 10.0.3.0/24 in eu-west-1b and eu-west-1b.
(B) VPC has an internet gateway and a classic load balancer (ELB)
(C) Routing is setup up to allow all traffic between subnets and out to external addresses.
(D) There are 2 security groups, one for the single EC2 application instance, and one for the ELB.
(E) DNS is enabled and the instance has a public IP address

1.2 Troubleshooting

1.2.1 ELB healthcheck on wrong instance port

The EC2 instance runs a user-data script that installs and starts `Httpd` on port 80. The Elastic load balancer (ELB) correctly forwards ports from from 80 to instance port 80. However, the load balancers healthcheck looks to verify instance health on port 443 through a tcp connection. See `https://docs.aws.amazon.com/elasticloadbalancing/latest/classic/elb-troubleshooting.html`. The simplest method to resolve this is to change the ELB port for healthcheck from 443 to 80

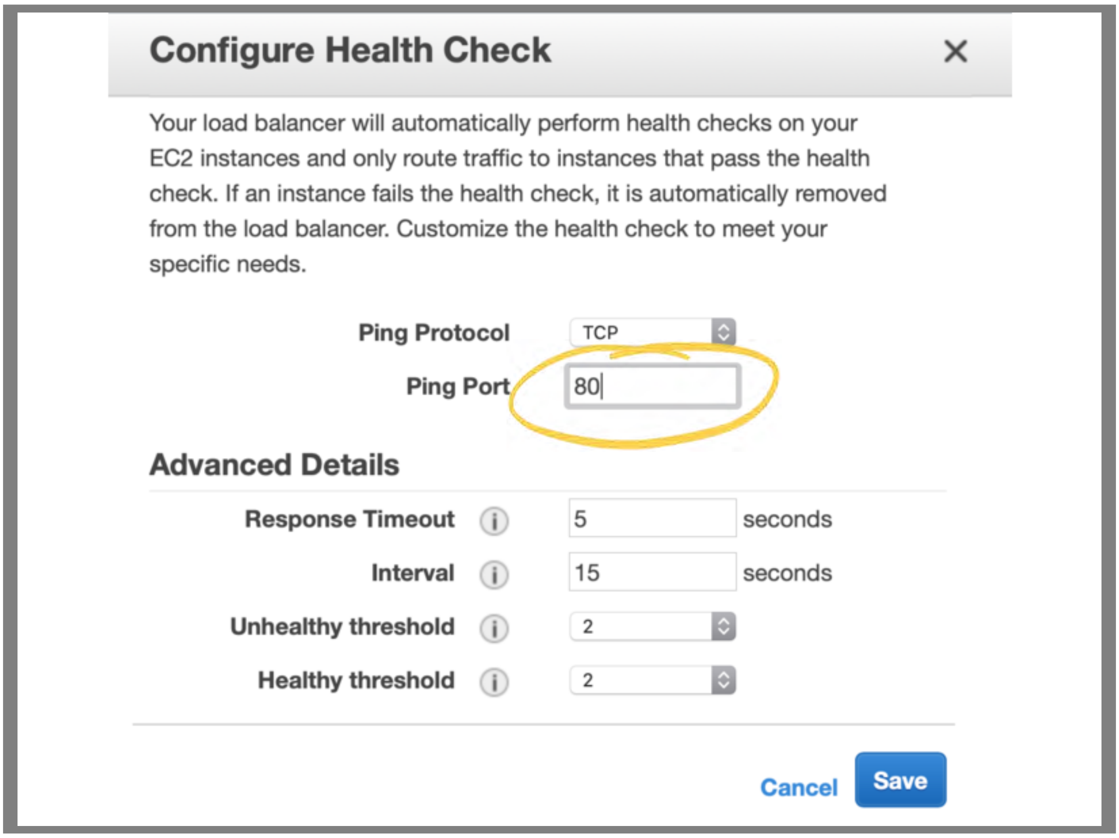


Name	DNS name
testv0-SAelb-1AJF26MK6WHNF	testv0-SAelb-1AJF26MK6WHNF-1429670809.eu-west-1.elb.amazonaw...

Load balancer: testv0-SAelb-1AJF26MK6WHNF

Ping Target	TCP:443
Timeout	5 seconds
Interval	15 seconds
Unhealthy threshold	2
Healthy threshold	2

Figure 1.2: In the AWS console, navigate to Services → EC2 → Load Balancers and select the 'Health check' tab.



Configure Health Check

Your load balancer will automatically perform health checks on your EC2 instances and only route traffic to instances that pass the health check. If an instance fails the health check, it is automatically removed from the load balancer. Customize the health check to meet your specific needs.

Ping Protocol: TCP

Ping Port: 80

Advanced Details

Response Timeout: 5 seconds

Interval: 15 seconds

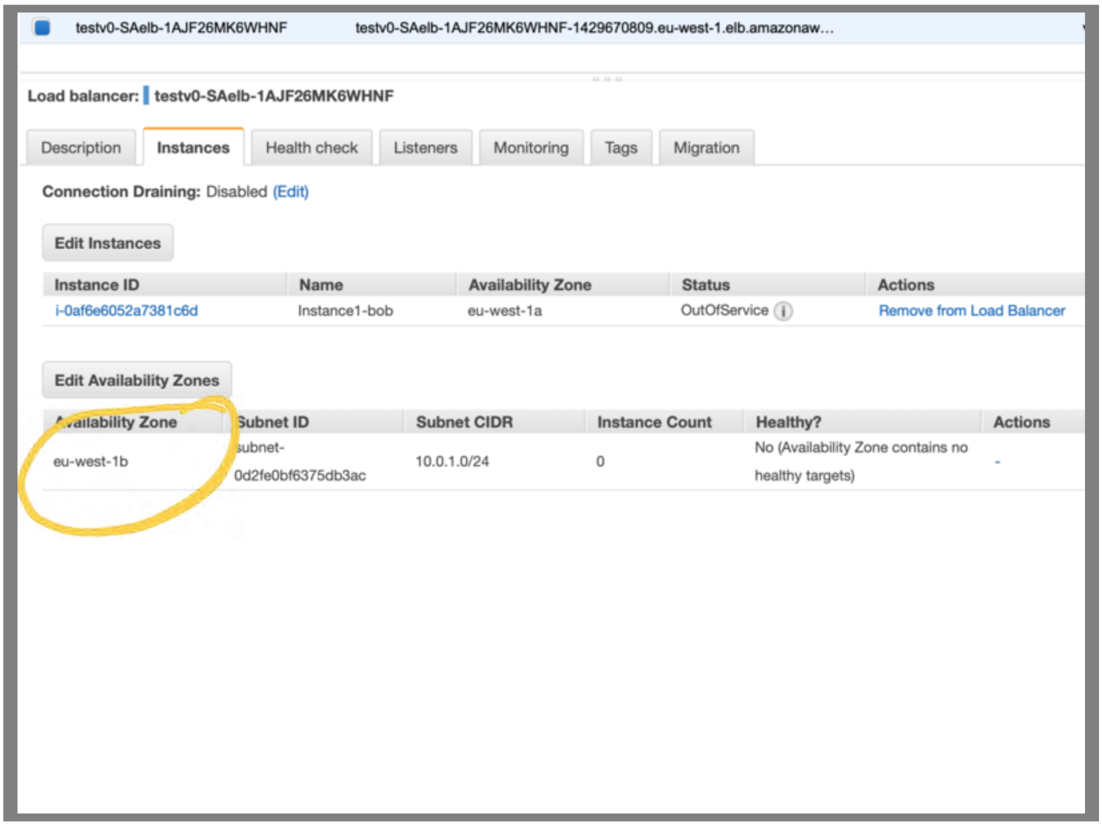
Unhealthy threshold: 2

Healthy threshold: 2

Figure 1.3: Change the port from 443 to 80. This will leave the load balancer checking the instance health by connecting through tcp on the servers default HTTP port.

1.2.2 Load balancer cannot route to subnet

The load balancer can only route to instances in `PublicSubnetB`. However, the instance running the application is in `PublicSubnetA` so the ELB cannot pass traffic to it. By adding `PublicSubnetA` to the load balancers available subnets the instance can have traffic routed through to it.



testv0-SAelb-1AJF26MK6WHNF testv0-SAelb-1AJF26MK6WHNF-1429670809.eu-west-1.elb.amazonaw...

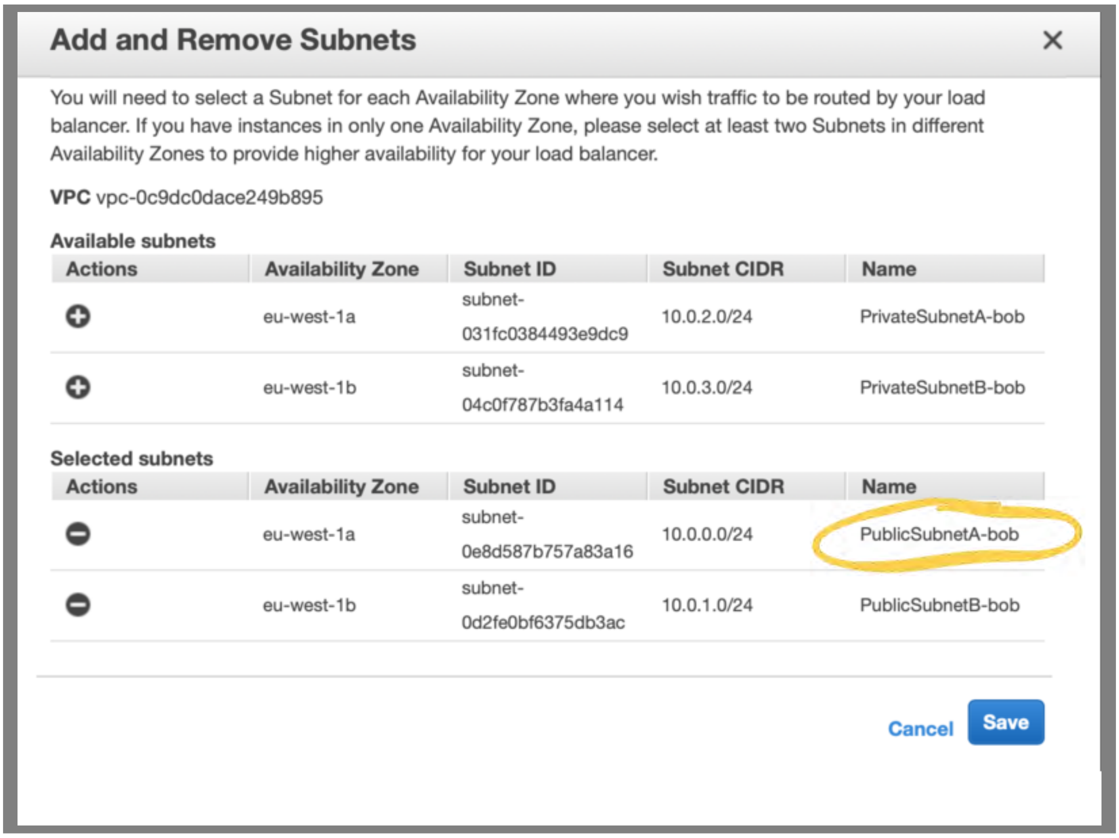
Load balancer: testv0-SAelb-1AJF26MK6WHNF

Connection Draining: Disabled (Edit)

Instance ID	Name	Availability Zone	Status	Actions
i-0af6e6052a7381c6d	Instance1-bob	eu-west-1a	OutOfService	Remove from Load Balancer

Availability Zone	Subnet ID	Subnet CIDR	Instance Count	Healthy?	Actions
eu-west-1b	subnet-0d2fe0bf6375db3ac	10.0.1.0/24	0	No (Availability Zone contains no healthy targets)	-

Figure 1.4: In the Load Balancers configuration page, select the load balancer and then the 'Instances' tab. Note that only the `eu-west-1b` zone is available to the load balancer, which has no instances



Add and Remove Subnets

You will need to select a Subnet for each Availability Zone where you wish traffic to be routed by your load balancer. If you have instances in only one Availability Zone, please select at least two Subnets in different Availability Zones to provide higher availability for your load balancer.

VPC vpc-0c9dc0dace249b895

Available subnets

Actions	Availability Zone	Subnet ID	Subnet CIDR	Name
⊕	eu-west-1a	subnet-031fc0384493e9dc9	10.0.2.0/24	PrivateSubnetA-bob
⊕	eu-west-1b	subnet-04c0f787b3fa4a114	10.0.3.0/24	PrivateSubnetB-bob

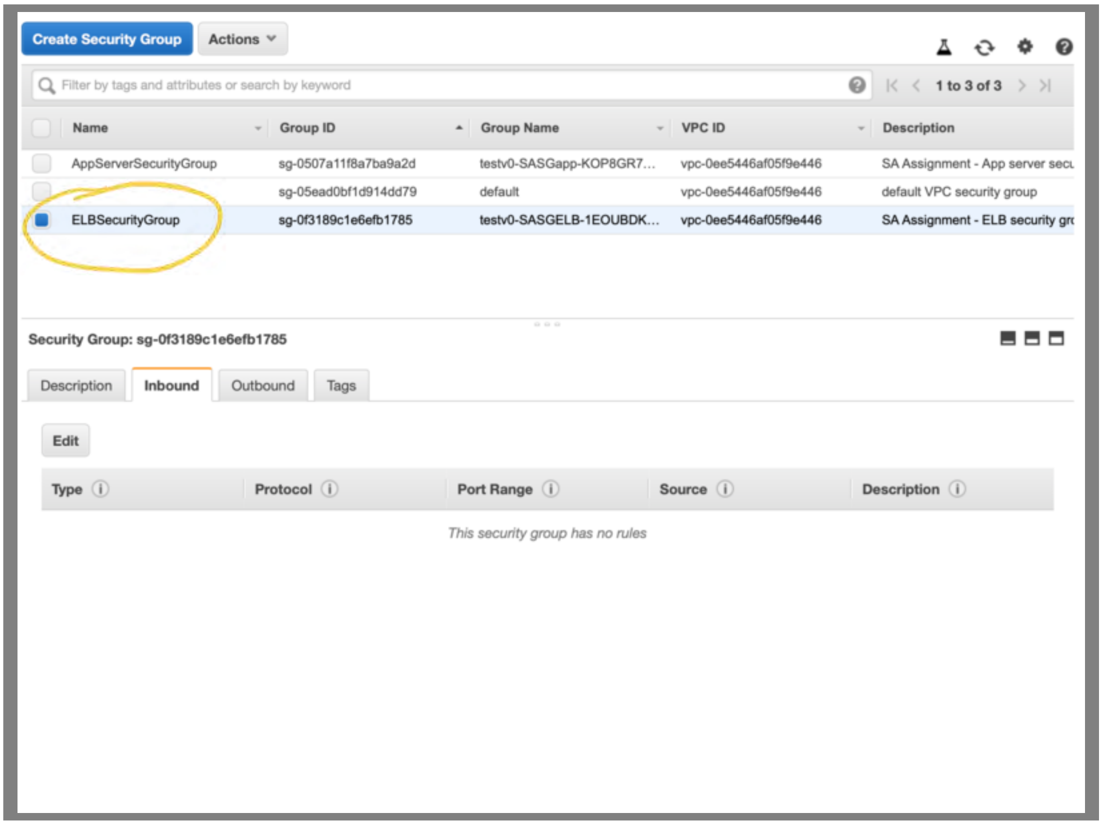
Selected subnets

Actions	Availability Zone	Subnet ID	Subnet CIDR	Name
⊖	eu-west-1a	subnet-0e8d587b757a83a16	10.0.0.0/24	PublicSubnetA-bob
⊖	eu-west-1b	subnet-0d2fe0bf6375db3ac	10.0.1.0/24	PublicSubnetB-bob

Figure 1.5: Add `PublicSubnetA` to the load balancers available subnets. This means that the load balancer can now direct traffic to the instance in `eu-west-1a`

1.2.3 The site cannot be accessed from external addresses

There are no inbound security group rules for the group `ELBSecurityGroup`, which means that the ELB will not route any traffic to the instance. As we want the site to be accessible by everyone, we allow all addresses, by using the CIDR range 0.0.0.0/0, to access the load balancer on port 80.



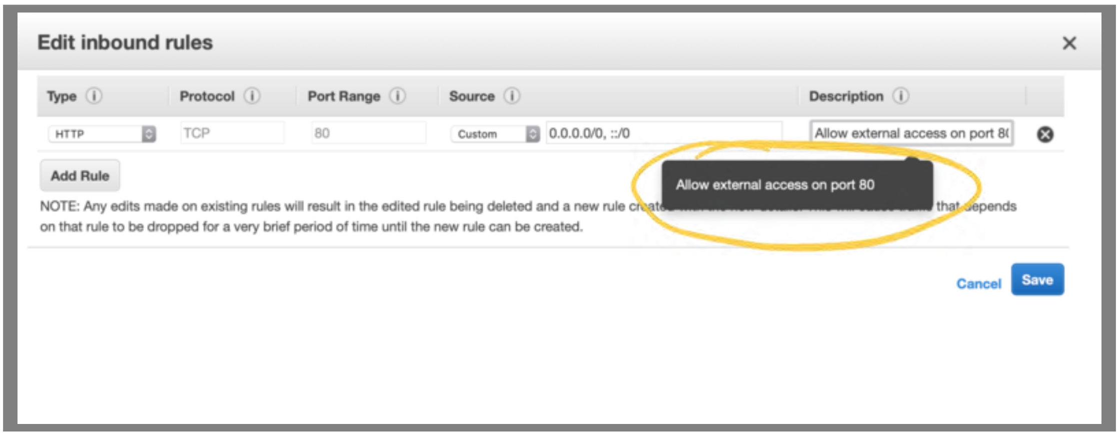
	Name	Group ID	Group Name	VPC ID	Description
□	AppServerSecurityGroup	sg-0507a11f8a7ba9a2d	testv0-SASGapp-KOP8GR7...	vpc-0ee5446af05f9e446	SA Assignment - App server secu
□		sg-05ead0bf1d914dd79	default	vpc-0ee5446af05f9e446	default VPC security group
■	ELBSecurityGroup	sg-0f3189c1e6efb1785	testv0-SASGELB-1EOUBDK...	vpc-0ee5446af05f9e446	SA Assignment - ELB security gro

Security Group: sg-0f3189c1e6efb1785

Type	Protocol	Port Range	Source	Description

This security group has no rules

Figure 1.6: Navigate to Services → EC2 → Security Groups. Select the `ELBSecurityGroup` group and the 'Inbound' tab. By default, no inbound rules are set.


Edit inbound rules

Type	Protocol	Port Range	Source	Description
HTTP	TCP	80	Custom 0.0.0.0/0, ::/0	Allow external access on port 8(

NOTE: Any edits made on existing rules will result in the edited rule being deleted and a new rule creat that depends on that rule to be dropped for a very brief period of time until the new rule can be created.

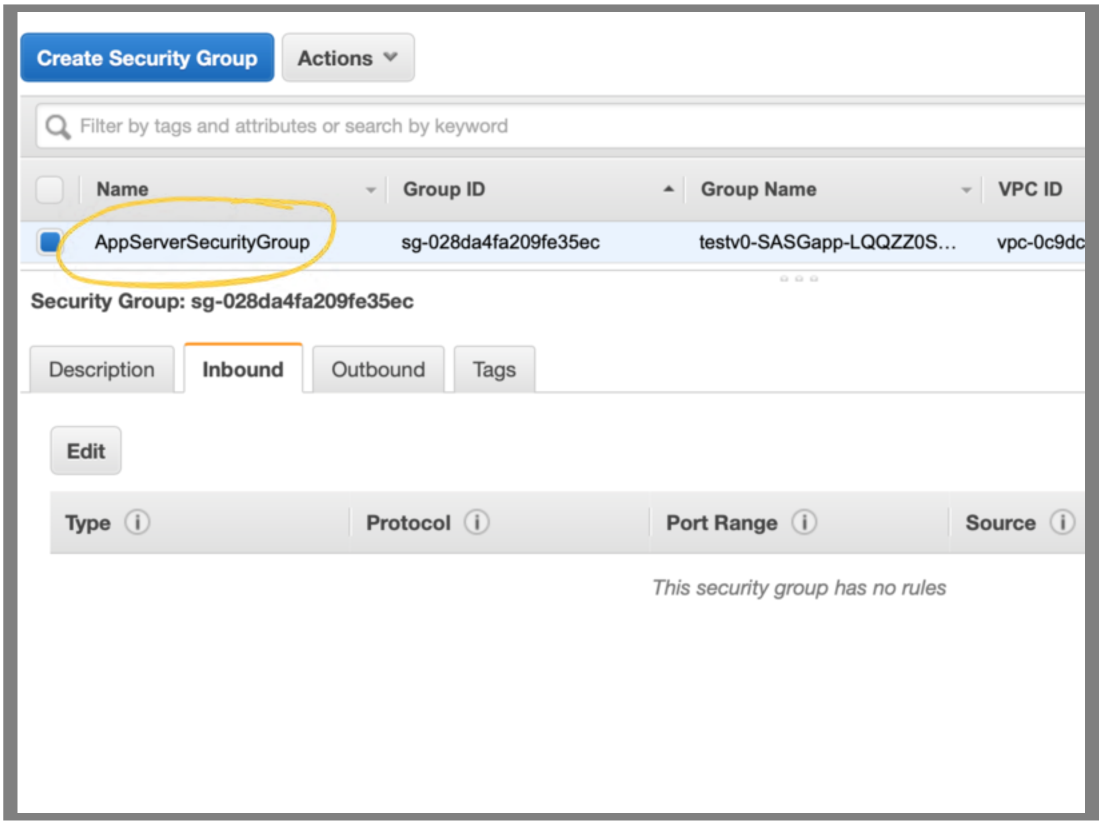
Allow external access on port 80

Figure 1.7: Edit the group and add an inbound rule to allow http access from everywhere, 0.0.0.0/0. Users will now be able to reach the load balancer from the internet and other external networks.

1.2.4 Instances cannot be accessed from the load balancer

The current security group for the EC2 instances does not contain any inbound rules. This means that traffic from the load balancer is blocked. We can change the security group to allow traffic from the

ELB to the instance by adding a rule to allow TCP traffic to port 80. This also allows the ELBs TCP-based healthcheck to pass



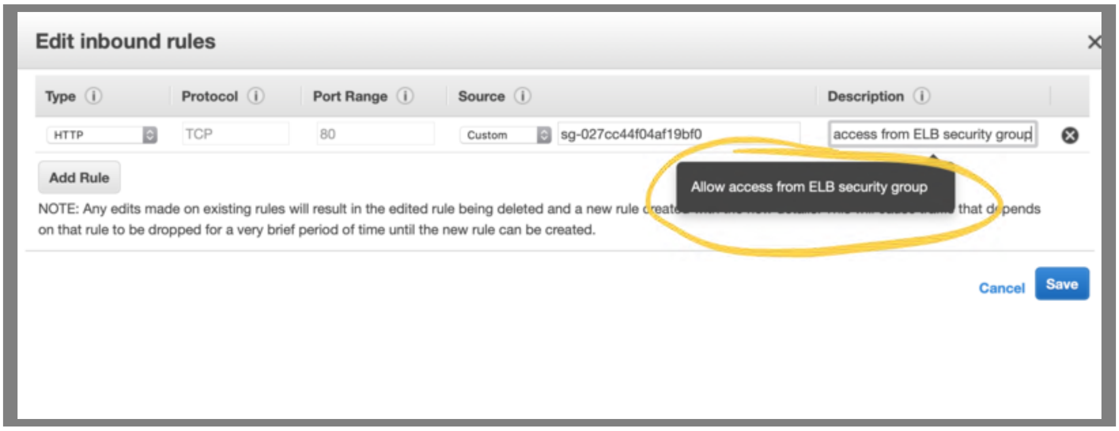
Name	Group ID	Group Name	VPC ID
AppServerSecurityGroup	sg-028da4fa209fe35ec	testv0-SASGapp-LQQZZ0S…	vpc-0c9dc

Security Group: sg-028da4fa209fe35ec

Type	Protocol	Port Range	Source

This security group has no rules

Figure 1.8: Still in the 'Security Groups' section, select the `AppServerSecurityGroup` group and the 'Inbound' tab. As we can see, there are no rules set.


Edit inbound rules

Type	Protocol	Port Range	Source		Description
HTTP	TCP	80	Custom	sg-027cc44f04af19bf0	access from ELB security group

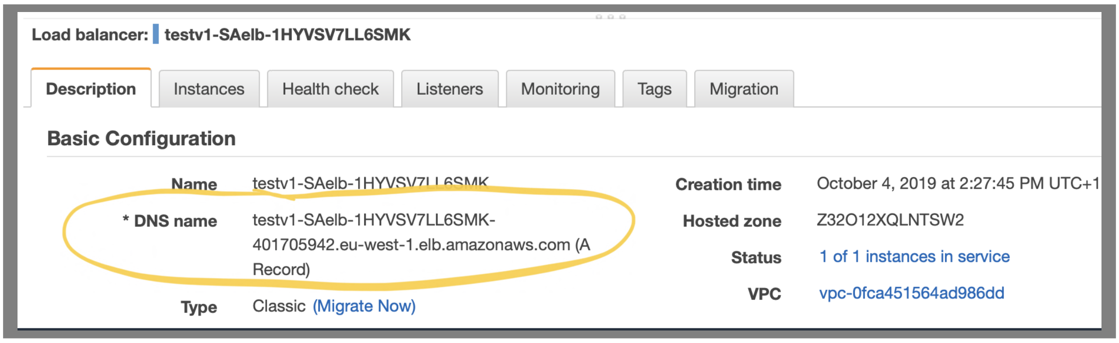
NOTE: Any edits made on existing rules will result in the edited rule being deleted and a new rule creat [illegible] that depends on that rule to be dropped for a very brief period of time until the new rule can be created.

Figure 1.9: Edit the group and add an inbound rule to allow http access from the `ELBSecurityGroup`. The security group Id needed for the 'Source' value can be found by typing 'sg' then choosing from one of the values in the popup menu.

1.3 Success!

The DNS name for the site can be found on the 'Description' tab of the 'Load balancers' configuration page when your load balancer is selected.

`http://<load-balancer-dns-name>/demo.html`

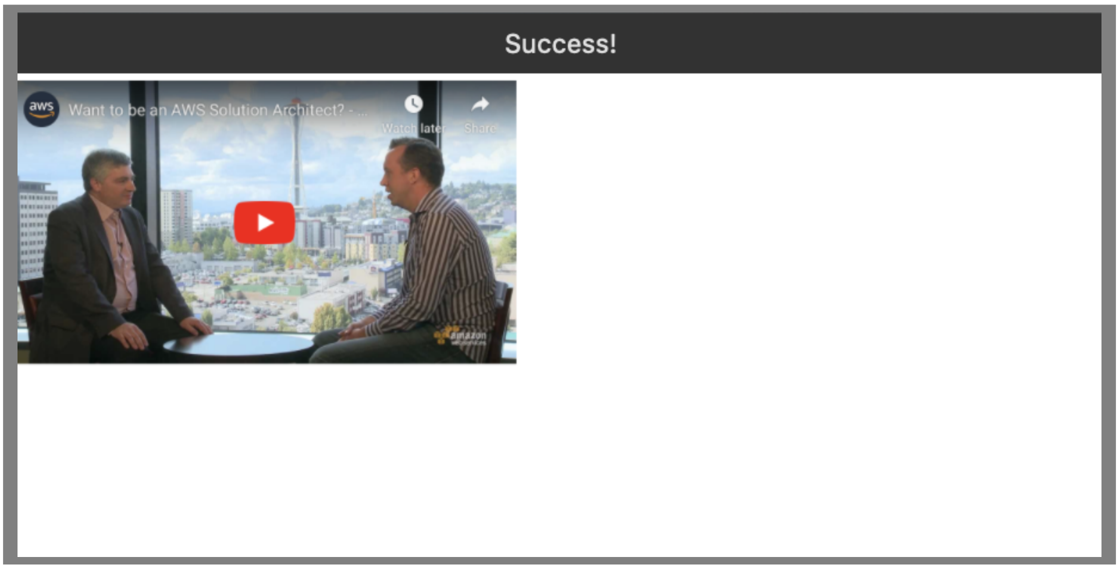


Load balancer: testv1-SAelb-1HYVSV7LL6SMK

Basic Configuration

Name	testv1-SAelb-1HYVSV7LL6SMK	Creation time	October 4, 2019 at 2:27:45 PM UTC+1
* DNS name	testv1-SAelb-1HYVSV7LL6SMK-401705942.eu-west-1.elb.amazonaws.com (A Record)	Hosted zone	Z32O12XQLNTSW2
		Status	1 of 1 instances in service
Type	Classic (Migrate Now)	VPC	vpc-0fca451564ad986dd

Figure 1.10: The DNS name of the load balancer can be found in the load balancers description tab



Success!

Figure 1.11: The instances are now reachable through the load-balancer to customers on the internet

2 | Enhancement

2.1 Overview

There are a number of immediate improvements we can make to the initial solution that will bring benefits in reliability, security, and observability. These improvements are small and iterative but have a large impact on the production performance.

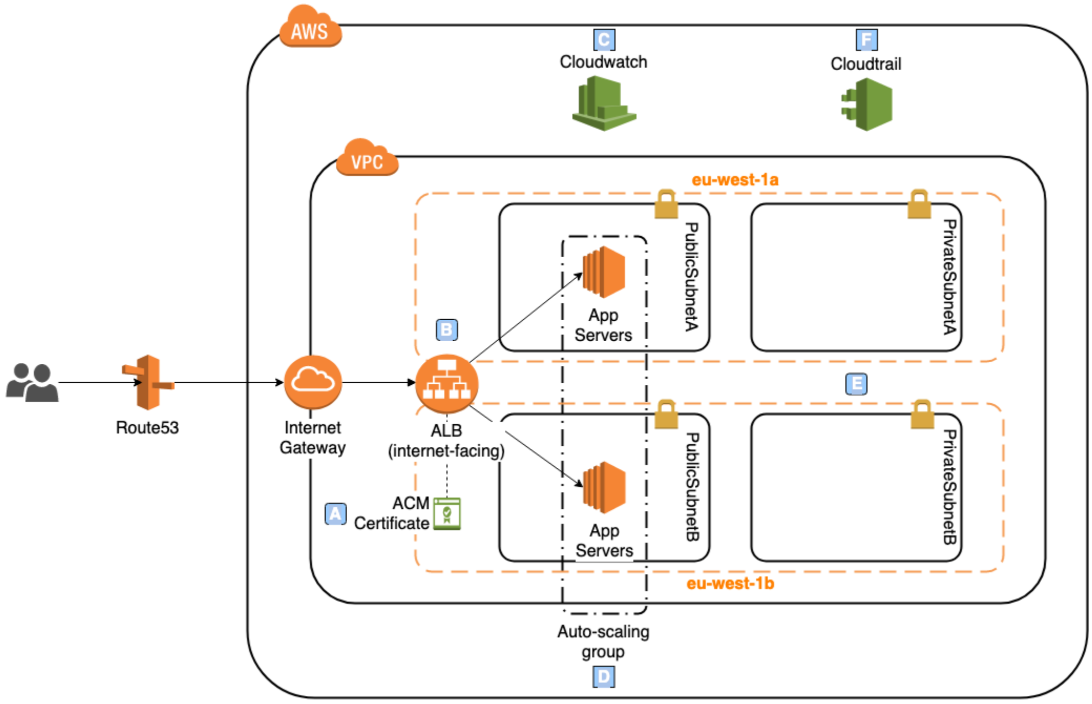


Figure 2.1: Architecture diagram of an improved solution.

Changes and enhancements to the initial solution (Figure 2.1)

(A) Addition of ACM certificate to load balancer to allow HTTPS to be enabled [5].

(B) Moving to Application Load Balancer(ALB) for HTTP->HTTPS redirection and layer 7 routing and WAF filtering [12].

(C) Enable detailed instance and load balancer metrics, shipping to Cloudwatch with dashboard. Log shipping and OS-level metrics through collectd and cloudwatch agent installation on AMI [1].

(D) Instances placed in Auto-scaling group (ASG) for automatic management and healing of instances using load balancer `HTTP:80` healthcheck [2].

(E) Instances are replicated into multiple availability zones.

(F) Cloudtrail is enabled in the AWS account to log all AWS API access [7].

2.2 Operational

Monitoring and logging on the existing instance can be increased by installing and enabling the cloudwatch agent on the application instances. The agent can then be set up to ship os-level metrics and application logs to Cloudwatch. Detailed metrics can also be enabled on the load balancer, auto-scaling group, and instances `(C)`.

2.3 Security

By moving from a classic load balancer (ELB) to the newer layer 7 Application Load Balancer (ALB), there are gains not only in performance, but much more flexibility in routing to different targets, alongside the ability to use layer HTTP header information `(B)`. By adding an automatically renewing ACM certificate we enable HTTPS support for the service. Termination of TLS on the load balancer means that the application servers themselves experience no additional load. We can also enable HTTP->HTTPS redirection on the load balancer, further enhancing security.

Future placing of the AWS WAF service in front of the ALB mean that granular controls in mitigating attacks can be added at minimal extra cost. NACL are quite open currently and could be more restrictive, the private NACL allows all external traffic to pass for example. We can increase security by allowing only access from public subnets, or additionally from private endpoints, NAT gateways etc.

In addtion to load balancer enhancements, the business should look at methods of hardening the EC2 instances, such as pre-baking AMI's, or moving them into private subnets and adding the NAT service to allow internet access. In this case adding the SSM agent to instances and using session manager to allow IAM users SSH access would be preferable to installing publically facing bastion servers.

Cloudtrail is enabled across all accounts and regions so that access to the AWS API can be controlled, alerted, and audited `(F)`.

2.4 Reliability

In the initial solution there is a single instance with no automatic recovery in the event of failure. With the application server running in only one availability zone, in the event of network disruption, the entire service would become unavailable. By replicating EC2 instances into more than one availlbilty zone, and enabling cross-zone load-balancing, we greatly increase the reliability of the service health `(E)`.

Placing the instances into an auto-scaling group not only helps to ensure we have spread the application servers across availability zones, but also allows the ASG to replace failing servers with new ones based on the load balancers health check, giving the service an element of auto-healing `(D)`.

2.5 Performance

With the addition of the auto-scaling group, we can add in cloudwatch alarms to control the number of instances running. For example, we could set a CPU percentage or network utilisation target, ensuring that the ASG increased or decreased the number of instances as required to maintain that usage level.

Note, the current solution uses bursting t2.micro instances with CPU credit limits. This is low cost, but performance is not suitable for sustained traffic levels where exhausting CPU credits will cause degradation of availability. The instance type will need to be right-sized given realistic production traffic patterns, and a non-bursting instance type may be preferable.

2.6 Cost

The auto-scaling functionality should mean that service costs are kept minimal. Further choices should be made as the service is evaluated in production, where reserving some baseline instances or combining capacity with spot purchases as part of an EC2 fleet may be applicable as the service evolves.

2.7 Summary

The changes we've covered here will provide a robust and scalable system. Depending on the clients balance between change, cost, and performance characteristics, it would also be recommended to look at some more advanced changes such as moving the applications into private subnets and using the public NAT instances to allow them outbound access to the internet. Note also that its likely that a custom zone and domain name routing to the load balancer would be a requirement of a live system to give the service a friendly name.

We have also assumed here that the applications are stateless, and that no data is stored in a database as yet. The system is designed so that adding an RDS database such as Aurora mysql/postgres will be simple. If we expect non-stateless EC2 instances themselves then additional options such as an S3 bucket or EFS filesystem to preserve state for instances as they are terminated or created.

3 | Future expansion

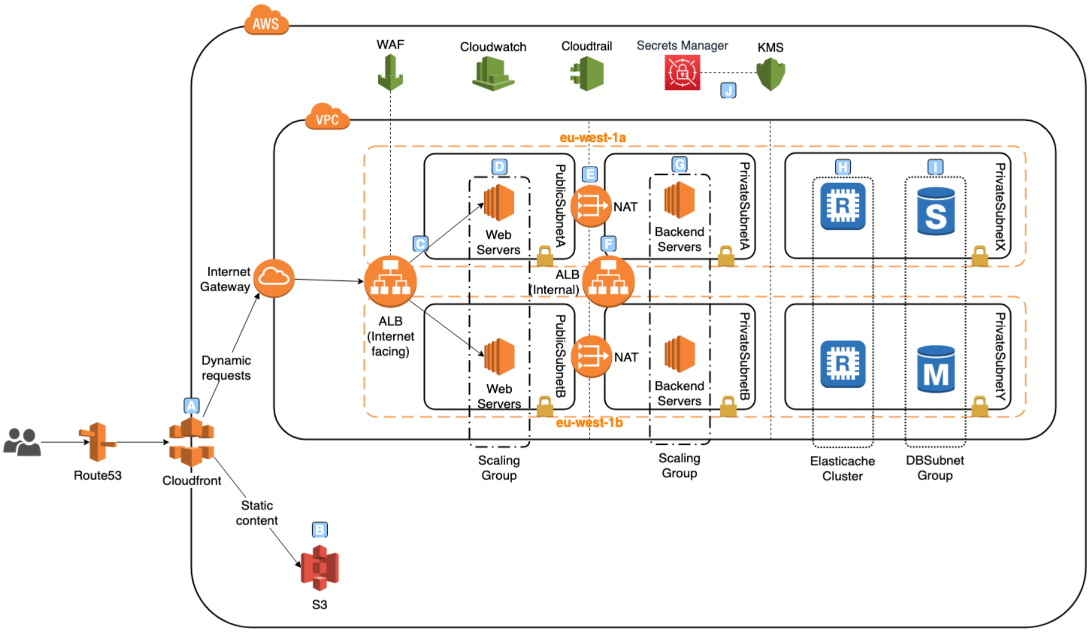


Figure 3.1: Large scalable production solution

Building on the initial solution but with the use of a number of additional AWS services, the site can scale globally and meet the performance demands of a high capacity business

(A) Cloudfront provides cached content from edge locations around the world [6].
(B) A secured S3 bucket provides a highly scalable source of static content
(C) Active content is sourced through a public application load balancer (ALB).
(D) WAF is configured with rules in front of the ALB [9, 10, 11]
(E) Applications requiring public internet addresses are installed on EC2 instances inside an auto-scaling group (ASG) in public subnets distributed across more than one availability zone.
(F) The NAT gateway service provides address translation to allow outbound internet access for the private subnets.
(G) Applications that do not require public internet addresses are installed on EC2 instances inside an ASG in private subnets distributed across more than one availability zone.
(H) Elasticache (redis) provides in-memory caching for the database backend [3].
(I) RDS in multi-AZ mode gives resilient failover from primary to secondary, as well as < 5 min point in time recovery [4].
(J) Secrets manager works with the Key Management Service (KMS) to allow instances with the right IAM roles to access their relevant credentials [8].

3.1 Operational

3.2 Security

By moving as much of the application into non-accessible private subnets, the exposure of running services to attack is greatly reduced. In addition, strong security group and NACL rules can protect the independent application and data components. There may be options depending on the behaviour of the services moving forward to restrict access to running services further and integrate private subnets with VPC endpoint services to prevent internal traffic traversing networks outside of AWS.

Cloudfront can also be set to filter requests, allow only certain request types, filter cookies, etc. Meaning there the site can be restricted to the smallest set of requests that it needs to be functional for the end-users.

Although bastion servers are an option, access to private servers should be through the SSM session manager and IAM user access. This not only removes the need to run publically exposed bastion servers, but also means that access can be logged and audited through Cloudtrail.

Secrets access is kept secure through AWS Secrets manager, allowing services to have granular access to encrypted data during runtime. There is also the option of regularly rotating credentials such as database passwords.

3.3 Reliability

The caching provided by Cloudfront means that the site can remain functional if degraded, for users even in the event of the servers becoming unavailable. There is also the option for a fallback to a static version of the site through Route53 healthchecks.

3.4 Performance

The use of cloudfront for static assets such as images, videos, and javascript, means that the performance overhead is moved from the EC2 instances, onto globally distributed edge locations, giving greater responsiveness for users.

3.5 Cost

Moving assets to edge locations reduces bandwidth costs for moving data through the network, as well as reducing the needed EC2 compute power to run the service.

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