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AWS CERTIFIED SOLUTIONS ARCHITECT ASSOCIATE

Tutorials Dojo
Study Guide and Cheat Sheets

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INTRODUCTION

As more and more businesses migrate their on-premises workloads to Amazon Web Services (AWS), the demand for highly skilled and certified AWS Professionals will continue to rise over the coming years ahead. Companies are now leveraging on the power of cloud computing to significantly lower their operating costs and dynamically scale their resources based on demand.

Gone are the days of over-provisioning your resources that turn out to be underutilized over time. With AWS, companies can now easily provision the number of resources that they actually need and pay only the computing resources they consume. AWS helps customers to significantly reduce upfront capital investment and replace it with lower variable costs. You can opt to pay your cloud resources using an on-demand pricing option with no long-term contracts or up-front commitments. You can easily discontinue your on-demand cloud resources if you don't need them to stop any recurring operational costs, thereby reducing your operating expenses.

This flexibility isn't available in a traditional on-premises environment where you have to maintain and pay for the resources even if you aren't using them. Moreover, companies can simply launch new AWS resources in seconds to scale and accommodate the surge of incoming requests to their enterprise applications. These are the financial and technical benefits, and the reason why thousands of companies are hiring skilled IT professionals to migrate their workload to the cloud. Conversely, this is also one of the reasons why there is a demand for certified AWS professionals.

The AWS Solutions Architect Associate certification has been consistently regarded as one of the highest-paying certifications in the IT Industry today. This eBook contains essential information about the AWS Certified Solutions Architect Associate exam, as well as the topics you have to review in order to pass it. You will learn the basics of the AWS Global Infrastructure and the relevant AWS services required to build a highly available and fault-tolerant cloud architecture.

Note: We took extra care to come up with these study guides and cheat sheets, however, this is meant to be just a supplementary resource when preparing for the exam. We highly recommend working on **hands-on sessions** and **practice exams** to further expand your knowledge and improve your test taking skills.

AWS CERTIFIED SOLUTIONS ARCHITECT ASSOCIATE EXAM OVERVIEW

In 2013, Amazon Web Services (AWS) began the Global Certification Program with the primary purpose of validating the technical skills and knowledge for building secure and reliable cloud-based applications using the AWS platform. By successfully passing the AWS exam, individuals can prove their AWS expertise to their current and future employers. The AWS Certified Solutions Architect - Associate exam was the first AWS certification that was launched followed by the other two role-based certifications: Systems Operations (SysOps) Administrator and Developer Associate later that year.

AWS has continuously expanded the certification program since then, launching the Professional and Specialty-level certifications that cover various domains such as machine learning, data analytics, networking, and many others. As AWS services continue to evolve, a new and updated version of the AWS certification exams are released on a regular basis to reflect the service changes and to include new knowledge areas. After almost 5 years since its initial release, an updated version of the AWS Certified Solutions Architect - Associate certification was launched in February 2018 with an exam code of SAA-C01. And after two years, in March 2020, AWS released yet another version of the exam (SAA-C02).

Exam Details

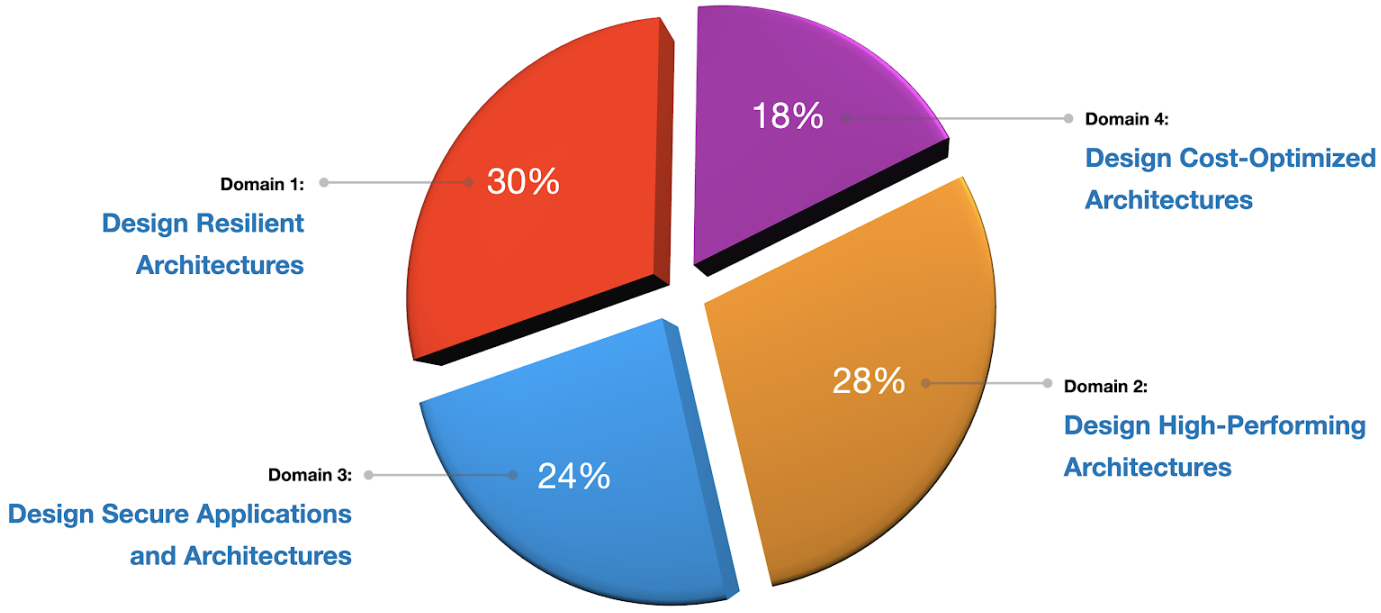
The AWS Certified Solutions Architect - Associate certification is intended for IT Professionals who perform a Solutions Architect or DevOps role and have substantial years of hands-on experience designing available, cost-efficient, fault-tolerant, and scalable distributed systems on the AWS platform. It is composed of scenario-based questions that can be either in multiple-choice or multiple response formats. The first question type has one correct answer and three incorrect responses, while the latter has two or more correct responses out of five or more options. You can take the exam from a local testing center or online from the comforts of your home.

Exam Code:	SAA-C02
Release Date:	March 2020
Prerequisites:	None
No. of Questions:	65
Score Range:	100/1000
Cost:	150 USD (Practice exam: 20 USD)
Passing Score:	720/1000
Time Limit:	2 hours 10 minutes (130 minutes)
Format:	Scenario-based. Multiple choice/multiple answers.
Delivery Method:	Testing center or online proctored exam

Don't be confused if you see in your Pearson Vue booking that the duration is 140 minutes since they included an additional 10 minutes for reading the Non-Disclosure Agreement (NDA) at the start of the exam and the survey at the end of it. If you booked in PSI, the exam duration time that you will see is 130 minutes.

Exam Domains

The AWS Certified Solutions Architect - Associate (SAA-C02) exam has 4 different domains, each with corresponding weight and topic coverage. The exam domains are as follows: **Design Resilient Architectures** (30%), **Design High-Performing Architectures** (28%), **Design Secure Applications and Architectures** (24%), and **Design Cost-Optimized Architectures** (18%).



Domain 1: Design Resilient Architectures (30%)

- 1.1 Design a multi-tier architecture solution
- 1.2 Design highly available and/or fault-tolerant architectures
- 1.3 Design decoupling mechanisms using AWS services
- 1.4 Choose appropriate resilient storage

Domain 2: Design High-Performing Architectures (28%)

- 2.1 Identify elastic and scalable compute solutions for a workload
- 2.2 Select high-performing and scalable storage solutions for a workload
- 2.3 Select high-performing networking solutions for a workload

2.4 Choose high-performing database solutions for a workload

Domain 3: Design Secure Applications and Architectures (24%)

3.1 Design secure access to AWS resources
3.2 Design secure application tiers
3.3 Select appropriate data security options

Domain 4: Design Cost-Optimized Architectures (18%)

4.1 Identify cost-effective storage solutions
4.2 Identify cost-effective compute and database services
4.3 Design cost-optimized network architectures

Exam Scoring System

You can get a score from 100 to 1,000 with a minimum passing score of **720** when you take the AWS Certified Solutions Architect - Associate exam. AWS is using a scaled scoring model to equate scores across multiple exam types that may have different difficulty levels. The complete score report will be sent to you by email after a few days. Right after you completed the actual exam, you'll immediately see a pass or fail notification on the testing screen. A *"Congratulations! You have successfully passed..."* message will be shown if you passed the exam.

Individuals who unfortunately do not pass the AWS exam must wait 14 days before they are allowed to retake the exam. Fortunately, there is no hard limit on exam attempts until you pass the exam. Take note that on each attempt, the full registration price of the AWS exam must be paid.

Within 5 business days of completing your exam, your AWS Certification Account will have a record of your complete exam results. The score report contains a table of your performance at each section/domain, which indicates whether you met the competency level required for these domains or not. AWS is using a compensatory scoring model, which means that you do not necessarily need to pass each and every individual section, only the overall examination. Each section has a specific score weighting that translates to the number of questions; hence, some sections have more questions than others. The Score Performance table highlights your strengths and weaknesses that you need to improve on.

Section	% of Scored Items	Score Performance: Needs Improvement	Score Performance: Meets Competencies
Section 1.0: Design Resilient Architectures	30%		
Section 2.0: Design High-Performing Architectures	28%		
Section 3.0: Design Secure Applications and Architectures	24%		
Section 4.0: Design Cost-Optimized Architectures	18%		

Exam Benefits

If you successfully passed any AWS exam, you will be eligible for the following benefits:

- **Exam Discount** - You'll get a 50% discount voucher that you can apply for your recertification or any other exam you plan to pursue. To access your discount voucher code, go to the "Benefits" section of your AWS Certification Account, and apply the voucher when you register for your next exam.

- **Free Practice Exam** - To help you prepare for your next exam, AWS provides another voucher that you can use to take any official AWS practice exam for free. You can access your voucher code from the "Benefits" section of your AWS Certification Account.

- **AWS Certified Store** - All AWS certified professionals will be given access to exclusive AWS Certified merchandise. You can get your store access from the "Benefits" section of your AWS Certification Account.

- **Certification Digital Badges** - You can showcase your achievements to your colleagues and employers with digital badges on your email signatures, Linkedin profile, or on your social media accounts. You can also show your Digital Badge to gain exclusive access to Certification Lounges at AWS re:Invent, regional Appreciation Receptions, and select AWS Summit events. To view your badges, simply go to the "Digital Badges" section of your AWS Certification Account.

- **Eligibility to join AWS IQ -** With the AWS IQ program, you can monetize your AWS skills online by providing hands-on assistance to customers around the globe. AWS IQ will help you stay sharp and be well-versed on various AWS technologies. You can work at the comforts of your home and decide when or where you want to work. Interested individuals must be based in the US, have an Associate, Professional, or Specialty AWS Certification and be over 18 of age.

You can visit the official AWS Certification FAQ page to view the frequently asked questions about getting AWS Certified and other information about the AWS Certification: https://aws.amazon.com/certification/faqs/.

AWS CERTIFIED SOLUTIONS ARCHITECT ASSOCIATE EXAM - STUDY GUIDE AND TIPS

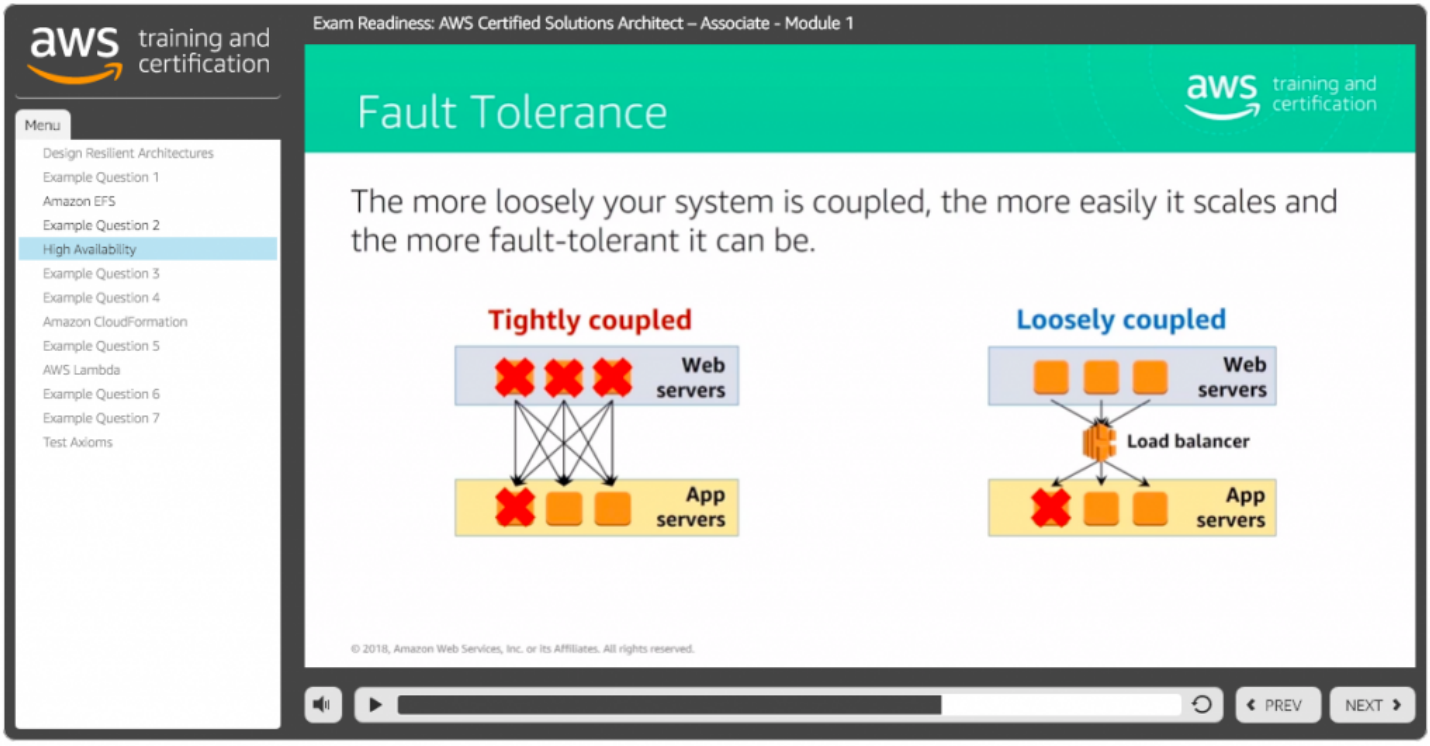
The AWS Certified Solutions Architect Associate SAA-C02 exam, or SAA for short, is one of the most sought after certifications in the Cloud industry. This certification attests to your knowledge of the AWS Cloud and building a well-architected infrastructure in AWS.

As a Solutions Architect, it is your responsibility to be familiar with the services that meet your customer requirements. Aside from that, you should also have the knowledge to create an efficient, secure, reliable, fault tolerant, and cost-effective infrastructure out of these services. Your AWS SA Associate exam will be based upon these topics.

Whitepapers, FAQs, and the AWS Documentation will be your primary study materials for this exam. Experience in building systems will also be helpful, since the exam consists of multiple scenario type questions. You can learn more details on your exam through the official SAA-C02 Exam Guide here. Do a quick read on it to be aware of how to prepare and what to expect on the exam itself.

SAA-C02 Study Materials

For the AWS Certified Solutions Architect Associate exam, we recommend going through the FREE AWS Exam Readiness video course, official AWS sample questions, AWS whitepapers, FAQs, AWS cheat sheets, and AWS practice exams.



We recommend that you read the following whitepapers for your review. They contain a lot of concepts and strategies which are important for you to know.

We recommend that you read the following whitepapers for your review. They contain a lot of concepts and strategies which are important for you to know.

1. Overview of Amazon Web Services: This paper provides a good introduction on Cloud Computing, the AWS Global Infrastructure, and the available AWS Services. Reading this whitepaper before proceeding to the other whitepapers below will clear up many jargons found on the succeeding materials.
2. AWS Well Architected Framework: This paper is the most important one to read. It discusses the Five Pillars of a Well Architected Framework, with each pillar having a whitepaper of its own, and can all be found on this webpage. Be sure to understand well architected framework not just conceptually, but also in actual practice and application.
3. AWS Best Practices: This paper teaches you the best practices to perform when running your applications in AWS. It points out the advantages of Cloud over traditional hosting infrastructures and how you can implement them to keep your applications up and running all the time. The SA Associate exam will include questions that will test your knowledge on the best practices through different example scenarios.
4. Using Amazon Web Services for Disaster Recovery: This paper explains the different types of disaster recovery plans that you can perform in AWS. It is your responsibility as a Solutions Architect to mitigate any potential downtime when disaster strikes. Depending on your RPO and RTO, a proper disaster recovery plan will be a deciding factor between business continuity and revenue loss.

Additional SAA-C02 Whitepapers

1. AWS Security Practices: This paper supplements your study on the AWS services and features such as IAM, Security Groups, nACLs, etc. You should read this paper since security specific questions occasionally pop up in the exam.
2. AWS Storage Services Overview: This paper supplements your study on the different AWS Storage options such as S3, EBS, EFS, Glacier, etc. It contains a good detail of information and comparison for each storage service, which is crucial in knowing the best service to use for a situation.
3. Building Fault-Tolerant Applications on AWS: This paper discusses the many ways you can ensure your applications are fault-tolerant in AWS. It also contains multiple scenarios where the practices are applied and which AWS services were crucial for the scenario.

For the exam version (SAA-C02), you should also know the following services:

- AWS Global Accelerator
- Elastic Fabric Adapter (EFA)
- Elastic Network Adapter (ENA)
- AWS ParallelCluster
- Amazon FSx
- AWS DataSync
- AWS Directory Service
- High Performance Computing
- Aurora Serverless

... plus a few more services and new SAA-C02 topics that we have recently added to our **AWS Certified Solutions Architect Associate Practice Exams**.

For more information, check out the SAA-C02 official exam guide here.

Core AWS Services to Focus On for the SAA-C02 Exam

1. EC2 - As the most fundamental compute service offered by AWS, you should know about EC2 inside out.
2. Lambda - Lambda is the common service used for serverless applications. Study how it is integrated with other AWS services to build a full stack serverless app.
3. Elastic Load Balancer - Load balancing is very important for a highly available system. Study about the different types of ELBs, and the features each of them supports.
4. Auto Scaling - Study what services in AWS can be auto scaled, what triggers scaling, and how auto scaling increases/decreases the number of instances.
5. Elastic Block Store - As the primary storage solution of EC2, study on the types of EBS volumes available. Also study how to secure, backup and restore EBS volumes.
6. S3 / Glacier - AWS offers many types of S3 storage depending on your needs. Study what these types are and what differs between them. Also review on the capabilities of S3 such as hosting a static

website, securing access to objects using policies, lifecycle policies, etc. Learn as much about S3 as you can.

7. Storage Gateway - There are occasional questions about Storage Gateway in the exam. You should understand when and which type of Storage Gateway should be used compared to using services like S3 or EBS. You should also know the use cases and differences between DataSync and Storage Gateway.
8. EFS - EFS is a service highly associated with EC2, much like EBS. Understand when to use EFS, compared to using S3, EBS or instance store. Exam questions involving EFS usually ask the trade off between cost and efficiency of the service compared to other storage services.
9. RDS / Aurora - Know how each RDS database differs from one another, and how they are different from Aurora. Determine what makes Aurora unique, and when it should be preferred from other databases (in terms of function, speed, cost, etc). Learn about parameter groups, option groups, and subnet groups.
10. DynamoDB - The exam includes lots of DynamoDB questions, so read as much about this service as you can. Consider how DynamoDB compares to RDS, Elasticache and Redshift. This service is also commonly used for serverless applications along with Lambda.
11. Elasticache - Familiarize yourself with Elasticache redis and its functions. Determine the areas/services where you can place a caching mechanism to improve data throughput, such as managing session state of an ELB, optimizing RDS instances, etc.
12. VPC/NACL/Security Groups - Study every service that is used to create a VPC (subnets, route tables, internet gateways, nat gateways, VPN gateways, etc). Also, review on the differences of network access control lists and security groups, and during which situations they are applied.
13. Route 53 - Study the different types of records in Route 53. Study also the different routing policies. Know what hosted zones and domains are.
14. IAM - Services such as IAM Users, Groups, Policies and Roles are the most important to learn. Study how IAM integrates with other services and how it secures your application through different policies. Also read on the best practices when using IAM.
15. CloudWatch - Study how monitoring is done in AWS and what types of metrics are sent to CloudWatch. Also read upon Cloudwatch Logs, CloudWatch Alarms, and the custom metrics made available with CloudWatch Agent.
16. CloudTrail - Familiarize yourself with how CloudTrail works, and what kinds of logs it stores as compared to CloudWatch Logs.
17. Kinesis - Read about Kinesis sharding and Kinesis Data Streams. Have a high level understanding of how each type of Kinesis Stream works.
18. CloudFront - Study how CloudFront helps speed up websites. Know what content sources CloudFront can serve from. Also check the kinds of certificates CloudFront accepts.
19. SQS - Gather info on why SQS is helpful in decoupling systems. Study how messages in the queues are being managed (standard queues, FIFO queues, dead letter queues). Know the differences between SQS, SNS, SES, and Amazon MQ.
20. SNS - Study the function of SNS and what services can be integrated with it. Also be familiar with the supported recipients of SNS notifications.

21. SWF / CloudFormation / OpsWorks - Study how these services function. Differentiate the capabilities and use cases of each of them. Have a high level understanding of the kinds of scenarios they are usually used in.

Based on our exam experience, you should also know when to use the following:

- AWS DataSync vs Storage Gateway
- FSx (Cold and Hot Storage)
- Cross-Region Read Replicas vs. Multi-Az RDS - which database provides high-availability
- Amazon Object key vs Object Metadata
- Direct Connect vs. Site-to-Site VPN
- AWS Config vs AWS CloudTrail
- Security Group vs NACL
- NAT Gateway vs NAT Instance
- Geolocation routing policy vs. Geoproximity routing policy on Route 53

The AWS Documentation and FAQs will be your primary source of information. You can also visit **Tutorials Dojo's AWS Cheat Sheets** to gain access to a repository of thorough content on the different AWS services mentioned above. Lastly, try out these services yourself by signing up in AWS and performing some lab exercises. Experiencing them on your own will help you greatly in remembering what each service is capable of.

Also check out this article: **Top 5 FREE AWS Review Materials**.

Common Exam Scenarios

Scenario	Solution
Domain 1: Design Resilient Architectures	
Set up asynchronous data replication to another RDS DB instance hosted in another AWS Region	Create a Read Replica
A parallel file system for "hot" (frequently accessed) data	Amazon FSx For Lustre
Implement synchronous data replication across Availability Zones with automatic failover in Amazon RDS.	Enable Multi-AZ deployment in Amazon RDS.
Needs a storage service to host "cold" (infrequently accessed) data	Amazon S3 Glacier

Set up a relational database and a disaster recovery plan with an RPO of 1 second and RTO of less than 1 minute.	Use Amazon Aurora Global Database.
Monitor database metrics and send email notifications if a specific threshold has been breached.	Create an SNS topic and add the topic in the CloudWatch alarm.
Set up a DNS failover to a static website.	Use Route 53 with the failover option to a static S3 website bucket or CloudFront distribution.
Implement an automated backup for all the EBS Volumes.	Use Amazon Data Lifecycle Manager to automate the creation of EBS snapshots.
Monitor the available swap space of your EC2 instances	Install the CloudWatch agent and monitor the SwapUtilizationmetric.
Implement a 90-day backup retention policy on Amazon Aurora.	Use AWS Backup
Domain 2: Design High-Performing Architectures	
Implement a fanout messaging.	Create an SNS topic with a message filtering policy and configure multiple SQS queues to subscribe to the topic.
A database that has a read replication latency of less than 1 second.	Use Amazon Aurora with cross-region replicas.
A specific type of Elastic Load Balancer that uses UDP as the protocol for communication between clients and thousands of game servers around the world.	Use Network Load Balancer for TCP/UDP protocols.
Monitor the memory and disk space utilization of an EC2 instance.	Install Amazon CloudWatch agent on the instance.
Retrieve a subset of data from a large CSV file stored in the S3 bucket.	Perform an S3 Select operation based on the bucket's name and object's key.
Upload 1 TB file to an S3 bucket.	Use Amazon S3 multipart upload API to upload large objects in parts.
Improve the performance of the application by reducing the response times from milliseconds to microseconds.	Use Amazon DynamoDB Accelerator (DAX)

Retrieve the instance ID, public keys, and public IP address of an EC2 instance.	Access the url: http://169.254.169.254/latest/meta-data/ using the EC2 instance.
Route the internet traffic to the resources based on the location of the user.	Use Route 53 Geolocation Routing policy.
Domain 3: Design Secure Applications and Architectures	
Encrypt EBS volumes restored from the unencrypted EBS snapshots	Copy the snapshot and enable encryption with a new symmetric CMK while creating an EBS volume using the snapshot.
Limit the maximum number of requests from a single IP address.	Create a rate-based rule in AWS WAF and set the rate limit.
Grant the bucket owner full access to all uploaded objects in the S3 bucket.	Create a bucket policy that requires users to set the object's ACL to bucket-owner-full-control.
Protect objects in the S3 bucket from accidental deletion or overwrite.	Enable versioning and MFA delete.
Access resources on both on-premises and AWS using on-premises credentials that are stored in Active Directory.	Set up SAML 2.0-Based Federation by using a Microsoft Active Directory Federation Service.
Secure the sensitive data stored in EBS volumes	Enable EBS Encryption
Ensure that the data-in-transit and data-at-rest of the Amazon S3 bucket is always encrypted	Enable Amazon S3 Server-Side or use Client-Side Encryption
Secure the web application by allowing multiple domains to serve SSL traffic over the same IP address.	Use AWS Certificate Manager to generate an SSL certificate. Associate the certificate to the CloudFront distribution and enable Server Name Indication (SNI).
Control the access for several S3 buckets by using a gateway endpoint to allow access to trusted buckets.	Create an endpoint policy for trusted S3 buckets.
Enforce strict compliance by tracking all the configuration changes made to any AWS services.	Set up a rule in AWS Config to identify compliant and non-compliant services.
Provide short-lived access tokens that acts as temporary security credentials to allow access to AWS resources.	Use AWS Security Token Service

Encrypt and rotate all the database credentials, API keys, and other secrets on a regular basis.	Use AWS Secrets Manager and enable automatic rotation of credentials.
Domain 4: Design Cost-Optimized Architectures	
A cost-effective solution for over-provisioning of resources.	Configure a target tracking scaling in ASG.
The application data is stored in a tape backup solution. The backup data must be preserved for up to 10 years.	Use AWS Storage Gateway to backup the data directly to Amazon S3 Glacier Deep Archive.
Accelerate the transfer of historical records from on-premises to AWS over the Internet in a cost-effective manner.	Use AWS DataSync and select Amazon S3 Glacier Deep Archive as the destination.
Globally deliver the static contents and media files to customers around the world with low latency.	Store the files in Amazon S3 and create a CloudFront distribution. Select the S3 bucket as the origin.
An application must be hosted to two EC2 instances and should continuously run for three years. The CPU utilization of the EC2 instances is expected to be stable and predictable.	Deploy the application to a Reserved instance.
Implement a cost-effective solution for S3 objects that are accessed less frequently.	Create an Amazon S3 lifecycle policy to move the objects to Amazon S3 Standard-IA.
Minimize the data transfer costs between two EC2 instances.	Deploy the EC2 instances in the same Region.
Import the SSL/TLS certificate of the application.	Import the certificate into AWS Certificate Manager or upload it to AWS IAM.

Validate Your Knowledge

When you are feeling confident with your review, it is best to validate your knowledge through sample exams. You can take this practice exam from AWS for free as additional material, but do not expect your real exam to be on the same level of difficulty as this practice exam on the AWS website. **Tutorials Dojo** offers a very useful and well-reviewed set of practice tests for AWS Solutions Architect Associate SAA-C02 takers **here**. Each test contains unique questions that will surely help verify if you have missed out on anything important that might appear on your exam. You can pair our practice exams with this study guide eBook to further help in your exam preparations.

If you have scored well on the **Tutorials Dojo AWS Certified Solutions Architect Associate practice tests** and you think you are ready, then go earn your certification with your head held high. If you think you are lacking in certain areas, better go review them again, and take note of any hints in the questions that will help you select the correct answers. If you are not that confident that you'll pass, then it would be best to reschedule your exam to another day, and take your time preparing for it. In the end, the efforts you have put in for this will surely reward you.

Sample SAA-C02 Practice Test Questions:

Question 1

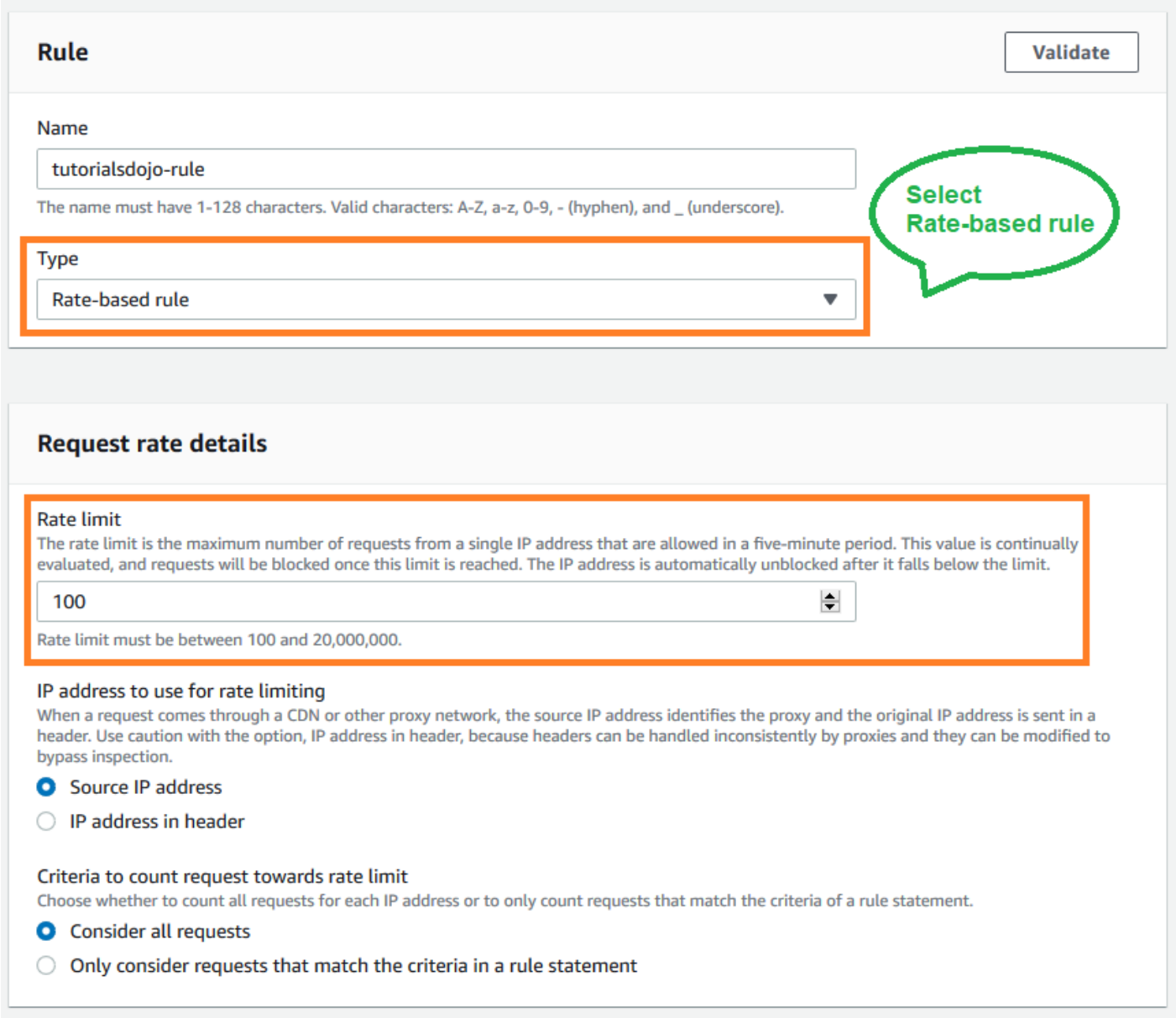
A company hosted an e-commerce website on an Auto Scaling group of EC2 instances behind an Application Load Balancer. The Solutions Architect noticed that the website is receiving a large number of illegitimate external requests from multiple systems with IP addresses that constantly change. To resolve the performance issues, the Solutions Architect must implement a solution that would block the illegitimate requests with minimal impact on legitimate traffic.

Which of the following options fulfills this requirement?

1. Create a regular rule in AWS WAF and associate the web ACL to an Application Load Balancer.
2. Create a custom network ACL and associate it with the subnet of the Application Load Balancer to block the offending requests.
3. Create a rate-based rule in AWS WAF and associate the web ACL to an Application Load Balancer.
4. Create a custom rule in the security group of the Application Load Balancer to block the offending requests.

Correct Answer: 3

AWS WAF is tightly integrated with Amazon CloudFront, the Application Load Balancer (ALB), Amazon API Gateway, and AWS AppSync – services that AWS customers commonly use to deliver content for their websites and applications. When you use AWS WAF on Amazon CloudFront, your rules run in all AWS Edge Locations, located around the world close to your end-users. This means security doesn't come at the expense of performance. Blocked requests are stopped before they reach your web servers. When you use AWS WAF on regional services, such as Application Load Balancer, Amazon API Gateway, and AWS AppSync, your rules run in the region and can be used to protect Internet-facing resources as well as internal resources.



A rate-based rule tracks the rate of requests for each originating IP address and triggers the rule action on IPs with rates that go over a limit. You set the limit as the number of requests per 5-minute time span. You can use this type of rule to put a temporary block on requests from an IP address that's sending excessive requests. Based on the given scenario, the requirement is to limit the number of requests from the illegitimate requests without affecting the genuine requests. To accomplish this requirement, you can use AWS WAF web ACL. There are two types of rules in creating your own web ACL rule: regular and rate-based rules. You need to select the latter to add a rate limit to your web ACL. After creating the web ACL, you can associate it with ALB. When the rule action triggers, AWS WAF applies the action to additional requests from the IP address until the request rate falls below the limit.

Hence, the correct answer is: **Create a rate-based rule in AWS WAF and associate the web ACL to an Application Load Balancer.**

The option that says: **Create a regular rule in AWS WAF and associate the web ACL to an Application Load Balancer** is incorrect because a regular rule only matches the statement defined in the rule. If you need to add a rate limit to your rule, you should create a rate-based rule.

The option that says: **Create a custom network ACL and associate it with the subnet of the Application Load Balancer to block the offending requests** is incorrect. Although NACLs can help you block incoming traffic, this option wouldn't be able to limit the number of requests from a single IP address that is dynamically changing.

The option that says: **Create a custom rule in the security group of the Application Load Balancer to block the offending requests** is incorrect because the security group can only allow incoming traffic. Remember that you can't deny traffic using security groups. In addition, it is not capable of limiting the rate of traffic to your application unlike AWS WAF.

References:
https://docs.aws.amazon.com/waf/latest/developerguide/waf-rule-statement-type-rate-based.html
https://aws.amazon.com/waf/faqs/

Check out this AWS WAF Cheat Sheet:
https://tutorialsdojo.com/aws-waf/

Question 2

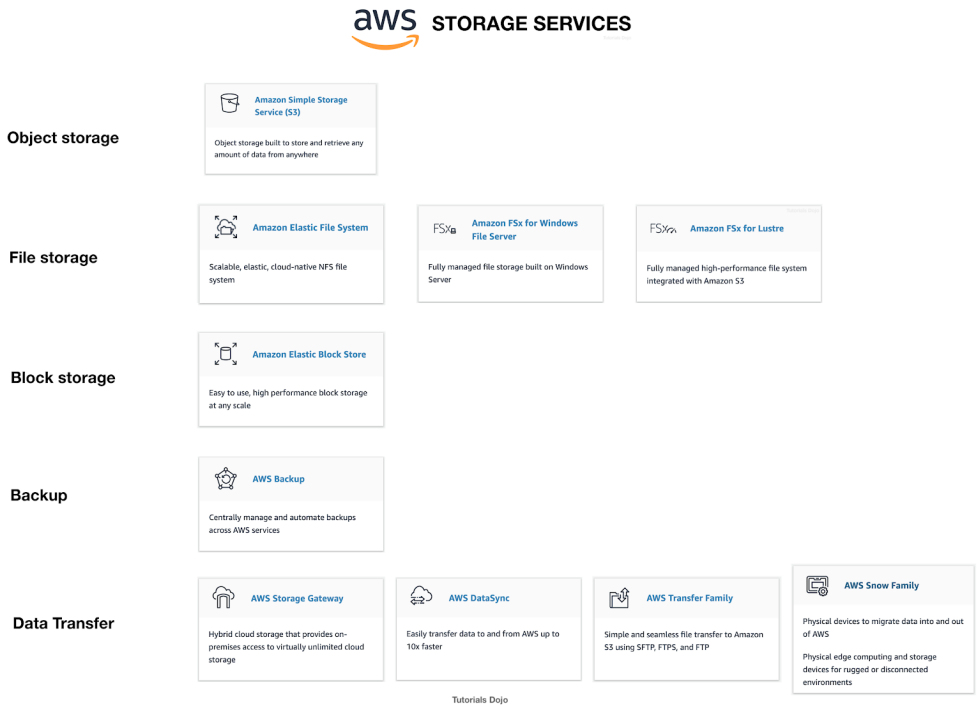
An AI-powered Forex trading application consumes thousands of data sets to train its machine learning model. The application's workload requires a high-performance, parallel hot storage to process the training datasets concurrently. It also needs cost-effective cold storage to archive those datasets that yield low profit.

Which of the following Amazon storage services should the developer use?

1. Use Amazon FSx For Lustre and Amazon EBS Provisioned IOPS SSD (io1) volumes for hot and cold storage respectively.
2. Use Amazon FSx For Lustre and Amazon S3 for hot and cold storage respectively.
3. Use Amazon Elastic File System and Amazon S3 for hot and cold storage respectively.
4. Use Amazon FSx For Windows File Server and Amazon S3 for hot and cold storage respectively.

Correct Answer: 2

Hot storage refers to the storage that keeps frequently accessed data (hot data). **Warm storage** refers to the storage that keeps less frequently accessed data (warm data). **Cold storage** refers to the storage that keeps rarely accessed data (cold data). In terms of pricing, the colder the data, the cheaper it is to store, and the costlier it is to access when needed.



Amazon FSx For Lustre is a high-performance file system for fast processing of workloads. Lustre is a popular open-source **parallel file system** which stores data across multiple network file servers to maximize performance and reduce bottlenecks.

Amazon FSx for Windows File Server is a fully managed Microsoft Windows file system with full support for the SMB protocol, Windows NTFS, Microsoft Active Directory (AD) Integration.

Amazon Elastic File System is a fully-managed file storage service that makes it easy to set up and scale file storage in the Amazon Cloud.

Amazon S3 is an object storage service that offers industry-leading scalability, data availability, security, and performance. S3 offers different storage tiers for different use cases (frequently accessed data, infrequently accessed data, and rarely accessed data).

The question has two requirements:

1. High-performance, parallel hot storage to process the training datasets concurrently.
2. Cost-effective cold storage to keep the archived datasets that are accessed infrequently

In this case, we can use **Amazon FSx For Lustre** for the first requirement, as it provides a high-performance, parallel file system for hot data. On the second requirement, we can use Amazon S3 for storing the cold data. Amazon S3 supports a cold storage system via Amazon S3 Glacier / Glacier Deep Archive.

Hence, the correct answer is: **Use Amazon FSx For Lustre and Amazon S3 for hot and cold storage respectively**.

Using Amazon FSx For Lustre and Amazon EBS Provisioned IOPS SSD (io1) volumes for hot and cold storage respectively is incorrect because the Provisioned IOPS SSD (io1) volumes are designed as a hot storage to meet the needs of I/O-intensive workloads. EBS has a storage option called Cold HDD but it is not used for storing cold data. In addition, EBS Cold HDD is a lot more expensive than using Amazon S3 Glacier / Glacier Deep Archive.

Using Amazon Elastic File System and Amazon S3 for hot and cold storage respectively is incorrect because although EFS supports concurrent access to data, it does not have the high-performance ability that is required for machine learning workloads.

Using Amazon FSx For Windows File Server and Amazon S3 for hot and cold storage respectively is incorrect because Amazon FSx For Windows File Server does not have a parallel file system, unlike Lustre.

References:
https://aws.amazon.com/fsx/
https://docs.aws.amazon.com/whitepapers/latest/cost-optimization-storage-optimization/aws-storage-services.html
https://aws.amazon.com/blogs/startups/picking-the-right-data-store-for-your-workload/

Check out this Amazon FSx Cheat Sheet:
https://tutorialsdojo.com/amazon-fsx/

Click **here** for more **AWS Certified Solutions Architect Associate practice exam questions**.

Check out our other AWS practice test courses **here**:

Additional SAA-C02 Training Materials: High Quality Video Courses for the AWS Certified Solutions Architect Associate Exam

There are a few top-rated AWS Certified Solutions Architect Associate SAA-C02 video courses that you can check out as well, which can complement your exam preparations especially if you are the type of person who can learn better through visual courses instead of reading long whitepapers:

1. AWS Certified Solutions Architect - Associate by Adrian Cantrill
2. AWS Certified Solutions Architect - Associate by DolfinEd

Based on the feedback of thousands of our students in our practice test course, the combination of any of these video courses plus our practice tests and this study guide eBook were enough to pass the exam and even get a good score.

Some Notes Regarding Your SAA-C02 Exam

The AWS Solutions Architect Associate (SAA-C02) exam loves to end questions that ask for highly available or cost-effective solutions. Be sure to understand the choices provided to you, and verify that they have correct details. Some choices are very misleading such that it seems it is the most appropriate answer to the question, but contains an incorrect detail of some service.

When unsure of which options are correct in a multi-select question, try to eliminate some of the choices that you believe are false. This will help narrow down the feasible answers to that question. The same goes for multiple choice type questions. Be extra careful as well when selecting the number of answers you submit. Check out the tips mentioned in this article for more information.

As mentioned in this review, you should be able to differentiate services that belong in one category with one another. Common comparisons include:

- EC2 vs ECS vs Lambda
- S3 vs EBS vs EFS
- CloudFormation vs OpsWorks vs Elastic Beanstalk
- SQS vs SNS vs SES vs MQ
- Security Group vs nACLs
- The different S3 storage types vs Glacier
- RDS vs DynamoDB vs Elasticache
- RDS engines vs Aurora

The **Tutorials Dojo Comparison of AWS Services** contains excellent cheat sheets comparing these seemingly similar services which are crucial to solving the tricky scenario-based questions in the actual exam. By knowing each service's capabilities and use cases, you can consider these types of questions already half-solved.

Lastly, be on the lookout for “key terms” that will help you realize the answer faster. Words such as millisecond latency, serverless, managed, highly available, most cost effective, fault tolerant, mobile, streaming, object storage, archival, polling, push notifications, etc are commonly seen in the exam. Time management is very important when taking AWS certification exams, so be sure to monitor the time you consume for each question.

CLOUD COMPUTING BASICS

Cloud computing is a piece of technology that the industry has embraced to be a strong driver of innovation. Having resources available at your fingertips makes work just way easier and faster to accomplish. With virtually unlimited compute power and storage that one can provision on-demand from anywhere with internet access, companies can shift their focus to delivering their products and services to their customers, and reach their highest potential. Rather than owning these infrastructures, they can rent them as a service and pay only for what they consume.

Cloud computing allows companies and merchants to create a predictable and controllable budget plan that they can allocate and maximize in any way they see fit. Best of all, as more people use the cloud, the more the cost of using cloud services drops, thanks to economies of scale.

The concept of cloud computing has been there for quite a long time already, but it has only gained traction recently when more and more companies began to adopt these cloud providers such as Amazon Web Services. It is not a secret that it was tough to build such large scales of infrastructure and gain the trust of customers to run their applications on these shared spaces. Only in 2006 did Amazon Web Services (AWS) begin offering IT infrastructure services to businesses in the form of web services, which is now known as cloud computing. Even though the cloud provider is still fairly young, AWS has been an initiator and a constant leader in delivering what cloud computing promises to its customers – fast, cheap and reliable infrastructure and software services.

Services in the cloud can be categorized into different models depending on how they work. The most common models include:

1. **IaaS** – which stands for “infrastructure-as-a-service”. These cloud computing services are the counterpart of purchasing your own hardware on-premises, minus the purchasing part. You rent them from the cloud provider and use them as if they were your own compute and storage devices.
2. **PaaS** – which stands for “platform-as-a-service”. These services are a bit similar with IaaS, but offer more utility and convenience for the customer. One example is a web hosting service, where you won’t need to worry about the underlying hardware your website is running on, so you can focus on your website deployment and management instead.
3. **SaaS** – which stands for “software-as-a-service”. These services totally remove the infrastructure part from the equation. You use these services according to the features and utility they offer to you. A good example is email.

There are other models that you might encounter here and there, such as DBaaS, which means “database-as-a-service, but for the sake of this study guide, we will be focusing primarily on the three above.

As with every piece of technology, there are pros and cons to using cloud computing. *Cloud computing is not for everyone.* It is not always the case that moving to the cloud lowers your overall expenses, or gives you that

competitive edge against your competitors. It takes careful planning for one to commit to the cloud. You might rashly board on to the cloudspace, only to realize later that it is not working out for you financially and functionally. Moving out of the cloud can be as hard *and as expensive* as moving into the cloud. Therefore, you must properly evaluate the benefits that you want to achieve with cloud computing vs having things run on-premises.

CLOUD COMPUTING CONCEPTS

Before we jump into the nitty-gritty of AWS, let's first go through some of the general concepts of cloud computing.

1. **Public Cloud**
   As the name suggests, public cloud is the type of cloud computing that the majority are using right now. This is what you may know as AWS, Azure, Google Cloud and many more. The public cloud offers a lot of benefits to its users given that their infrastructures commonly span multiple locations, which are continuously improved and have dedicated support. The public cloud, therefore, has enough capacity to support a large number of customers simultaneously, and is often the go-to for future companies looking into cloud technology.

2. **Private Cloud**
   Private cloud is a type of cloud computing deployment model that only spans within the network of a company or a corporation. The company manages the hardware and the network that it has, while still enjoying some of the benefits of the cloud. An internal team then decides how to allocate and distribute their resources amongst their developers so that there is less security risk. Companies that have strict compliances against public cloud services use private cloud instead to ensure that their operations can operate with enough capacity and minimal downtime. The catch is that, with this level of infrastructure, the expenses can become much higher and/or it will not be as globally extensive as the public cloud providers.

3. **Hybrid Cloud**
   Hybrid cloud is like a buffet. You take a piece of this and a piece of that, but the whole point of it is you eat happily in the end. Hybrid cloud means you are not committing everything into the public or private cloud. You can have a mix of operations running in the public cloud, while all your data is kept on-premises. Or you can also have different cloud providers handling different projects, depending on the strengths and weaknesses of these cloud providers. There is no rule stating that you should put all your eggs in one basket. By carefully deciding how you want to build your operations, you not only achieve the desired efficiency of your projects, but also gain the best value for your money.

4. **High Availability**
   High availability means having redundant copies of an object or resource to make sure that another can take its place when something happens to it. High availability can apply to almost anything: compute servers, data storage, databases, networks, etc. High availability is one of the main selling points of using the cloud. It might be expensive, but companies that cannot risk having downtime nor data loss should build highly available infrastructures in the cloud to protect their assets. Furthermore, because the data centers in the cloud are geographically distributed and are usually far apart from one another, in case one of these data centers go offline, other data centers are not affected and can continue serving you.

5. **Fault Tolerance**
   Fault tolerance is different from high availability. Fault tolerance means that a system can continue operating even if one or more components begin to degrade and fail. Oftentimes, fault tolerance can be attributed to redundancy as well. When a component begins to fail, the system detects this and replaces the faulty component to restore working operations. Other times, fault tolerance can mean proper error handling. When a component begins to fail, the system detects this and reroutes the operation to somewhere else that is healthy. A properly built infrastructure is capable of withstanding component degradation and eventual failure, and if possible, repair itself as well.

6. **Elasticity**
   Elasticity is the ability to quickly provision resources when you need them, and release them once you don't need them anymore. Unlike traditional infrastructure, in the cloud, you should treat servers and storage as disposable. They should not be kept beyond their usefulness. Compute power and storage space can be easily acquired anyway when you need it, so be cost-effective with your budget, use only what you need and don't keep them idle. Elasticity is another major selling point of the cloud, since you do not have hardware ownership. You don't need to worry about purchasing new hardware to meet your requirements and think about how to get your money back once it is beyond its lifespan.

7. **Scalability**
   Scalability is the concept of provisioning additional resources to increase performance and support high demand, and reducing them once demand is not as high anymore. Scalability is an important practice that you must apply to keep your users happy. Imagine if your website suddenly receives a high number of traffic, and you don't have enough compute power to serve content to all your customers. The negative impact on customer satisfaction will greatly affect your reputation and your profits. When scaling a resource, like a website for example, make sure that it is stateless so that you won't lose any important data once it scales down. You should also use appropriate metrics as a basis of your scaling activity.

8. **Redundancy**
   Redundancy is a mix of all the things above. It is important that you practice redundancy in the cloud, as it can protect you from all sorts of issues that are not as tolerable in an on-premises setup. There are a lot of things in the cloud that you can *and must* apply redundancy. It's not just servers and databases, but also file storages, security applications, networks, monitoring tools and even personnel. By having additional layers of safeguards, you lessen the risk of things going haywire and costing you more than a few bucks of extra servers.

9. **Disaster Recovery**
   Disaster recovery is the practice of ensuring that you have a standardized plan on how to recover your operations in case of total failure. Usually, this means having a copy of your infrastructure running in a different location, so that if your primary experiences a disaster, you can quickly failover to your secondary. Your disaster recovery plan depends on the amount of time that you have to bring back up

your operations (RTO), and the amount of data loss that your business can tolerate (RPO). Having a disaster recovery plan is crucial especially for live production databases. We have a number of DR strategies that meet different RTO and RPO objectives, which we will discuss in more detail later on.

10. **Serverless**
    Serverless is a cloud computing model wherein the cloud provider handles the server and all maintenance, while you just put your code in. The term “Serverless” confuses a bunch of people who think that there are literally no servers involved in this model. That’s not true. Serverless is still using servers in the backend, but it takes away from you the responsibility of provisioning and maintaining one, so you can dedicate everything to your code and not have to worry about scalability, patching, etc. Serverless involves a whole new dynamic of writing code and building applications, so it may not fit everyone’s bill. The technology can save you a lot of cost due to its lower pricing than those of traditional server models, but it may also introduce additional complexity to your code due to its distributed nature. You also lose a lot of control over your environment if you usually manage your own runtimes, etc. Serverless functions are also event-driven. If you’re a Node JS developer, get ready for a lot of callbacks with this one.

AWS BASICS

There is much for us to know about Amazon Web Services. What is their cloud computing model? What advantages do they bring to us users? Are they secure enough for us to trust them with our applications? These are just some of the questions that we will be tackling in this section.

AWS Overview

In 2006, AWS started offering IT infrastructure services to businesses as web services. The intention was to solve common infrastructure troubles that businesses often encounter in a traditional setup. With the cloud, businesses no longer need to plan for and procure servers and other IT infrastructure in advance. In AWS, they can instantly provision hundreds to thousands of servers in a few minutes and deliver results faster. Today, AWS provides a highly reliable, scalable, low-cost infrastructure platform in the cloud that supports multiple businesses around the globe.

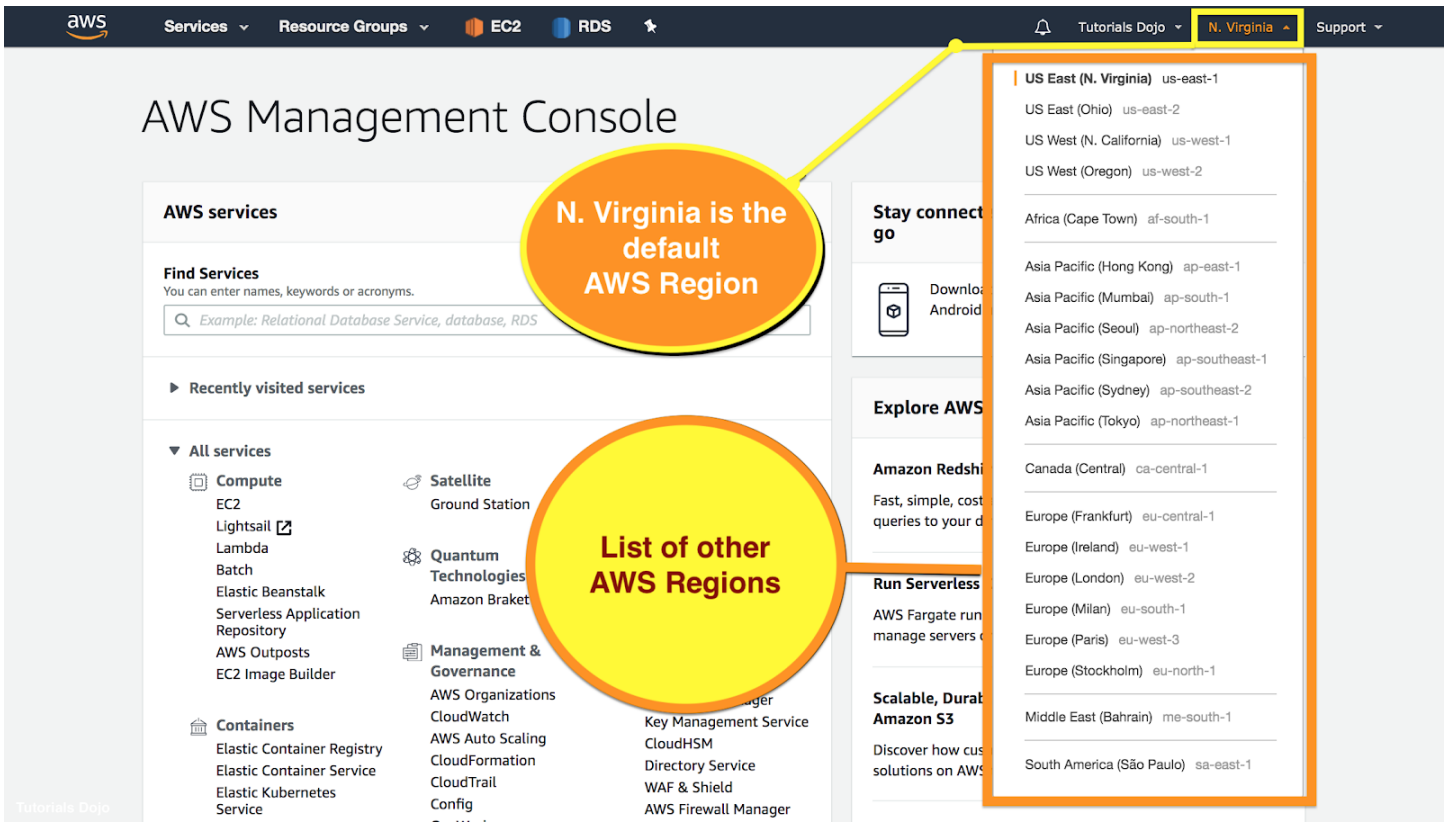
Advantages of AWS Cloud Computing

- **Trade capital expense for variable expense** – The principle of cloud is, pay for what you use, and how much you use it. You don't need to allocate a huge chunk of your capital just so you can purchase additional servers or additional storage *that you think you might need* and leave them idle collecting dust. That's why in the cloud, you should treat resources as something easily attainable, as well as something easily disposable.
- **Benefit from massive economies of scale** – By using cloud computing, you can achieve a lower variable cost than you can get on your own. Many customers adopt AWS as their cloud provider, and the number increases each day. The more customers use AWS, the more AWS can achieve higher economies of scale, which lowers pay as-you-go prices.
- **Stop guessing capacity** – Not knowing how much capacity you need is alright in AWS. AWS can easily scale compute and storage as much as you need it to. That is why it is also a great idea to do some benchmarking in the cloud, since you do not have to worry about running out of resources. Once you have a baseline, you can adjust your scaling metrics and running resources to save on cost.
- **Increase speed and agility** – In a cloud computing environment, new resources can be provisioned in a single click of a button. The cloud brings a lot of convenience to your developers since it reduces the time needed to obtain additional resources. In return, you gain a dramatic increase in agility for the organization, since the cost and time it takes to experiment and innovate is significantly lower.
- **Stop spending money running and maintaining data centers** – Cloud computing lets you focus on your own customers, rather than on the physical maintenance of your servers. Use your time and money on your projects, on your applications and on your people. You can save up on huge capital if you remove the physical aspect from the equation.
- **Go global in minutes** – You can easily deploy your application in multiple regions around the world with just a few clicks thanks to the wide coverage of AWS data centers. By strategically choosing which

regions and locations you deploy your applications in, you can provide lower latency and a better experience for your customers at minimal cost.

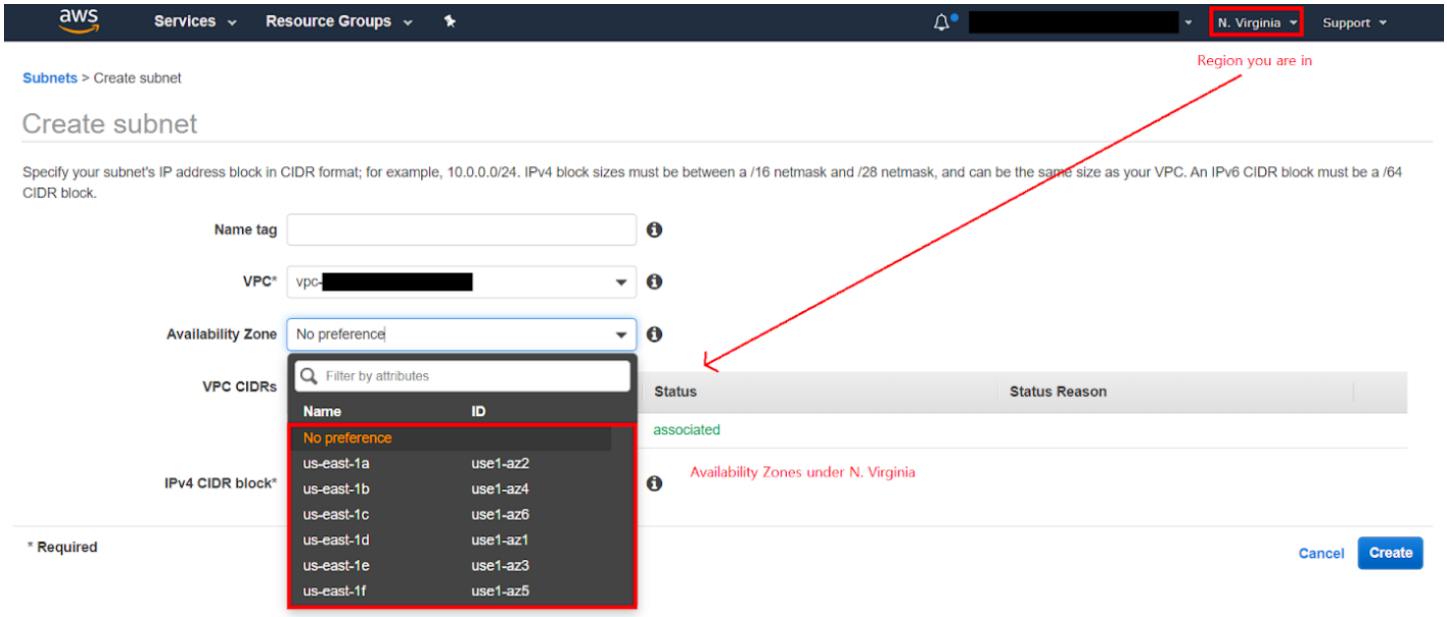
AWS Global Infrastructure

Regions provide multiple, physically separated and isolated **Availability Zones** which are connected with low latency, high throughput, and highly redundant networking.



Availability Zones offer highly availability, fault tolerance, and scalability.

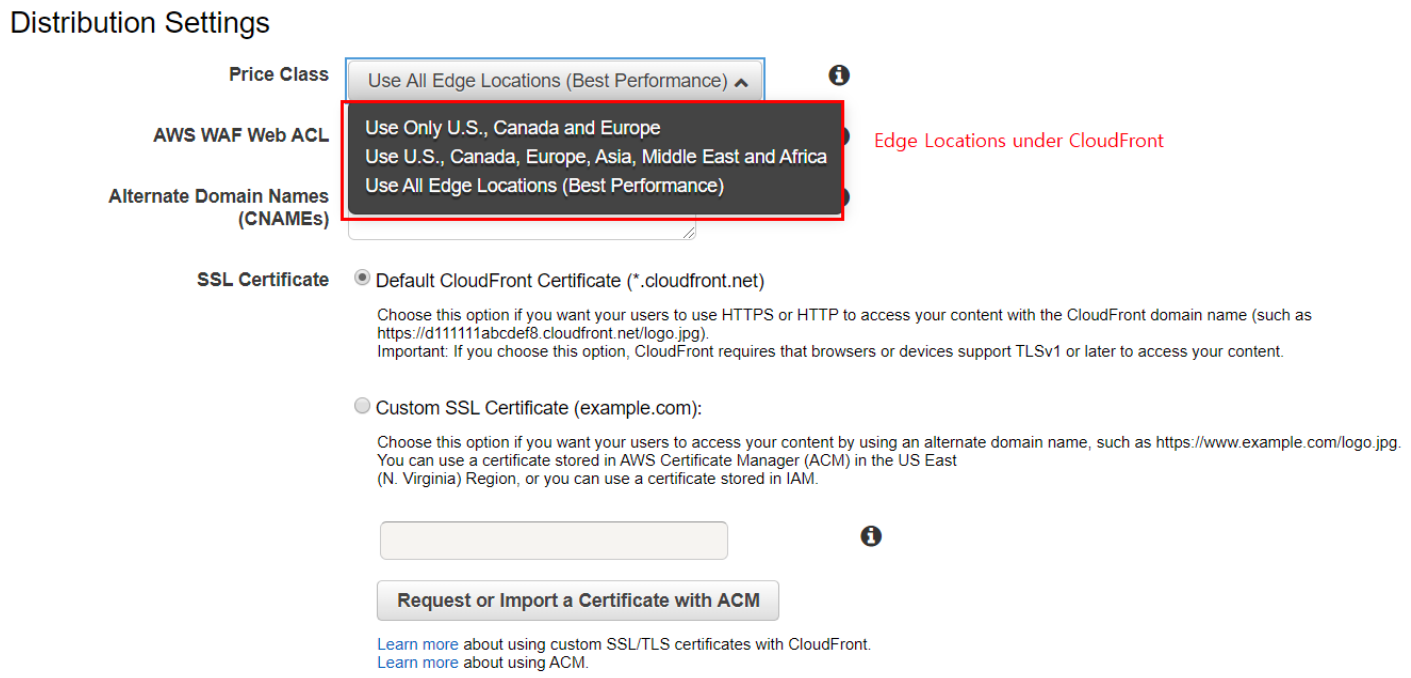
- They consist of one or more discrete data centers, each with redundant power, networking, and connectivity, housed in separate facilities.
- An Availability Zone is represented by a **region code** followed by a **letter identifier**; for example, us-east-1a.
- Availability Zone codes are used almost everywhere, especially if you are interacting with AWS programmatically.



An **AWS Local Region** is a single datacenter designed to complement an existing AWS Region. An **AWS Local Zone** places AWS compute, storage, database, and other select services closer to large population, industry, and IT centers, which makes it ideal for use cases such as content creation, real-time gaming, live video streaming, and more.

To deliver low-latency content to users around the globe, AWS has placed **Points of Presence**, which are either edge locations or edge caches. These points are used by Cloudfront and Lambda@Edge services.

Edge locations are sites that CloudFront uses to cache copies of your content for faster delivery to your users.



You can also view the Interactive AWS Global Infrastructure Map here.

AWS Security and Compliance

Since a lot of customers rely on AWS for their infrastructure needs, naturally it is THE PRIORITY of AWS to make sure their security is of the highest level. AWS offers multiple layers of protection to ensure that their hardware is well-protected and their customer data are fully secured. They also make sure to keep everything well-maintained and updated, both hardware and software. Having multiple tenants sharing the same server rack can cause a lot of businesses huge worries over their data privacy and data security. It is only through tight security checks and compliance audits can public cloud providers such as AWS gain the trust of their customers.

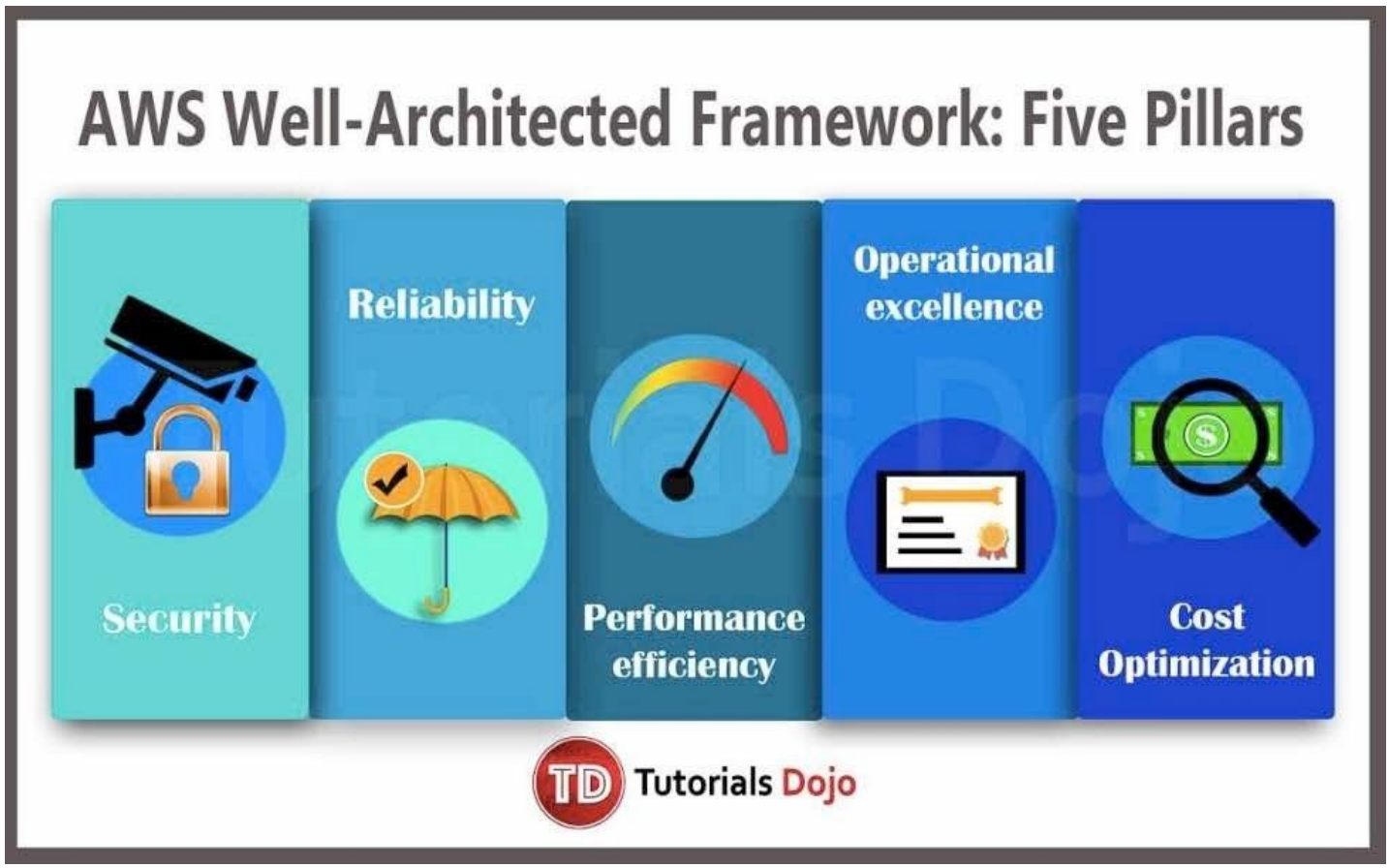
As an AWS customer, you inherit all the best practices of AWS policies, architecture, and operational processes built to satisfy the requirements of their most security-sensitive customers. In the cloud, the responsibility of security is a shared one. AWS secures what they can on their end, while you secure what you can on your end. Only this way can everyone protect their valuable data. And therefore, AWS has developed multiple tools and services to help you achieve your security objectives. You can also review the numerous audits and certifications that third-party auditors have conducted on AWS, so that whenever you need to fulfill strict compliance with the use of a service, you can simply verify its status through the catalog.

AWS Pricing

- There are three fundamental drivers of cost with AWS:
  - Compute
  - Storage
  - Outbound data transfer.
- AWS offers pay-as-you-go for pricing.
- For certain services like **Amazon EC2, Amazon EMR,** and **Amazon RDS**, you can invest in reserved capacity. With Reserved Instances, you can save up to 75% over equivalent on-demand capacity. When you buy Reserved Instances, the larger the upfront payment, the greater the discount.
  - With the **All Upfront** option, you pay for the entire Reserved Instance term with one upfront payment. This option provides you with the largest discount compared to On-Demand instance pricing.
  - With the **Partial Upfront** option, you make a low upfront payment and are then charged a discounted hourly rate for the instance for the duration of the Reserved Instance term.
  - The **No Upfront** option does not require any upfront payment and provides a discounted hourly rate for the duration of the term.
- There are also volume-based discounts for services such as **Amazon S3.**
- For new accounts, AWS Free Tier is available.
  - Free Tier offers limited usage of AWS products at no charge for 12 months since the account was created. More details at https://aws.amazon.com/free/.
- You can estimate your monthly AWS bill using **AWS Pricing Calculator**.

AWS Well-Architected Framework - Five Pillars

Having well-architected systems greatly increases the plausibility of business success which is why AWS created the AWS Well-Architected Framework. This framework is composed of five pillars that help you understand the pros and cons of decisions you make while building cloud architectures and systems on the AWS platform. You will learn the architectural best practices for designing and operating reliable, efficient, cost-effective and secure systems in the cloud by using the framework. It also provides a way to consistently measure your architectures against best practices and identify areas for improvement.

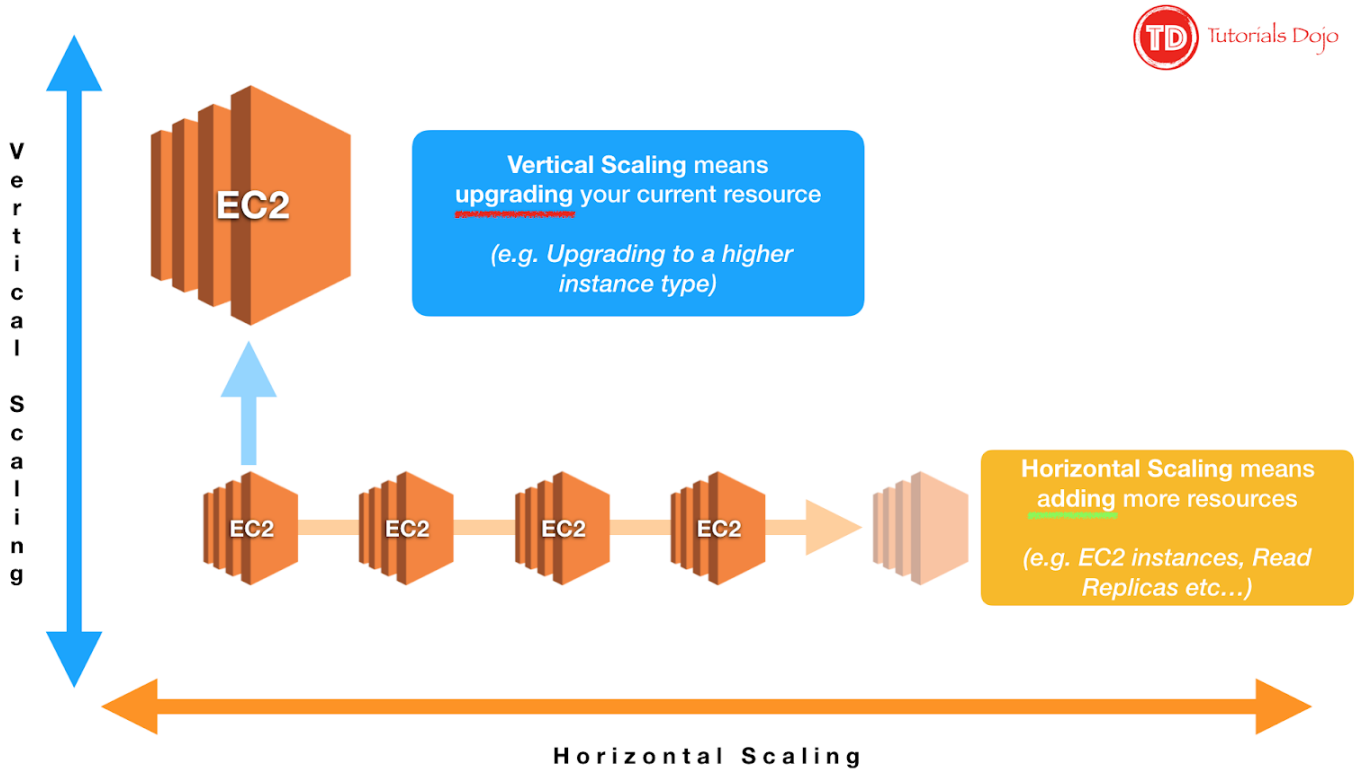


- Operational Excellence
  - The ability to support development and run workloads effectively, gain insight into their operations, and to continuously improve supporting processes and procedures to deliver business value.
  - Design Principles
    - Perform operations as code
    - Make frequent, small, reversible changes
    - Refine operations procedures frequently
    - Anticipate failure
    - Learn from all operational failures
- Security
  - The ability to protect data, systems, and assets to take advantage of cloud technologies to improve your security.
  - Design Principles
    - Implement a strong identity foundation
    - Enable traceability
    - Apply security at all layers

        - Automate security best practices
        - Protect data in transit and at rest
        - Keep people away from data
        - Prepare for security events
- Reliability
    - The ability of a workload to perform its intended function correctly and consistently when it's expected to. This includes the ability to operate and test the workload through its total lifecycle.
    - Design Principles
        - Automatically recover from failure
        - Test recovery procedures
        - Scale horizontally to increase aggregate workload availability
        - Stop guessing capacity
        - Manage change in automation
- Performance Efficiency
    - The ability to use computing resources efficiently to meet system requirements, and to maintain that efficiency as demand changes and technologies evolve.
    - Design Principles
        - Democratize advanced technologies
        - Go global in minutes
        - Use serverless architectures
        - Experiment more often
        - Consider mechanical sympathy
- Cost Optimization
    - The ability to run systems to deliver business value at the lowest price point.
    - Design Principles
        - Implement Cloud Financial Management
        - Adopt a consumption model
        - Measure overall efficiency
        - Stop spending money on undifferentiated heavy lifting
        - Analyze and attribute expenditure

Best Practices when Architecting in the Cloud

- **Focus on scalability**
    - **Scaling Horizontally** - an increase in the number of resources. When scaling horizontally, you want your resources to be stateless and receive a well-distributed load of work.
    - **Scaling Vertically** - an increase in the specifications of an individual resource, such as to a higher instance type for EC2 instances.

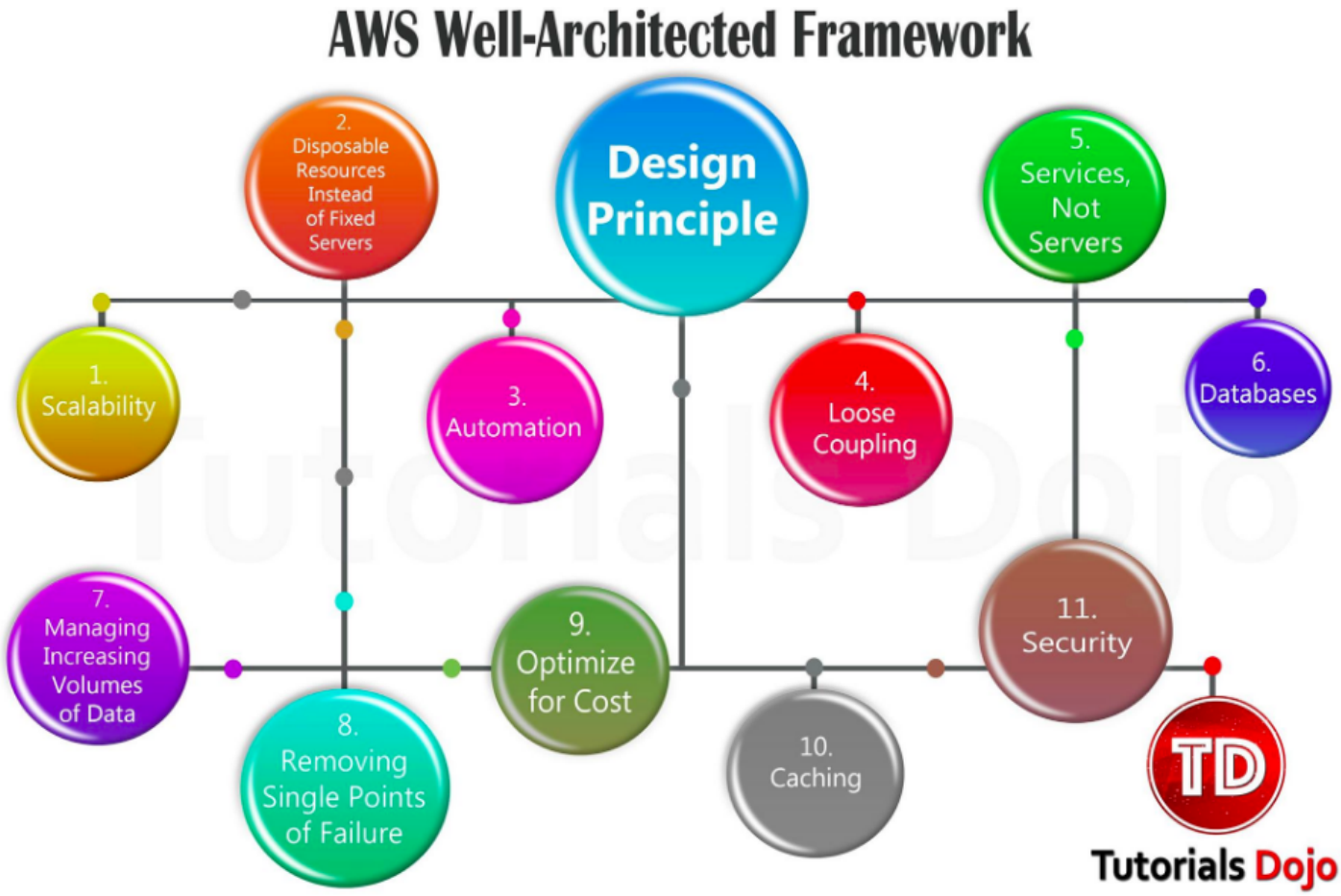


- **Disposable Resources Instead of Fixed Servers**
  - **Instantiating Compute Resources** - automate setting up of new resources along with their configuration and code through methods such as bootstrapping, Docker images or golden AMIs.
  - **Infrastructure as Code** - AWS assets are programmable. You can apply techniques, practices, and tools from software development to make your whole infrastructure reusable, maintainable, extensible, and testable.
- **Use Automation**
  - **Serverless Management and Deployment** - being serverless shifts your focus to automation of your code deployment. AWS handles the management tasks for you.
  - **Infrastructure Management and Deployment** - AWS automatically handles details, such as resource provisioning, load balancing, auto scaling, and monitoring, so you can focus on resource deployment.
  - **Alarms and Events** - AWS services will continuously monitor your resources and initiate events when certain metrics or conditions are met.
- **Implement Loose Coupling**
  - **Well-Defined Interfaces** - reduce interdependencies in a system by allowing various components to interact with each other only through specific, technology agnostic interfaces, such as RESTful APIs.

    - **Service Discovery** - applications that are deployed as microservices should be discoverable and usable without prior knowledge of their network topology details. Apart from hiding complexity, this also allows infrastructure details to change at any time.
    - **Asynchronous Integration** - interacting components that do not need an immediate response and where an acknowledgement that a request has been registered will suffice, should integrate through an intermediate durable storage layer.
    - **Distributed Systems Best Practices** - build applications that handle component failure in a graceful manner.
- **Services, Not Servers**
    - **Managed Services** - provide building blocks that developers can consume to power their applications, such as databases, machine learning, analytics, queuing, search, email, notifications, and more.
    - **Serverless Architectures** - allow you to build both event-driven and synchronous services without managing server infrastructure, which can reduce the operational complexity of running applications.
- **Appropriate Use of Databases**
    - Choose the right database technology for each type of workload.
    - **Relational Databases** provide a powerful query language, flexible indexing capabilities, strong integrity controls, and the ability to combine data from multiple tables in a fast and efficient manner.
    - **NoSQL Databases** trade some of the query and transaction capabilities of relational databases for a more flexible data model that seamlessly scales horizontally. It uses a variety of data models, including graphs, key-value pairs, and JSON documents, and are widely recognized for ease of development, scalable performance, high availability, and resilience.
    - **Data Warehouses** are a specialized type of relational database, which is optimized for analysis and reporting of large amounts of data.
    - **Graph Databases** uses graph structures for queries.
        - Search Functionalities
            - Search is often confused with query. A query is a formal database query, which is addressed in formal terms to a specific data set. Search enables datasets to be queried that are not precisely structured.
            - A search service can be used to index and search both structured and free text format and can support functionality that is not available in other databases, such as customizable result ranking, faceting for filtering, synonyms, and stemming.
- **Managing Increasing Volumes of Data**
    - **Data Lake** - an architectural approach that allows you to store massive amounts of data in a central location so that it's readily available to be categorized, processed, analyzed, and consumed by diverse groups within your organization.
- **Removing Single Points of Failure**
    - **Introducing Redundancy**

        - **Standby redundancy** - when a resource fails, functionality is recovered on a secondary resource with the failover process. The failover typically requires some time before it completes, and during this period the resource remains unavailable. This is often used for stateful components such as relational databases.
        - **Active redundancy** - requests are distributed to multiple redundant compute resources. When one of them fails, the rest can simply absorb a larger share of the workload.
    - **Detect Failure** - use health checks and collect logs all the time.
    - **Durable Data Storage**
        - **Synchronous replication** - only acknowledges a transaction after it has been durably stored in both the primary storage and its replicas. It is ideal for protecting the integrity of data from the event of a failure of the primary node.
        - **Asynchronous replication** - decouples the primary node from its replicas at the expense of introducing replication lag. This means that changes on the primary node are not immediately reflected on its replicas.
        - **Quorum-based replication** - combines synchronous and asynchronous replication by defining a minimum number of nodes that must participate in a successful write operation.
    - **Automated Multi-Data Center Resilience** - utilize AWS Regions and Availability Zones (Multi-AZ Principle).
    - **Fault Isolation and Traditional Horizontal Scaling** - apply *Shuffle Sharding*.
- **Optimize for Cost**
    - **Right Sizing** - AWS offers a broad range of resource types and configurations for many use cases.
    - **Elasticity** - save money with AWS by taking advantage of the platform's elasticity.
    - **Take Advantage of the Variety of Purchasing Options** - Reserved Instances vs Spot Instances vs Other Savings Plan options
- **Caching**
    - **Application Data Caching** - store and retrieve information from fast, managed, in-memory caches.
    - **Edge Caching** - serve content by infrastructure that is closer to viewers, which lowers latency and gives high, sustained data transfer rates necessary to deliver large popular objects to end users at scale.
- **Security**
    - **Use AWS Features for Defense in Depth** - secure multiple levels of your infrastructure from network down to application and database.
    - **Share Security Responsibility with AWS** - AWS handles security OF the Cloud while customers handle security IN the Cloud.
    - **Reduce Privileged Access** - implement Principle of Least Privilege controls.
    - **Security as Code** - firewall rules, network access controls, internal/external subnets, and operating system hardening can all be captured in a template that defines a *Golden Environment*.

- **Real-Time Auditing** - implement continuous monitoring and automation of controls on AWS to minimize exposure to security risks.



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Disaster Recovery in AWS

- **RTO or Recovery Time Objective** is the time it takes after a disruption to restore a business process to its service level.
- **RPO or Recovery Point Objective** is the acceptable amount of data loss measured in time.
- Disaster Recovery Methods
    - **Backup and Restore** - as the name implies, you take frequent backups of your most critical systems and data and store them in a secure, durable, and highly available location. Once disaster strikes, you simply restore these backups to recover data quickly and reliably. Backup and restore is usually considered the cheapest option, but also takes the longest RTO. Your RPO will depend on how frequent you take your backups.
    - **Pilot Light** - quicker recovery time than backup and restore because core pieces of the system are already running and are continually kept up to date. Examples are your secondary production databases that are configured with data mirroring or data replication to the primary. Data loss is very minimal in this scenario for the critical parts, but for the others, you have the same RTO and RPO as backup and restore.
    - **Warm Standby** - a scaled-down version of a fully functional environment that is always running. For example, you have a subset of undersized servers and databases that have the same exact configuration as your primary, and are constantly updated also. Once disaster strikes, you only have to make minimal reconfigurations to re-establish the environment back to its primary state. Warm standby is costlier than Pilot Light, but you have better RTO and RPO.
    - **Multi-Site** - run exact replicas of your infrastructure in an active-active configuration. In this scenario, all you should do in case of a disaster is to reroute traffic onto another environment. Multi-site is the most expensive option of all since you are essentially multiplying your expenses with the number of environment replicas. It does give you the best RTO and RPO however.
- A very valuable benefit of the cloud is that it enables you to set up the type of disaster recovery solution that you want, without having to worry about hardware procurement or data center facilities. AWS has a large number of regions, and an even larger set of availability zones for you to choose from. By strategically planning how you construct your disaster recovery operations, you can achieve your target RTOs and RPOs without paying too much.
- AWS also promotes their disaster recovery tool called **CloudEndure** which they are suggesting to their customers as the preferred solution for disaster recovery workloads. Although you can adopt this tool if you wish to, it is still important for you to learn about the different DR solutions available.

Sources:
https://d1.awsstatic.com/whitepapers/aws-disaster-recovery.pdf
https://aws.amazon.com/cloudendure-disaster-recovery/

Deep Dive on AWS Services

The Solutions Architect Associate exam will test your knowledge on choosing the right service for the right situation. There are many cases wherein two services may seem applicable to a situation, but one of them fulfills the requirement better or the other options have incorrect statements. In this deep dive section, we'll be going through different scenarios that you might encounter in the SAA exam. These scenarios can be related to the behavior of a service feature, integration of different services, or how you should use a certain service. We will go as detailed as we can in this section so that you will not only know the service, but also understand what it is capable of. We will also be adding official AWS references and/or diagrams to supplement the scenarios we'll discuss. Without further ado, let's get right into it.

Amazon EC2

Components of an EC2 Instance

You must know the components of an EC2 instance, since this is one of the core AWS services that you'll be encountering the most in the exam.

1) When creating an EC2 instance, you always start off by choosing a **base AMI or Amazon Machine Image**. An AMI contains the OS, settings, and other applications that you will use in your server. AWS has many pre-built AMIs for you to choose from, and there are also custom AMIs created by other users which are sold on the AWS Marketplace for you to use. If you have created your own AMI before, it will also be available for you to select. AMIs cannot be modified after launch.
2) After you have chosen your AMI, you select the **instance type and size** of your EC2 instance. The type and size will determine the physical properties of your instance, such as CPU, RAM, network speed, and more. There are many instance types and sizes to choose from and the selection will depend on your workload for the instance. You can freely modify your instance type even after you've launched your instance, which is commonly known as "right sizing".
3) Once you have chosen your AMI and your hardware, you can now configure your instance settings.
    a) If you are working on the console, the first thing you'll indicate is the **number of instances** you'd like to launch with these specifications you made.
    b) You specify whether you'd like to launch **spot instances** or use another instance billing type (on-demand or reserved).
    c) You configure which **VPC and subnet** the instance should be launched in, and whether it should receive a **public IP address** or not.
    d) You choose whether to include the instance in a **placement group** or not.
    e) You indicate if the instance will be joined to one of your **domains/directories**.
    f) Next is the **IAM role** that you'd like to provide to your EC2 instance. The IAM role will provide the instance with permissions to interact with other AWS resources indicated in its permission policy.

g) **Shutdown behavior** lets you specify if the instance should only be stopped or should be terminated once the instance goes into a stopped state. If the instance supports **hibernation**, you can also enable the hibernation feature.
h) You can enable the **termination protection** feature to protect your instance from accidental termination.
i) If you have **EFS file systems** that you'd like to immediately mount to your EC2 instance, you can specify them during launch.
j) Lastly, you can specify if you have commands you'd like your EC2 instance to execute once it has launched. These commands are written in the **user data** section and submitted to the system.

4) After you have configured your instance settings, you now need to add **storage** to your EC2 instance. A volume is automatically created for you since this volume will contain the OS and other applications of your AMI. You can add more storage as needed and specify the type and size of EBS storage you'd like to allocate. Other settings include specifying which EBS volumes are to be included for termination when the EC2 instance is terminated, and encryption.
5) When you have allocated the necessary storage for your instances, next is adding **tags** for easier identification and classification.
6) After adding in the tags, you now create or add **security groups** to your EC2 instance, which will serve as firewalls to your servers. Security groups will moderate the inbound and outbound traffic permissions of your EC2 instance. You can also add, remove, and modify your security group settings later on.
7) Lastly, the access to the EC2 instance will need to be secured using one of your **key pairs**. Make sure that you have a copy of this key pair so that you'll be able to connect to your instance when it is launched. There is no way to reassociate another key pair once you've launched the instance. You can also proceed without selecting a key pair, but then you would have no way of directly accessing your instance unless you have enabled some other login method in the AMI or via Systems Manager.
8) Once you are happy with your instance, proceed with the launch. Wait for your EC2 instance to finish preparing itself, and you should be able to connect to it if there aren't any issues.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EC2_GetStarted.html
https://tutorialsdojo.com/amazon-elastic-compute-cloud-amazon-ec2/

Types of EC2 Instances

1. **General Purpose** — Provides a balance of compute, memory, and networking resources, and can be used for a variety of diverse workloads. Instances under the T-family have burstable performance capabilities to provide higher CPU performance when CPU is under high load, in exchange for CPU credits. Once the credits run out, your instance will not be able to burst anymore. More credits can be earned at a certain rate per hour depending on the instance size.

2. **Compute Optimized** — Ideal for compute bound applications that benefit from high performance processors. Instances belonging to this family are well suited for batch processing workloads, media transcoding, high performance web servers, high performance computing, scientific modeling, dedicated gaming servers and ad server engines, machine learning inference and other compute intensive applications.
3. **Memory Optimized** — Designed to deliver fast performance for workloads that process large data sets in memory.
4. **Accelerated Computing** — Uses hardware accelerators or co-processors to perform functions such as floating point number calculations, graphics processing, or data pattern matching more efficiently than on CPUs.
5. **Storage Optimized** — Designed for workloads that require high, sequential read and write access to very large data sets on local storage. They are optimized to deliver tens of thousands of low-latency, random I/O operations per second (IOPS) to applications.
6. **Nitro-based** — The Nitro System provides bare metal capabilities that eliminate virtualization overhead and support workloads that require full access to host hardware. When you mount EBS Provisioned IOPS volumes on Nitro-based instances, you can provision from 100 IOPS up to 64,000 IOPS per volume compared to just up to 32,000 on other instances.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/instance-types.html
https://tutorialsdojo.com/amazon-elastic-compute-cloud-amazon-ec2/

Storage with Highest IOPS for EC2 Instance

When talking about storage and IOPS in EC2 instances, the first thing that pops into the minds of people is Amazon EBS Provisioned IOPS. Amazon EBS Provisioned IOPS volumes are the highest performing EBS volumes designed for your critical, I/O intensive applications. These volumes are ideal for both IOPS-intensive and throughput-intensive workloads that require extremely low latency. And since they are EBS volumes, your data will also persist even after shutdowns or reboots. You can create snapshots of these volumes and copy them over to your other instances, and much more.

But what if you require really high IOPS, low latency performance, and the data doesn't necessarily have to persist on the volume? If you have this requirement then the instance store volumes on specific instance types might be more preferable than EBS Provisioned IOPS volumes. EBS volumes are attached to EC2 instances virtually, so there is still some latency in there. Instance store volumes are physically attached to the EC2 instances themselves, so your instances are able to access the data much faster. Instance store volumes can come in HDD, SSD or NVME SSD, depending on the instance type you choose. Available storage space will depend on the instance type as well.

Reference:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/InstanceStorage.html

Instance Purchasing Options

AWS offers multiple options for you to purchase compute capacity that will best suit your needs. Aside from pricing on different instance types and instance sizes, you can also specify how you'd like to pay for the compute capacity. With EC2 instances, you have the following purchase options:

1) **On-Demand Instances** – You pay by the hour or the second depending on which instances you run for each running instance. If your instances are in a stopped state, then you do not incur instance charges. No long term commitments.
2) **Savings Plans** – Receive discounts on your EC2 costs by committing to a consistent amount of usage, in USD per hour, for a term of 1 or 3 years. You can achieve higher discount rates by paying a portion of the total bill upfront, or paying full upfront. There are two types of Savings Plans available:
    a) **Compute Savings Plans** provide the most flexibility since it automatically applies your discount regardless of instance family, size, AZ, region, OS or tenancy, and also applies to Fargate and Lambda usage.
    b) **EC2 Instance Savings Plans** provide the lowest prices but you are committed to usage of individual instance families in a region only. The plan reduces your cost on the selected instance family in that region regardless of AZ, size, OS, or tenancy. You can freely modify your instance sizes within the instance family in that region without losing your discount.
3) **Reserved Instances (RI)** – Similar to Saving Plans but less flexible since you are making a commitment to a consistent instance configuration, including instance type and Region, for a term of 1 or 3 years. You can also pay partial upfront or full upfront for higher discount rates. A Reserved Instance has four instance attributes that determine its price:
    a) Instance type
    b) Region
    c) Tenancy - shared (default) or single-tenant (dedicated) hardware.
    d) Platform or OS

    Reserved Instances are automatically applied to running On-Demand Instances provided that the specifications match. A benefit of Reserved Instances is that you can sell unused Standard Reserved Instances in the AWS Marketplace. There are also different types of RIs for you to choose from:
    a) Standard RIs - Provide the most significant discount rates and are best suited for steady-state usage.
    b) Convertible RIs - Provide a discount and the capability to change the attributes of the RI as long as the resulting RI is of equal or greater value.
    c) Scheduled RIs - These are available to launch within the time windows you reserve. This option allows you to match your capacity reservation to a predictable recurring schedule that only requires a fraction of a day, a week, or a month.

	Standard RI	**Convertible RI**
Applies to usage across all Availability Zones in an AWS region	Yes	Yes

Can be shared between multiple accounts within a consolidated billing family.	Yes	Yes
Change Availability Zone, instance size (for Linux OS), networking type	Yes	Yes
Change instance families, operating system, tenancy, and payment option	No	Yes
Benefit from Price Reductions	No	Yes
Can be bought/sold in Marketplace	Yes	No

4) **Spot Instances** – Unused EC2 instances that are available for a cheap price, which can reduce your costs significantly. The hourly price for a Spot Instance is called a Spot price. The Spot price of each instance type in each Availability Zone is set by Amazon EC2, and is adjusted gradually based on the long-term supply of and demand for Spot Instances. Your Spot Instance runs whenever capacity is available and the maximum price per hour that you've placed for your request exceeds the Spot price. When the Spot price goes higher than your specified price, your Spot Instance will be stopped or terminated after a two minute warning. Use Spot Instances only when your workloads can be interrupted
5) **Dedicated Hosts** – You pay for a physical host that is fully dedicated to running your instances, and bring your existing per-socket, per-core, or per-VM software licenses to reduce costs. Support for multiple instance sizes on the same Dedicated Host is available for the following instance families: c5, m5, r5, c5n, r5n, and m5n. Dedicated Hosts also offers options for upfront payment for higher discounts.
6) **Dedicated Instances** – Pay by the hour for instances that run on single-tenant hardware. Dedicated Instances that belong to different AWS accounts are physically isolated at a hardware level. Only your compute nodes run in single-tenant hardware; EBS volumes do not.

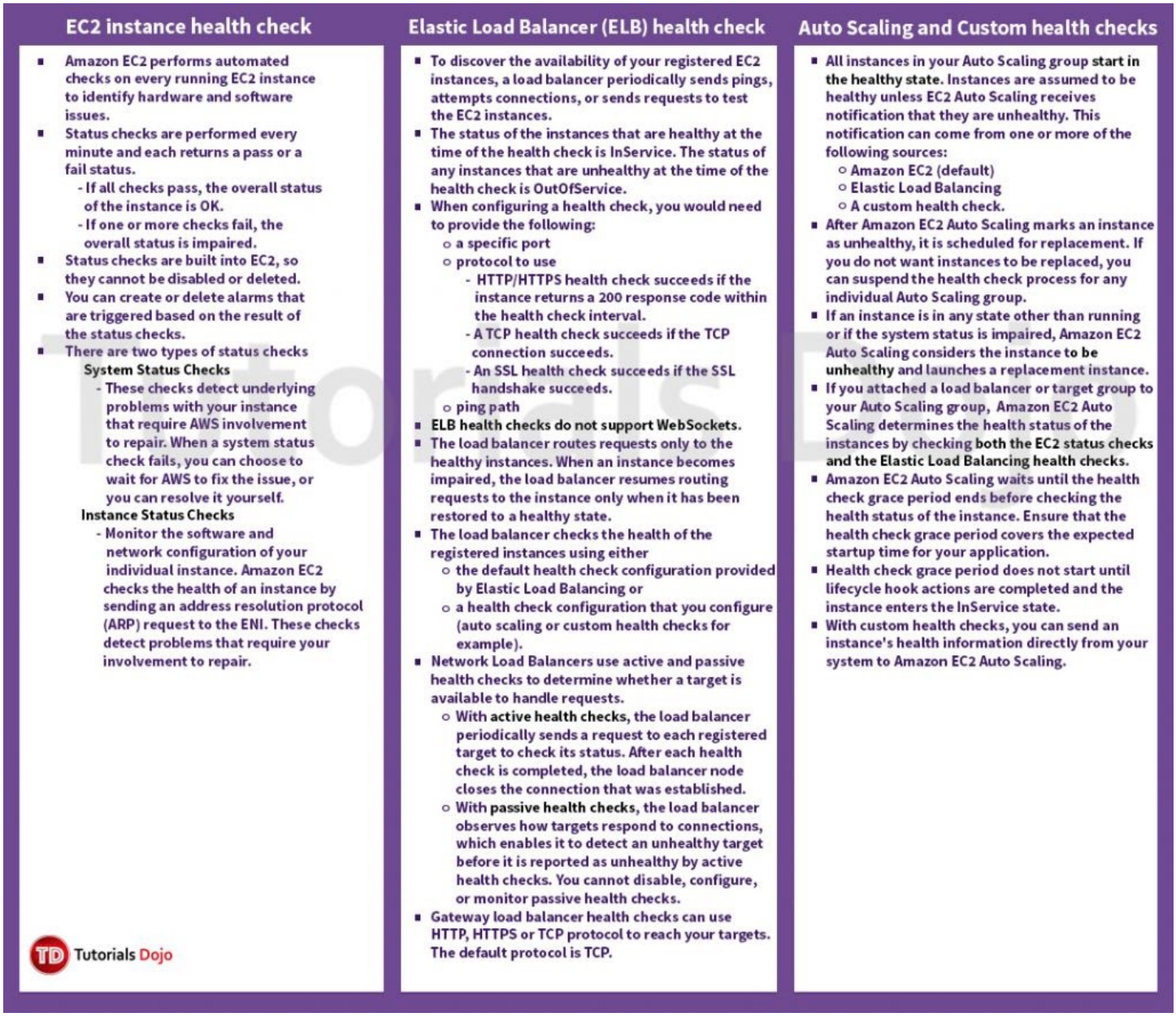
	Dedicated Hosts	**Dedicated Instances**
Billing	Per-host billing	Per-instance billing
Visibility of sockets, cores, and host ID	Provides visibility on the number of sockets and physical cores	No visibility
Host and instance affinity	Allows you to consistently deploy your instances to the same physical server over time	Not supported
Targeted instance placement	Provides additional visibility and control over how instances are placed	Not supported

	on a physical server	
Automatic instance recovery	Supported	Supported
Bring Your Own License (BYOL)	Supported	Not supported
Instances must run within a VPC	Yes	Yes
Can be combined with other billing options	On-demand Dedicated Hosts, Reserved Dedicated Hosts, Savings Plans	On-demand Instances, Reserved Dedicated Instances, Dedicated Spot Instances

7) **Capacity Reservations** – Allows you to reserve capacity for your EC2 instances in a specific Availability Zone for any duration. No commitment required.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/instance-purchasing-options.html
https://aws.amazon.com/ec2/pricing/
https://tutorialsdojo.com/amazon-elastic-compute-cloud-amazon-ec2/

Comparison of Different Types of EC2 Health Checks



EC2 instance health check

- Amazon EC2 performs automated checks on every running EC2 instance to identify hardware and software issues.
- Status checks are performed every minute and each returns a pass or a fail status.
  - If all checks pass, the overall status of the instance is OK.
  - If one or more checks fail, the overall status is impaired.
- Status checks are built into EC2, so they cannot be disabled or deleted.
- You can create or delete alarms that are triggered based on the result of the status checks.
- There are two types of status checks
  - **System Status Checks**
    - These checks detect underlying problems with your instance that require AWS involvement to repair. When a system status check fails, you can choose to wait for AWS to fix the issue, or you can resolve it yourself.
  - **Instance Status Checks**
    - Monitor the software and network configuration of your individual instance. Amazon EC2 checks the health of an instance by sending an address resolution protocol (ARP) request to the ENI. These checks detect problems that require your involvement to repair.

Tutorials Dojo

Elastic Load Balancer (ELB) health check

- To discover the availability of your registered EC2 instances, a load balancer periodically sends pings, attempts connections, or sends requests to test the EC2 instances.
- The status of the instances that are healthy at the time of the health check is InService. The status of any instances that are unhealthy at the time of the health check is OutOfService.
- When configuring a health check, you would need to provide the following:
  - a specific port
  - protocol to use
    - HTTP/HTTPS health check succeeds if the instance returns a 200 response code within the health check interval.
    - A TCP health check succeeds if the TCP connection succeeds.
    - An SSL health check succeeds if the SSL handshake succeeds.
  - ping path
- ELB health checks do not support WebSockets.
- The load balancer routes requests only to the healthy instances. When an instance becomes impaired, the load balancer resumes routing requests to the instance only when it has been restored to a healthy state.
- The load balancer checks the health of the registered instances using either
  - the default health check configuration provided by Elastic Load Balancing or
  - a health check configuration that you configure (auto scaling or custom health checks for example).
- Network Load Balancers use active and passive health checks to determine whether a target is available to handle requests.
  - With **active health checks**, the load balancer periodically sends a request to each registered target to check its status. After each health check is completed, the load balancer node closes the connection that was established.
  - With **passive health checks**, the load balancer observes how targets respond to connections, which enables it to detect an unhealthy target before it is reported as unhealthy by active health checks. You cannot disable, configure, or monitor passive health checks.
- Gateway load balancer health checks can use HTTP, HTTPS or TCP protocol to reach your targets. The default protocol is TCP.

Auto Scaling and Custom health checks

- All instances in your Auto Scaling group start in the healthy state. Instances are assumed to be healthy unless EC2 Auto Scaling receives notification that they are unhealthy. This notification can come from one or more of the following sources:
  - Amazon EC2 (default)
  - Elastic Load Balancing
  - A custom health check.
- After Amazon EC2 Auto Scaling marks an instance as unhealthy, it is scheduled for replacement. If you do not want instances to be replaced, you can suspend the health check process for any individual Auto Scaling group.
- If an instance is in any state other than running or if the system status is impaired, Amazon EC2 Auto Scaling considers the instance to be unhealthy and launches a replacement instance.
- If you attached a load balancer or target group to your Auto Scaling group, Amazon EC2 Auto Scaling determines the health status of the instances by checking both the EC2 status checks and the Elastic Load Balancing health checks.
- Amazon EC2 Auto Scaling waits until the health check grace period ends before checking the health status of the instance. Ensure that the health check grace period covers the expected startup time for your application.
- Health check grace period does not start until lifecycle hook actions are completed and the instance enters the InService state.
- With custom health checks, you can send an instance's health information directly from your system to Amazon EC2 Auto Scaling.

Reference:
https://tutorialsdojo.com/ec2-instance-health-check-vs-elb-health-check-vs-auto-scaling-and-custom-health-check/

EC2 Placement Groups

Launching EC2 instances in a placement group influences how they are placed in underlying AWS hardware. Depending on your type of workload, you can create a placement group using one of the following placement strategies:

- **Cluster** – your instances are placed close together inside an Availability Zone. A cluster placement group can span peered VPCs that belong in the same AWS Region. This strategy enables workloads to achieve low-latency, high network throughput network performance.
- **Partition** – spreads your instances across logical partitions, called partitions, such that groups of instances in one partition do not share the underlying hardware with groups of instances in different partitions. A partition placement group can have partitions in multiple Availability Zones in the same Region, with a maximum of seven partitions per AZ. This strategy reduces the likelihood of correlated hardware failures for your application.
- **Spread** – strictly places each of your instances across distinct underlying hardware racks to reduce correlated failures. Each rack has its own network and power source. A spread placement group can have partitions in multiple Availability Zones in the same Region, with a maximum of seven running EC2 instances per AZ per group.

If you try to add more instances to your placement group after you create it, or if you try to launch more than one instance type in the placement group, you might get an insufficient capacity error. If you stop an instance in a placement group and then start it again, it still runs in the placement group. However, the start fails if there isn't enough capacity for the instance. To remedy the capacity issue, simply retry the launch until you succeed.

Some limitations you need to remember:

- You can't merge placement groups.
- An instance cannot span multiple placement groups.
- You cannot launch Dedicated Hosts in placement groups.
- A cluster placement group can't span multiple Availability Zones.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/placement-groups.html
https://tutorialsdojo.com/amazon-elastic-compute-cloud-amazon-ec2/

Security Groups And Network Access Control Lists

Security groups and network ACLs are your main lines of defense in protecting your VPC network. These services act as firewalls for your VPCs and control inbound and outbound traffic based on the rules you set. Although both of them are used for VPC network security, they serve two different functions and operate in a different manner.

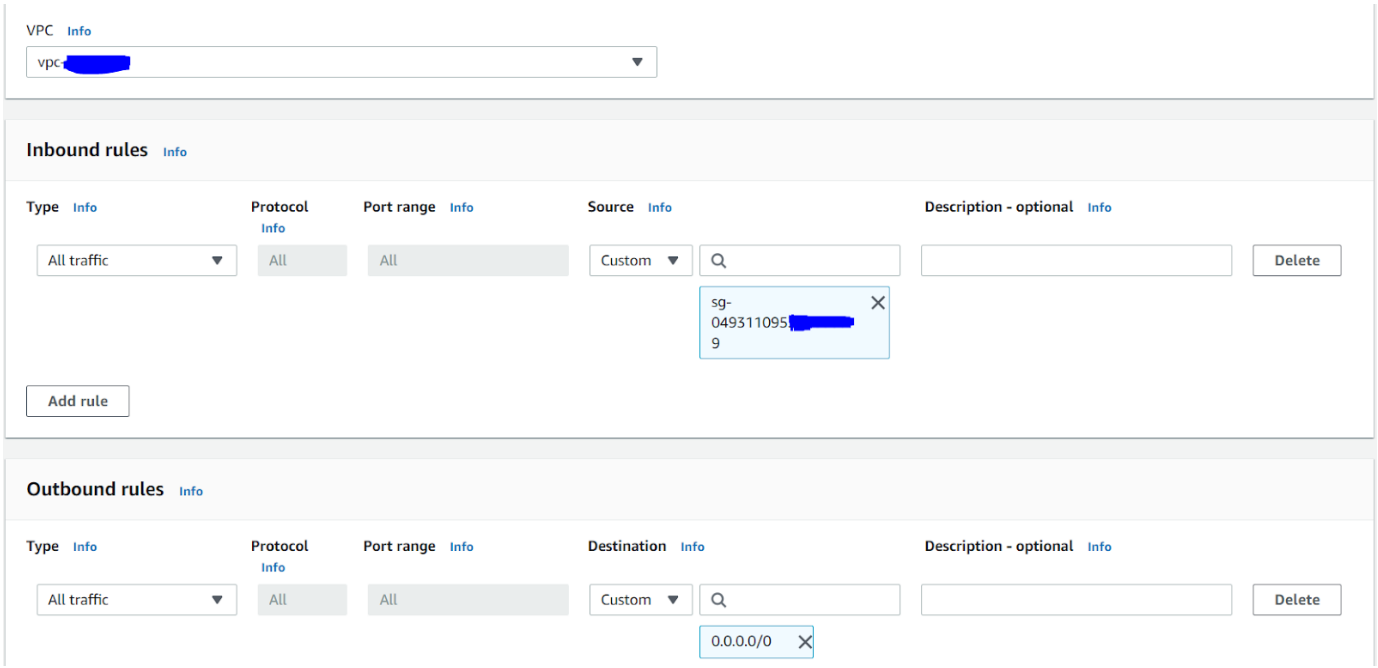
Security groups operate on the instance layer. They serve as virtual firewalls that control inbound and outbound traffic to your VPC resources. Not all AWS services support security groups, but the general idea is that if the service involves servers or EC2 instances then it should also support security groups. Examples of these services are:

1. Amazon EC2
2. AWS Elastic Beanstalk
3. Amazon Elastic Load Balancing
4. Amazon RDS
5. Amazon EFS
6. Amazon EMR
7. Amazon Redshift
8. Amazon Elasticache

To control the flow of traffic to your VPC resources, you define rules in your security group which specify the types of traffic that are allowed. A security group rule is composed of traffic type (SSH, RDP, etc), internet protocol (tcp or udp), port range, origin of the traffic for inbound rules or destination of the traffic for outbound rules, and an optional description for the rule. Origins and destinations can be defined as definite IP addresses, IP address ranges, or a security group ID. If you reference a security group ID in your rule then all resources that are associated with the security group ID are counted in the rule. This saves you the trouble of entering their IP addresses one by one.

You can only create rules that allow traffic to pass through. Traffic parameters that do not match any of your security group rules are automatically denied. By default, newly created security groups do not allow any inbound traffic while allowing all types of outbound traffic to pass through. Security groups are also stateful, meaning if you send a request from your instance, the response traffic for that request is allowed to flow in regardless of inbound rules. Responses to allowed inbound traffic are allowed to flow out, regardless of outbound rules. One thing to remember is, when you are adding rules to allow communication between two VPC instances, you should enter the private IP address of those instances and not their public IP or Elastic IP address.

Security groups are associated with network interfaces, and not the instances themselves. When you change the security groups of an instance, you are changing the security groups associated with its network interface. By default, when you create a network interface, it's associated with the default security group for the VPC, unless you specify a different security group. Network interfaces and security groups are bound to the VPC they are launched in, so you cannot use them for other VPCs. However, security groups belonging to a different VPC can be referenced as the origin and destination of a security group rule of peered VPCs.

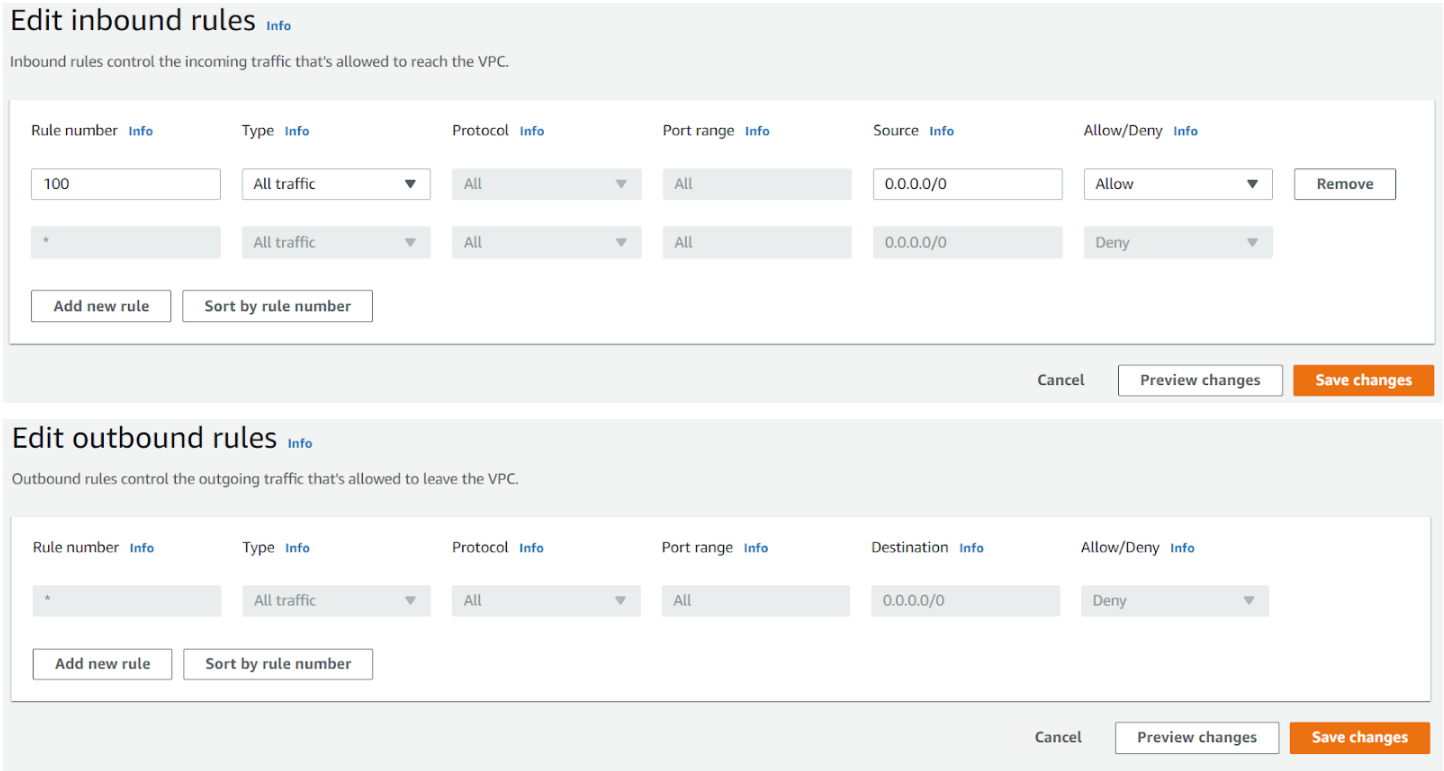


Network ACLs operate on the subnet layer, which means they protect your whole subnet rather than individual instances. Similar to security groups, traffic is managed through the use of rules. A network ACL rule consists of a rule number, traffic type, protocol, port range, source of the traffic for inbound rules or destination of the traffic for outbound rules, and an allow or deny setting.

In network ACL, rules are evaluated starting with the lowest numbered rule. As soon as a rule matches traffic, it's applied regardless of any higher-numbered rule that might contradict it. And unlike security groups, you can create allow rules and deny permissions in NACL for both inbound and outbound rules. Perhaps you want to allow public users to have HTTP access to your subnet, except for a few IP addresses that you found to be malicious. You can create an inbound HTTP allow rule that allows 0.0.0.0/0 and create another inbound HTTP deny rule that blocks these specific IPs. If no rule matches a traffic request or response then it is automatically denied. Network ACLs are also stateless, so sources and destinations need to be allowed on both inbound and outbound for them to freely communicate with the resources in your subnet.

Every VPC comes with a default network ACL, which allows all inbound and outbound traffic. You can create your own custom network ACL and associate it with a subnet. By default, each custom network ACL denies all inbound and outbound traffic until you add rules. Note that every subnet must be associated with a network ACL. If you don't explicitly associate a subnet with a network ACL, the subnet is automatically associated with the default network ACL. A network ACL can be associated with multiple subnets. However, a subnet can be associated with only one network ACL at a time.

One last thing to note is, for subnets that handle public network connections, you might encounter some issues if you do not add an allow rule for your ephemeral ports. The range varies depending on the client's operating system. A NAT gateway uses ports 1024-65535 for example.



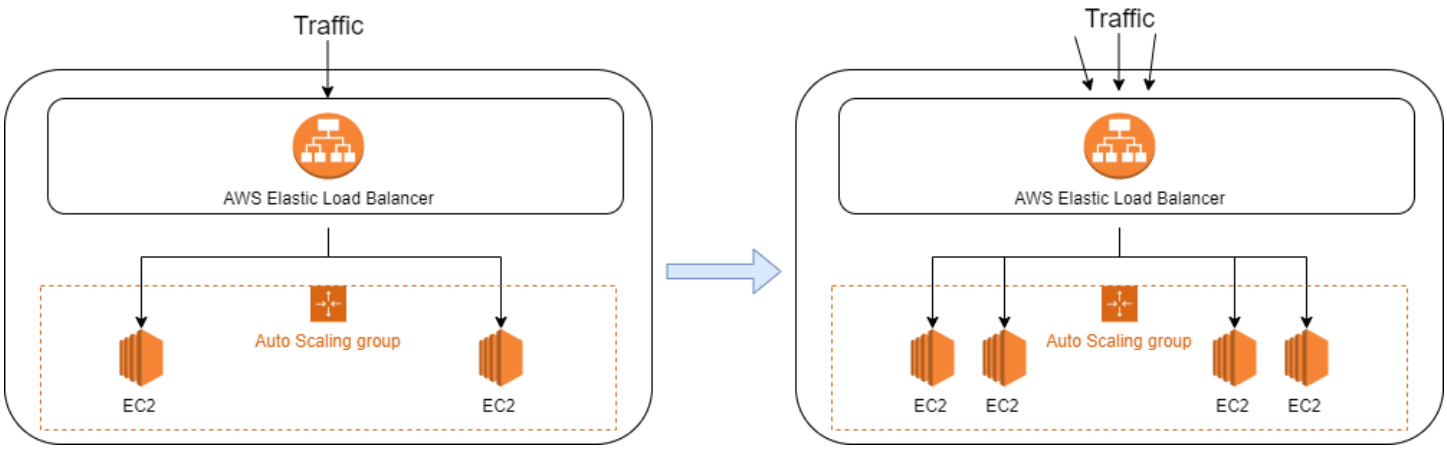
References:
https://docs.aws.amazon.com/vpc/latest/userguide/VPC_SecurityGroups.html
https://docs.aws.amazon.com/vpc/latest/userguide/vpc-network-acls.html
https://tutorialsdojo.com/security-group-vs-nacl/

Amazon EC2 Auto Scaling

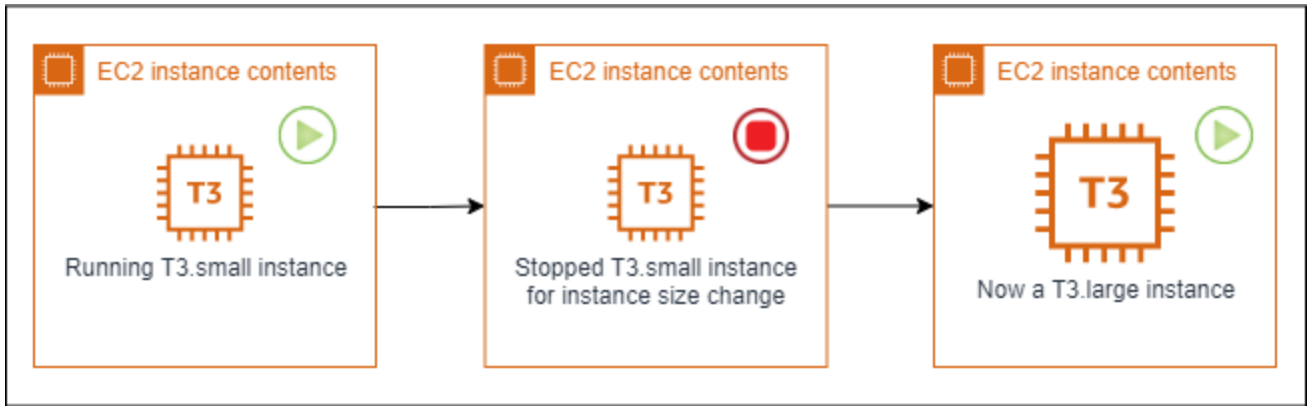
Horizontal Scaling and Vertical Scaling

When you have insufficient capacity for a workload, let's say for example serving a website, there are two ways to scale your resources to accommodate the increasing demand: scale horizontally or scale vertically.

When scaling horizontally, you are adding more servers to the system. More servers mean that workload is distributed to a greater number of workers, which thereby reduces the burden on each server. When you scale horizontally, you need a service such as EC2 auto scaling to manage the number of servers running at a time. You also need an Elastic Load Balancer to intercept and distribute the total incoming requests to your fleet of auto scaling servers. Horizontal scaling is a great way for stateless servers, such as public web servers, to meet varying levels of workloads.



Compared to scaling horizontally, scaling vertically refers to increasing or decreasing the resources of a single server, instead of adding new servers to the system. Vertical scaling is suited for resources that are stateful or have operations difficult to manage in a distributed manner, such as write queries to databases and IOPS sizing in storage volumes. For example, if your EC2 instance is performing slowly, then you can scale up its instance size to obtain more compute and memory capacity. Or when your EBS volumes are not hitting the required IOPS, you can increase their size or IOPS capacity by modifying the EBS volume. Note that for some services such as EC2 and RDS, the instance needs to be stopped before modifying the instance size.



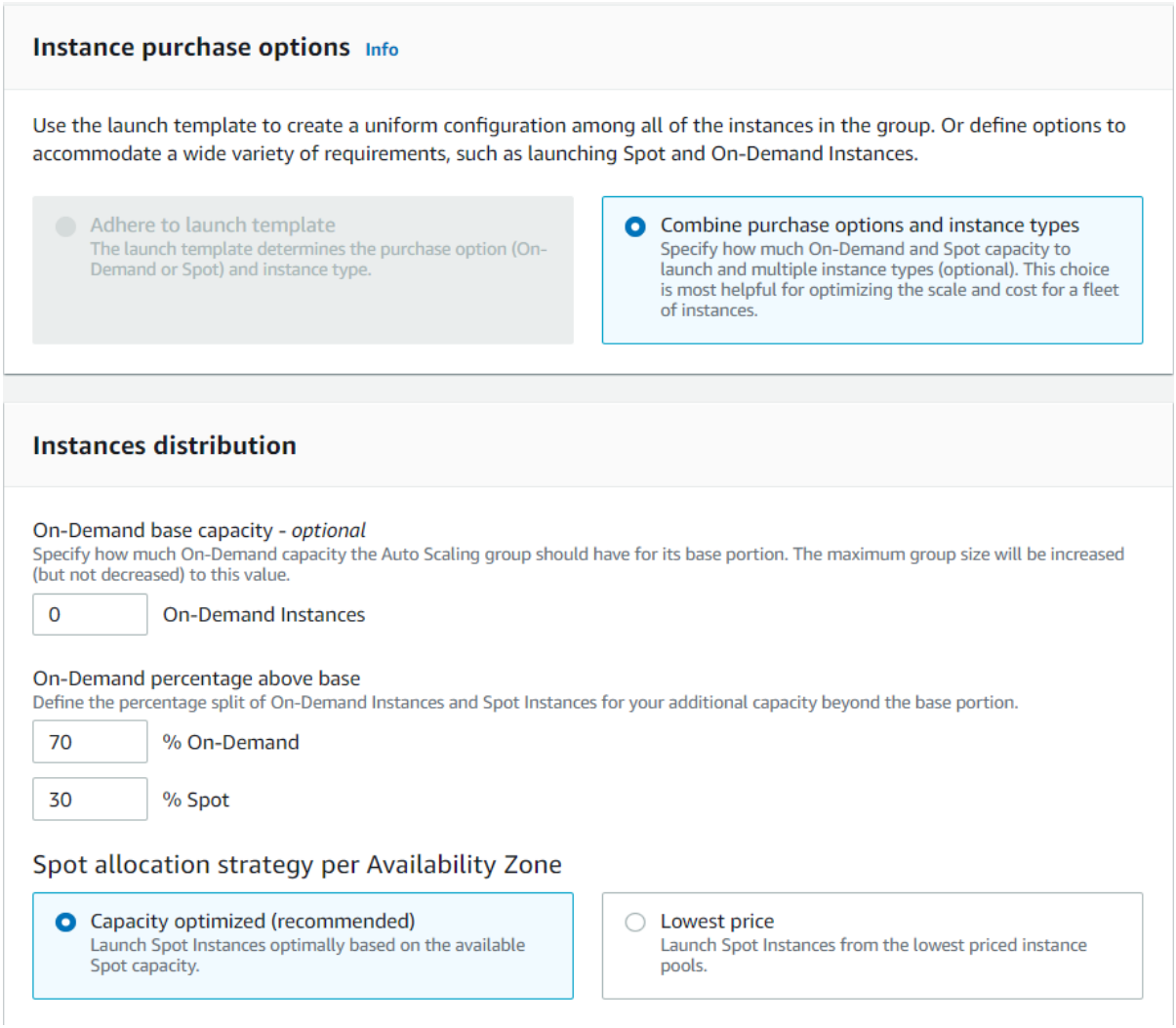
Components of an AWS EC2 Auto Scaling Group

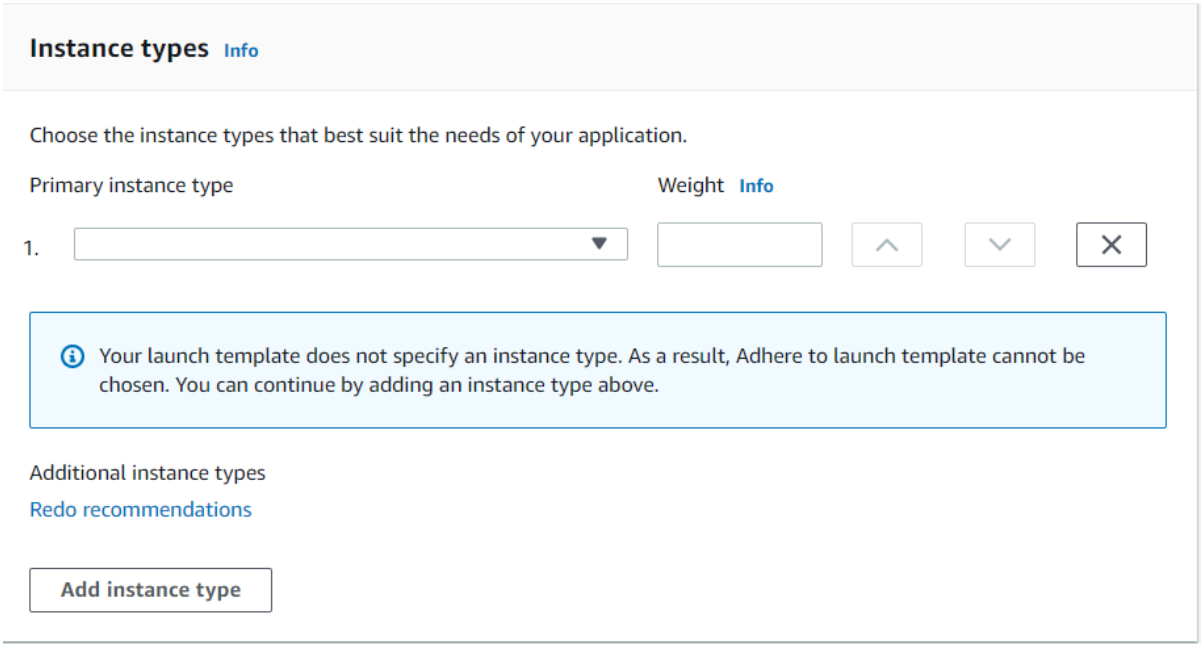
An EC2 Auto Scaling Group has two parts to it: a launch configuration or template that will define your auto scaling instances, and the auto scaling service that performs scaling and monitoring actions.

Creating a launch configuration is similar to launching an EC2 instance. Each launch configuration has a name that uniquely identifies it from your other launch configurations. You provide the AMI that it will use to launch your instances. You also get to choose the instance type and size for your auto scaling instances. You can request spot instances or just use the standard on-demand instances. You can also include an instance profile that will provide your auto scaling instances with permissions to interact with your other services.

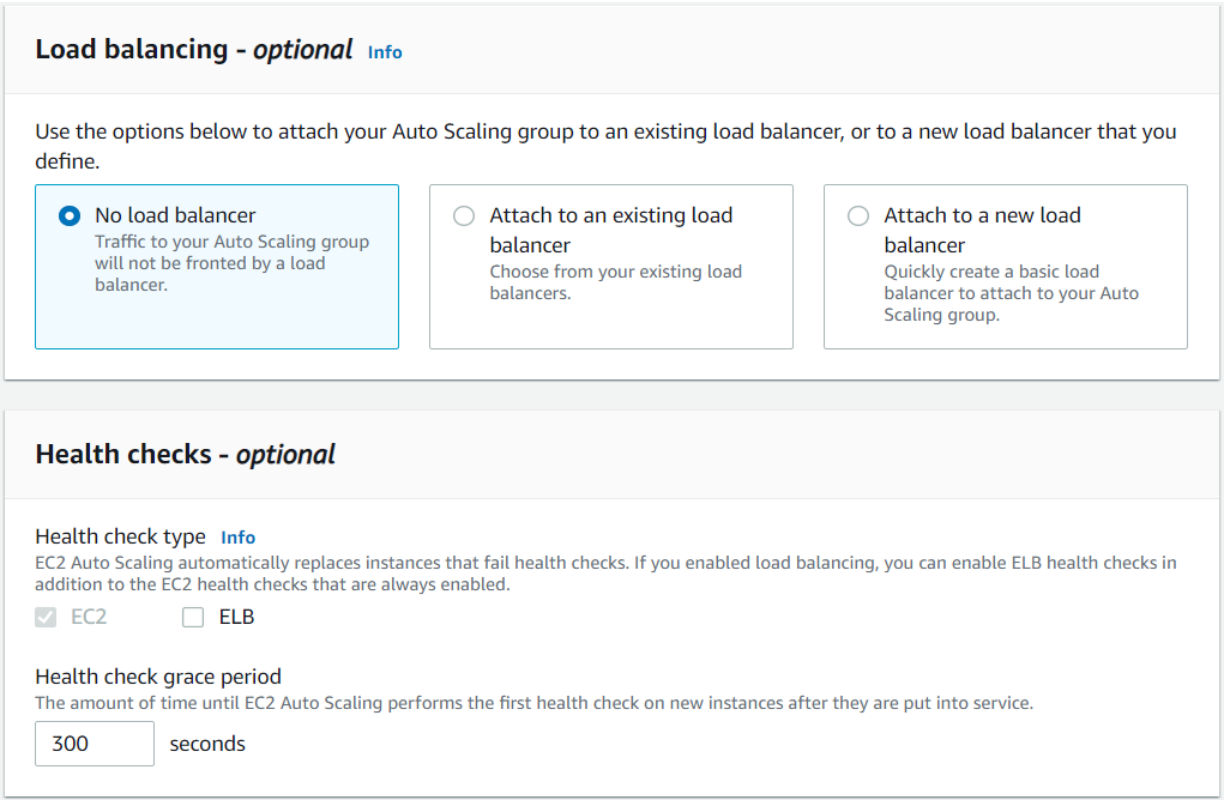
If you need Cloudwatch detailed monitoring, you can enable the option for a cost. Aside from that, you can include user data which will be executed every time an auto scaling instance is launched. You can also choose whether to assign public IP addresses to your instances or not. Lastly, you select which security groups you'd like to apply to your auto scaling instances, and configure EBS storage volumes for each of them. You also specify the key pair to be used to encrypt access.

A launch template is similar to a launch configuration, except that you can have multiple versions of a template. Also, with launch templates, you can create Auto Scaling Groups with multiple instance types and purchase options.


Instance purchase options Info
Use the launch template to create a uniform configuration among all of the instances in the group. Or define options to accommodate a wide variety of requirements, such as launching Spot and On-Demand Instances.
Adhere to launch template
The launch template determines the purchase option (On-Demand or Spot) and instance type.
Combine purchase options and instance types
Specify how much On-Demand and Spot capacity to launch and multiple instance types (optional). This choice is most helpful for optimizing the scale and cost for a fleet of instances.
Instances distribution
On-Demand base capacity - optional
Specify how much On-Demand capacity the Auto Scaling group should have for its base portion. The maximum group size will be increased (but not decreased) to this value.
0
On-Demand Instances
On-Demand percentage above base
Define the percentage split of On-Demand Instances and Spot Instances for your additional capacity beyond the base portion.
70
% On-Demand
30
% Spot
Spot allocation strategy per Availability Zone
Capacity optimized (recommended)
Launch Spot Instances optimally based on the available Spot capacity.
Lowest price
Launch Spot Instances from the lowest priced instance pools.



Once you have created your launch configuration or launch template, you can proceed with creating your auto scaling group. To start off, select the launch configuration/template you'd like to use. Next, you define the VPC and subnets in which the auto scaling group will launch your instances in. You can use multiple Availability Zones and let EC2 Auto Scaling balance your instances across the zones. You can optionally associate a load balancer to the auto scaling group, and the service will handle attaching and detaching instances from the load balancer as it scales. Note that when you do associate a load balancer, you should use the load balancer's health check for instance health monitoring so that when an instance is deemed unhealthy by the load balancer's health check, the load balancer will initiate a scaling event to replace the faulty instance.



Next, you define the size of the auto scaling group — the minimum, desired and the maximum number of instances that your auto scaling group should manage. Specifying a minimum size ensures that the number of running instances do not fall below this count at any time, and the maximum size prevents your auto scaling group from exploding in number. Desired size just tells the auto scaling group to launch this number of instances after you create it. Since the purpose of an auto scaling group *is to auto scale*, you can add cloudwatch monitoring rules that will trigger scaling events once a scaling metric passes a certain threshold. Lastly, you can optionally configure Amazon SNS notifications whenever a scaling event occurs, and add tags to your auto scaling group.

References:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/what-is-amazon-ec2-auto-scaling.html
https://tutorialsdojo.com/aws-auto-scaling/

Types of EC2 Auto Scaling Policies

Amazon's EC2 Auto Scaling provides an effective way to ensure that your infrastructure is able to dynamically respond to changing user demands. For example, to accommodate a sudden traffic increase on your web application, you can set your Auto Scaling group to automatically add more instances. And when traffic is low, have it automatically reduce the number of instances. This is a cost-effective solution since it only provisions

EC2 instances when you need them. EC2 Auto Scaling provides you with several dynamic scaling policies to control the scale-in and scale-out events.

In this article, we'll discuss the differences between a simple scaling policy, a step scaling policy and a target tracking policy. And we'll show you how to create an Auto Scaling group with step scaling policy applied.

Simple Scaling

Simple scaling relies on a metric as a basis for scaling. For example, you can set a CloudWatch alarm to have a CPU Utilization threshold of 80%, and then set the scaling policy to add 20% more capacity to your Auto Scaling group by launching new instances. Accordingly, you can also set a CloudWatch alarm to have a CPU utilization threshold of 30%. When the threshold is met, the Auto Scaling group will remove 20% of its capacity by terminating EC2 instances.

When EC2 Auto Scaling was first introduced, this was the only scaling policy supported. It does not provide any fine-grained control to scaling in and scaling out.

Target Tracking

Target tracking policy lets you specify a scaling metric and metric value that your auto scaling group should maintain at all times. Let's say for example your scaling metric is the average CPU utilization of your EC2 auto scaling instances, and that their average should always be 80%. When CloudWatch detects that the average CPU utilization is beyond 80%, it will trigger your target tracking policy to scale out the auto scaling group to meet this target utilization. Once everything is settled and the average CPU utilization has gone below 80%, another scale in action will kick in and reduce the number of auto scaling instances in your auto scaling group. With target tracking policies, your auto scaling group will always be running in a capacity that is defined by your scaling metric and metric value.

A limitation though – this type of policy assumes that it should scale out your Auto Scaling group when the specified metric is above the target value. You cannot use a target tracking scaling policy to scale out your Auto Scaling group when the specified metric is below the target value. Furthermore, the Auto Scaling group scales out proportionally to the metric as fast as it can, but scales in more gradually. Lastly, you can use AWS predefined metrics for your target tracking policy, or you can use other available CloudWatch metrics (native and custom). Predefined metrics include the following:

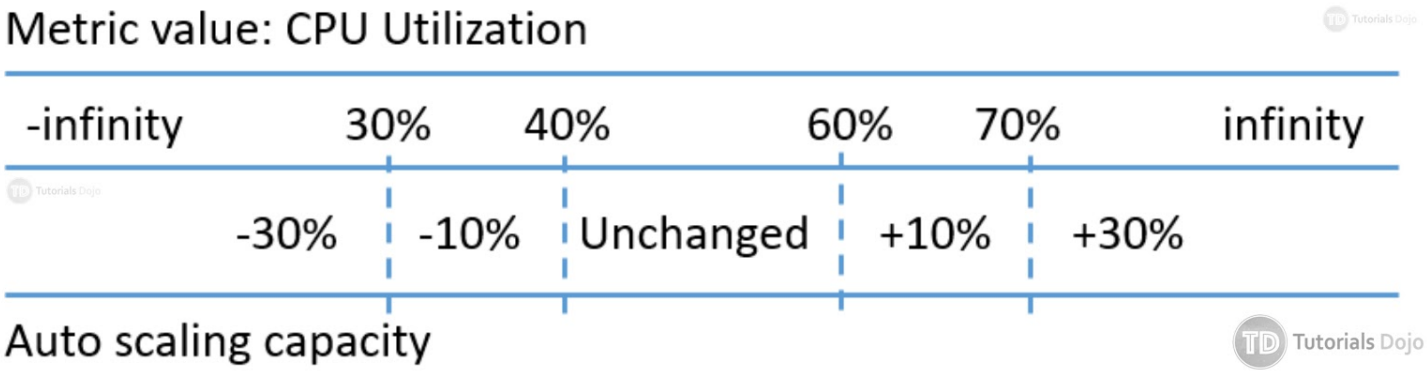
- **ASGAverageCPUUtilization** – Average CPU utilization of the Auto Scaling group.
- **ASGAverageNetworkIn** – Average number of bytes received on all network interfaces by the Auto Scaling group.
- **ASGAverageNetworkOut** – Average number of bytes sent out on all network interfaces by the Auto Scaling group.
- **ALBRequestCountPerTarget** – If the auto scaling group is associated with an ALB target group, this is the number of requests completed per target in the target group.

Step Scaling

Step Scaling further improves the features of simple scaling. Step scaling applies "step adjustments" which means you can set multiple actions to vary the scaling depending on the size of the alarm breach.

When a scaling event happens on simple scaling, the policy must wait for the health checks to complete and the cooldown to expire before responding to an additional alarm. This causes a delay in increasing capacity especially when there is a sudden surge of traffic on your application. With step scaling, the policy can continue to respond to additional alarms even in the middle of the scaling event.

Here is an example that shows how step scaling works:



In this example, the Auto Scaling group maintains its size when the CPU utilization is between 40% and 60%. When the CPU utilization is greater than or equal to 60% but less than 70%, the Auto Scaling group increases its capacity by an additional 10%. When the utilization is greater than 70%, another step in scaling is done and the capacity is increased by an additional 30%. On the other hand, when the overall CPU utilization is less than or equal to 40% but greater than 30%, the Auto Scaling group decreases the capacity by 10%. And if utilization further dips below 30%, the Auto Scaling group removes 30% of the current capacity.

This effectively provides multiple steps in scaling policies that can be used to fine-tune your Auto Scaling group response to dynamically changing workload.

Creating a Step Scaling Policy for an Auto Scaling Group

Based on the step scaling policy described above, the following guide will walk you through the process of applying this policy when creating your Auto Scaling group.

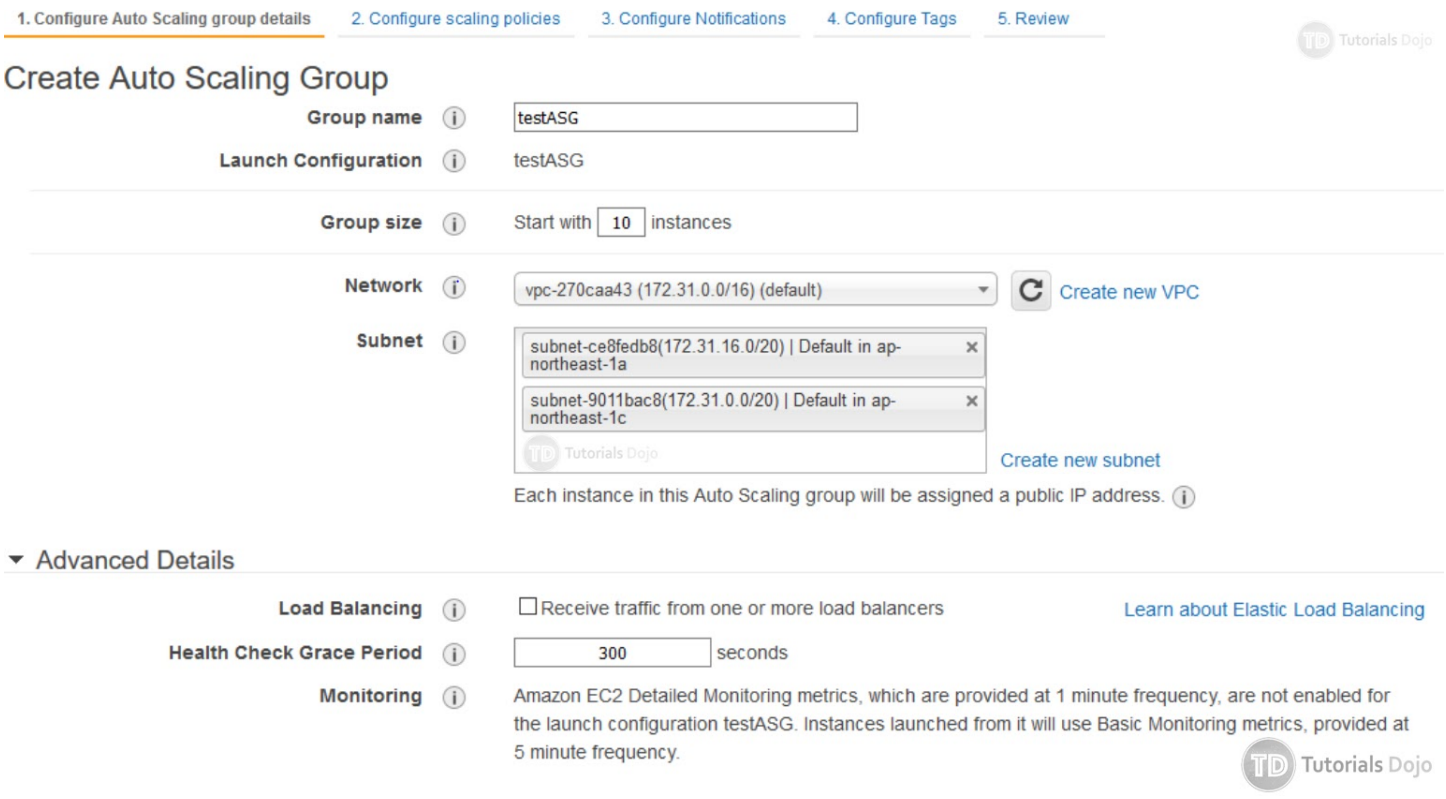
1. First, create your Launch Configuration for your EC2 instances. Check this guide if you haven't created one yet.

2. Go to **EC2** > **Auto Scaling Groups** > **Create Auto Scaling group**

3. Select your **Launch Configuration** and click **Next Step**.

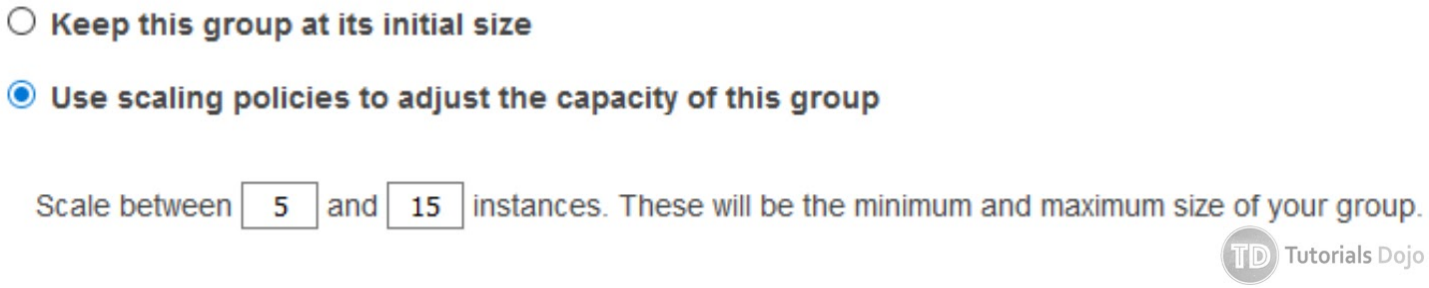
4. Configure details for your Auto Scaling group.

a. **Group name** – descriptive name for this ASG.
b. **Group size** – the initial size of your ASG. Let's set this to 10 for this example.
c. **Network** – the VPC to use for your ASG.
d. **Subnet** – the subnets in the VPC on where to place the EC2 instances. It's recommended to select subnets in multiple availability zones to improve the fault tolerance of your ASG.
e. **Advanced Details** – in this section, you can check the **Load Balancing** option to select which load balancer to use for your ASG. (We won't configure a load balancer for this example). You can also set the **Health Check Grace Period** in this section. This is the length of time that Auto Scaling waits before checking the instance's health status. We'll leave the default to 300 seconds but you can adjust this if you know your EC2 instances need more or less than 5 minutes before they become healthy.

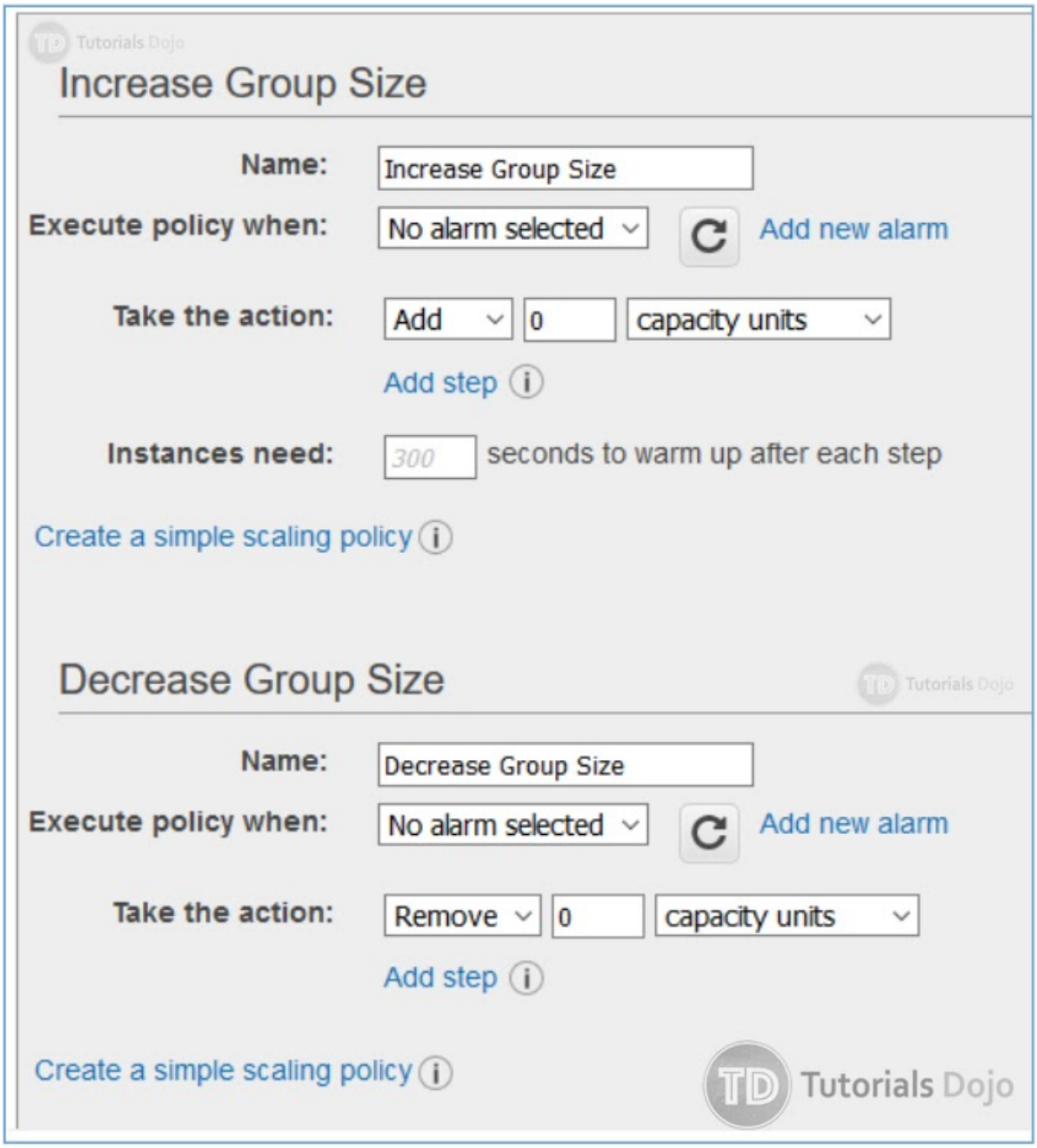


5. Click **Next: Configure scaling policies** to proceed.

6. Here, we'll configure the step scaling policy. Select the "**Use scaling policies to adjust the capacity of this group**" option and this will show an additional section for defining scaling policy. For this example, let's set 5 and 15 as the minimum and maximum size for this Auto Scaling group.

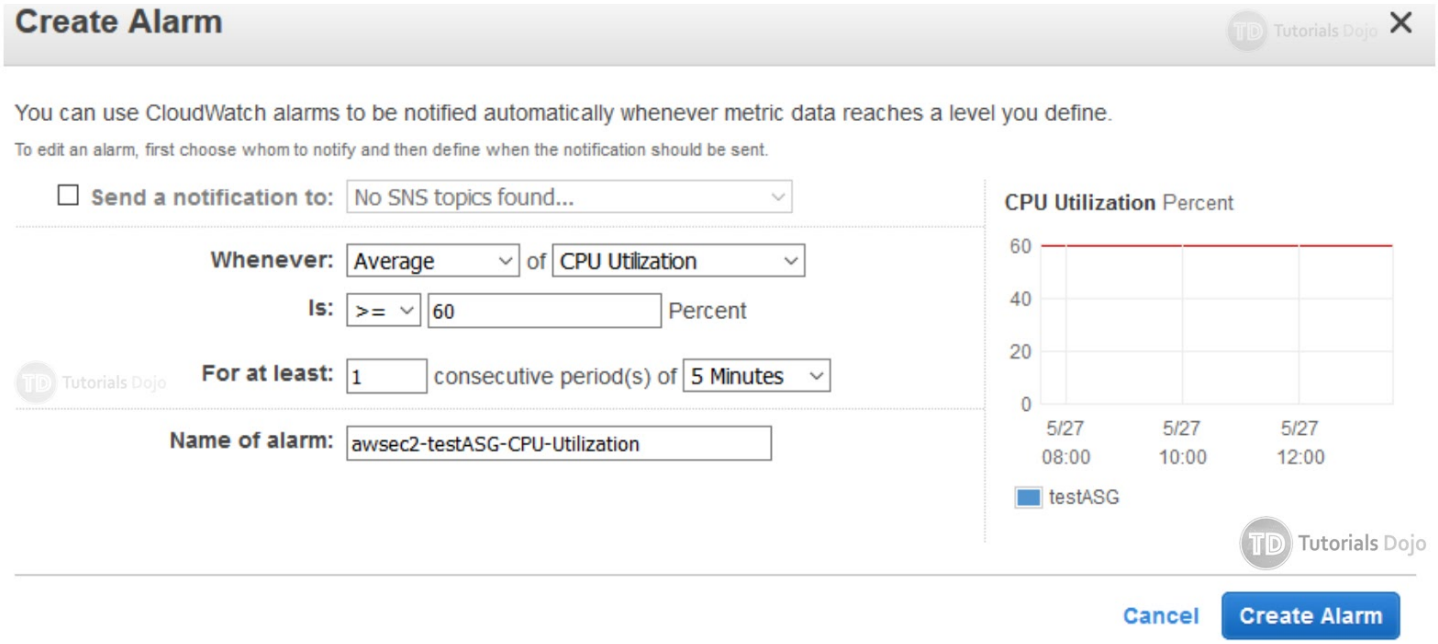


7. In the Scale Group Size section, you will be able to set the scaling policy for the group. But this is only for simple scaling so you have to click the **"Scale the Auto Scaling group using step or simple scaling policies"** link to show more advanced options for step scaling. You should see the **Increase Group Size** and **Decrease Group Size** section after clicking it.

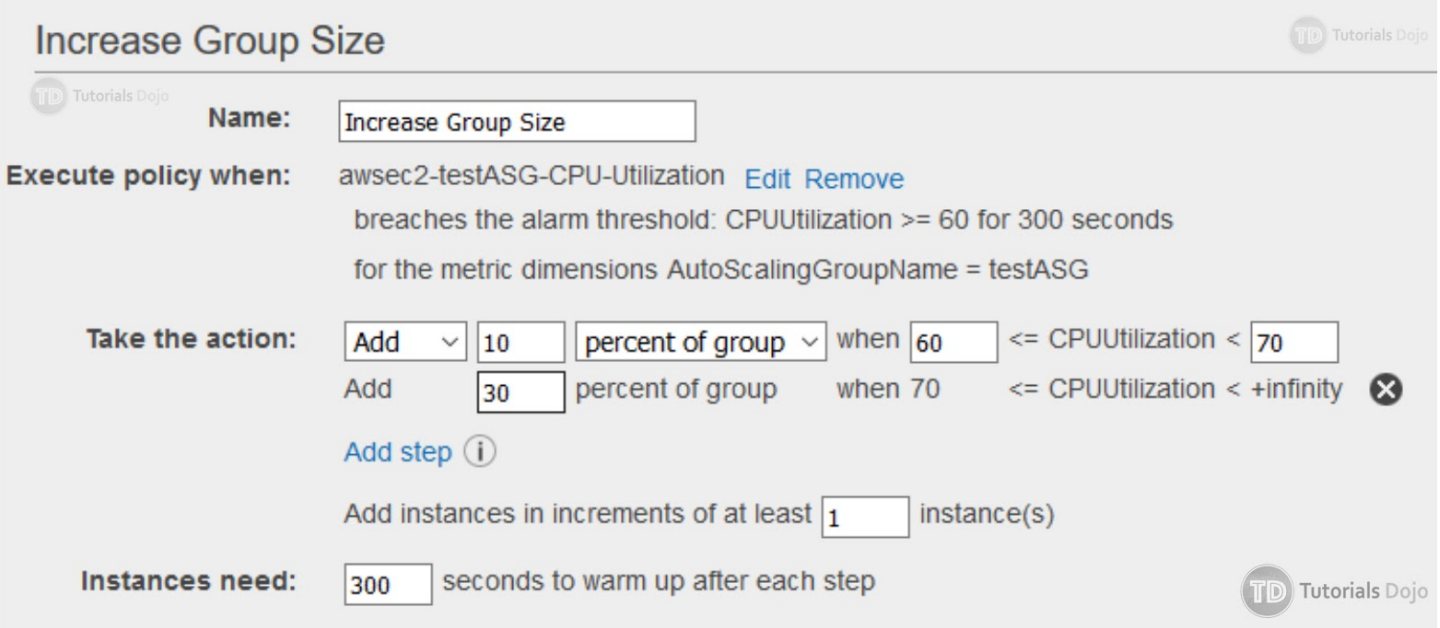


8. Now, we can set the step scaling policy for scaling out.

   a. Set a name for your "**Increase Group Size**" policy. Click "**Add a new alarm**" to add a CloudWatch rule on when to execute the policy.
   b. b. On the **Create Alarm** box, you can set an SNS notification. (We won't add it for this example).
   c. c. Create a rule for whenever the **Average CPU Utilization** is greater than or equal to 60 percent for at least 1 consecutive period of 5 minutes. Set a name for your alarm. Click **Create Alarm**.



d. For the "**Take the action**" setting, we'll **Add 10 percent** of the group when CPU Utilization is greater than or equal to **60 and less than 70 percent**.
e. Click "Add Step" to add another action, we'll **Add 30 percent** of the group when CPU Utilization is **greater than or equal to 70 percent**.



f. Set 1 for "**Add instances in increments of at least**". This will ensure that at least 1 instance is added when the threshold is reached.

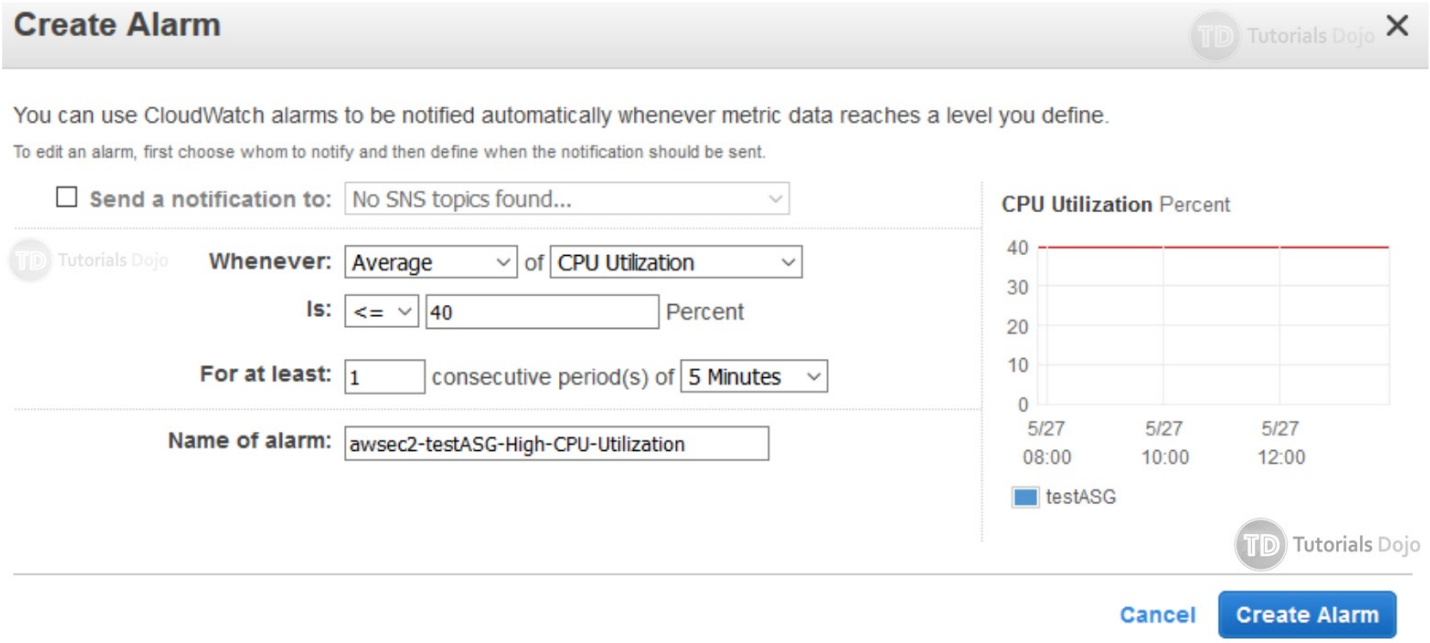
g. Set instances need **300 seconds to warm up** after each step.

Instance warmup – this specifies the timeout before the instance's own metric can be added to the group. Until the warmup time expires, the instance metric (CPU utilization in this case) is not counted toward the aggregated metric of the whole Auto Scaling group.

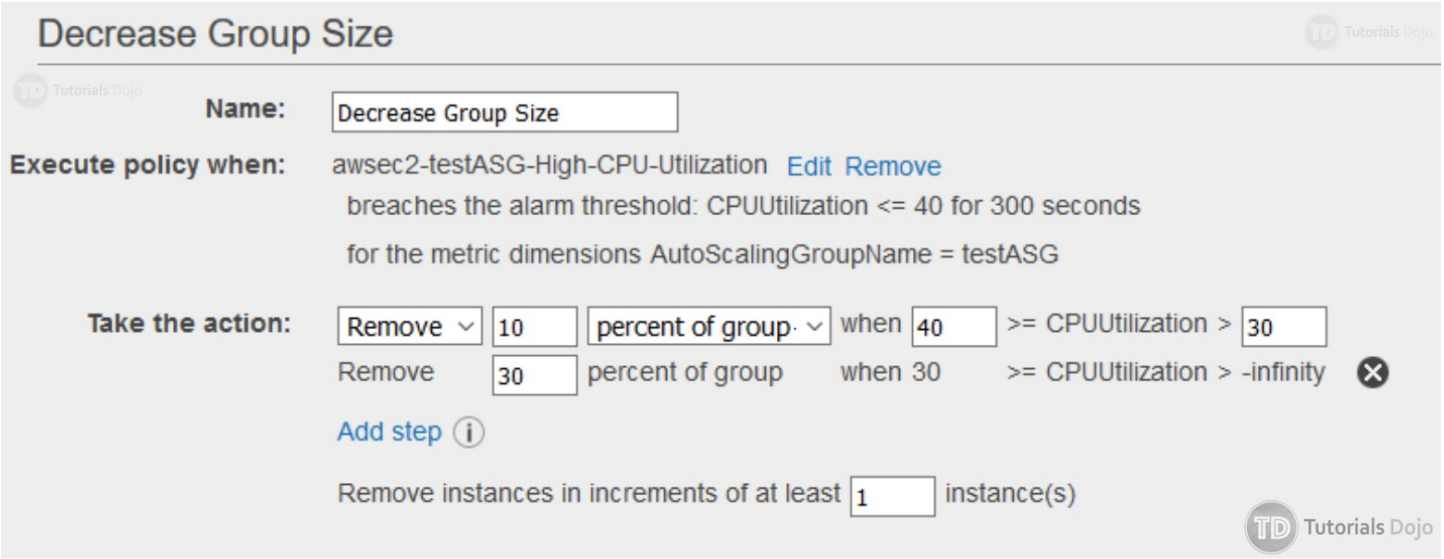
While scaling in, instances that are terminating are considered as part of the current capacity of the group. Therefore, it won't remove more instances from the Auto Scaling group than necessary.

9. Next, we can set the step scaling policy for the scaling in.

a. Set a name for your "**Decrease Group Size**" policy. Click "**Add a new alarm**" to add a CloudWatch rule on when to execute the policy.
b. On the **Create Alarm** box, you can set an SNS notification. (We won't add it for this example).
c. Create a rule for whenever the **Average CPU Utilization** is less than or equal to 40 percent for at least 1 consecutive period of 5 minutes. Set a name for your alarm. Click **Create Alarm**.

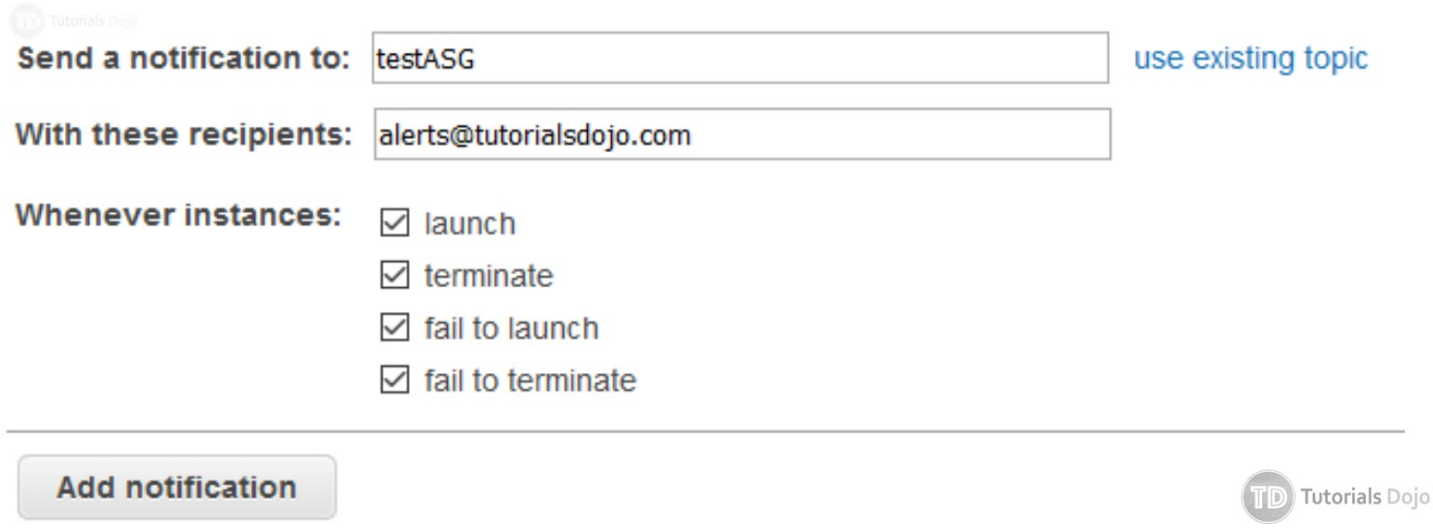


d. For the "**Take the action**" setting, we'll **remove 10 percent** of the group when CPU Utilization is less than or equal to **40 and greater than 30**.
e. Click "Add Step" to add another action, we'll **remove 30 percent** of the group when CPU Utilization is **less than or equal to 30 percent**.



f. Set 1 for "**Remove instances in increments of at least**". This will ensure that at least 1 instance is removed when the threshold is reached.

10. Click **Next: Configure Notifications** to proceed. On this part, you can click "**Add notification**" so that you can receive an email whenever a specific event occurs. Here's an example:



11.Click **Next: Configure Tags**. Create tags for instances in your Auto Scaling group.

12. Click **Review** to get to the review page.

13. After reviewing the details, click **Create Auto Scaling group**.

Your Auto Scaling group with step scaling policies should now be created. Remember, the initial desired size is 10, with a minimum of 5 and a maximum of 15.

The scale-out rule will have a step scaling policy, a 10% increase if CPU utilization is 60 – 70%, and will add 30% more instances if utilization is more than 70%.

The scale-in rule will have a step scaling policy, a 10% decrease if CPU utilization is 30 – 40%, and will remove 30% more instances if the utilization is less than 30%.

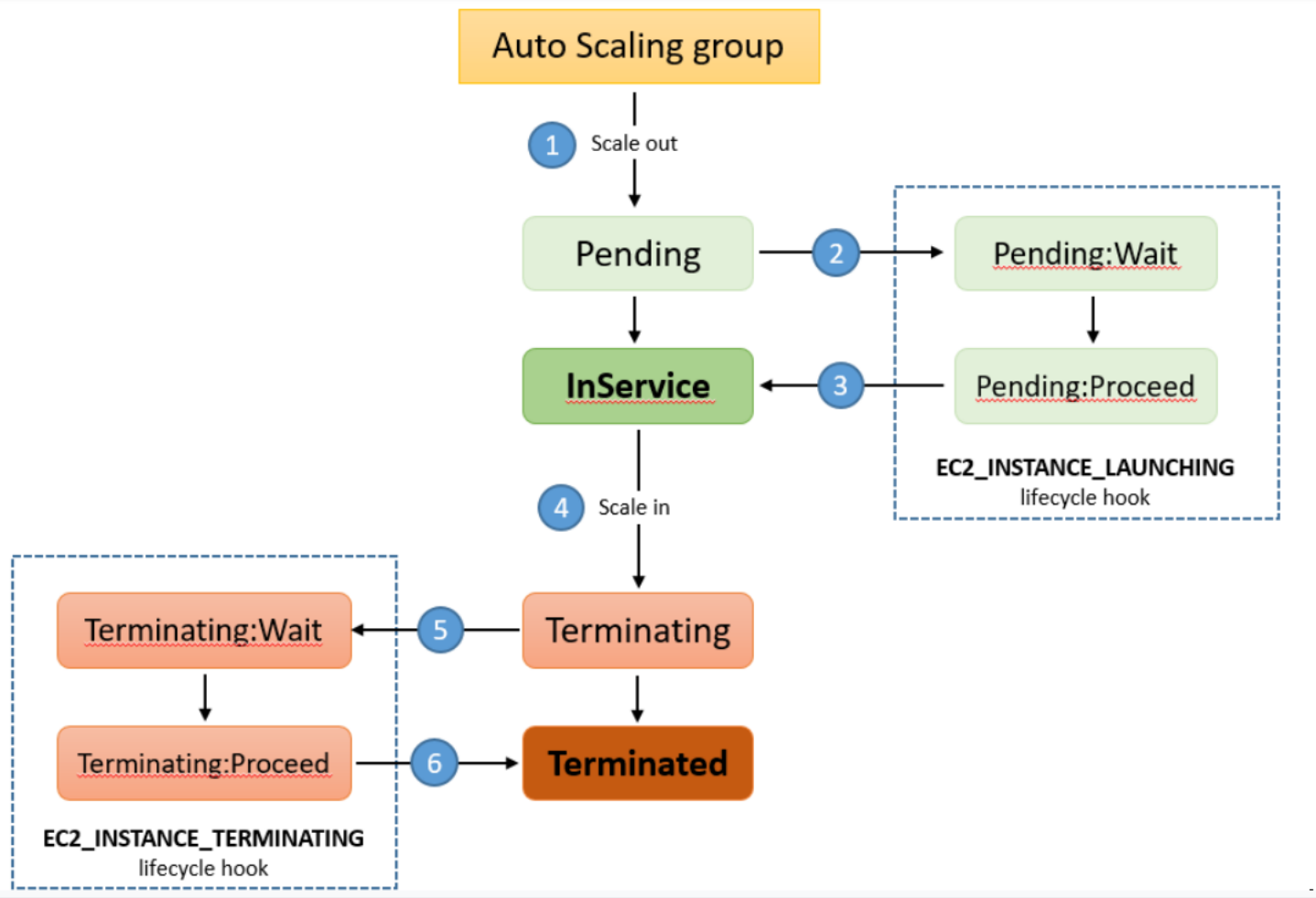
References:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/as-scaling-simple-step.html
https://docs.aws.amazon.com/autoscaling/ec2/userguide/Cooldown.html
https://docs.aws.amazon.com/autoscaling/ec2/userguide/GettingStartedTutorial.html

EC2 Auto Scaling Lifecycle Hooks

As your Auto Scaling group scale-out or scale-in your EC2 instances, you may want to perform custom actions before they start accepting traffic or before they get terminated. Auto Scaling Lifecycle Hooks allow you to perform custom actions during these stages.

For example, during the scale-out event of your ASG, you want to make sure that new EC2 instances download the latest code base from the repository and that your EC2 user data has completed before it starts accepting traffic. This way, the new instances will be fully ready and will quickly pass the load balancer health check when they are added as targets. Another example is this – during the scale-in event of your ASG, suppose your instances upload data logs to S3 every minute. You may want to pause the instance termination for a certain amount of time to allow the EC2 to upload all data logs before it gets completely terminated.

Lifecycle Hooks give you greater control of your EC2 during the launch and terminate events. The following diagram shows the transitions between the EC2 instance states with lifecycle hooks.



1. The Auto Scaling group responds to a scale-out event and provisions a new EC2 instance.
2. The lifecycle hook puts the new instance on *Pending:Wait* state. The instance stays in this paused state until you continue with the "*CompleteLifecycleAction*" operation or the default wait time of 3600 seconds is finished. For example, you can create a script that runs during the creation of the instance to download and install the needed packages for your application. Then the script can call the "*CompleteLifecycleAction*" operation to move the instance to the *InService* state. Or you can just wait for your configured timeout and the instance will be moved to the *InService* state automatically.
3. The instance is put to *InService* state. If you configured a load balancer for this Auto Scaling group, the instance will be added as targets and the load balancer will begin the health check. After passing the health checks, the instance will receive traffic.
4. The Auto Scaling group responds to a scale-in event and begins terminating an instance.
5. The instance is taken out of the load balancer target. The lifecycle hook puts the instance on *Terminating:Wait* state. For example, you can set a timeout of 2 minutes on this section to allow your instance to upload any data files inside it to S3. After the timeout, the instance is moved to the next state.

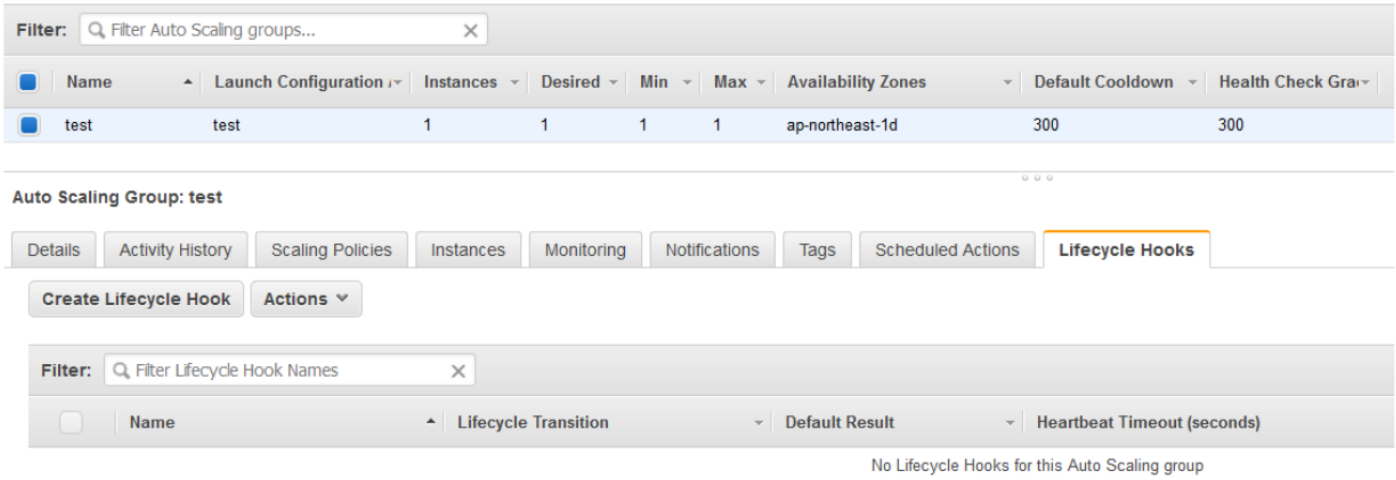
6. Auto scaling group completes the termination of the instance.

During the paused state (either launch or terminate), you can do more than just run custom scripts or wait for timeouts. CloudWatch Events (Amazon EventBridge) receives the scaling action and you can define a CloudWatch Events (Amazon EventBridge) Target to invoke a Lambda function that can perform a pre-configured task. You can also configure a notification target for the lifecycle hook so that you will receive a message when the scaling event occurs.

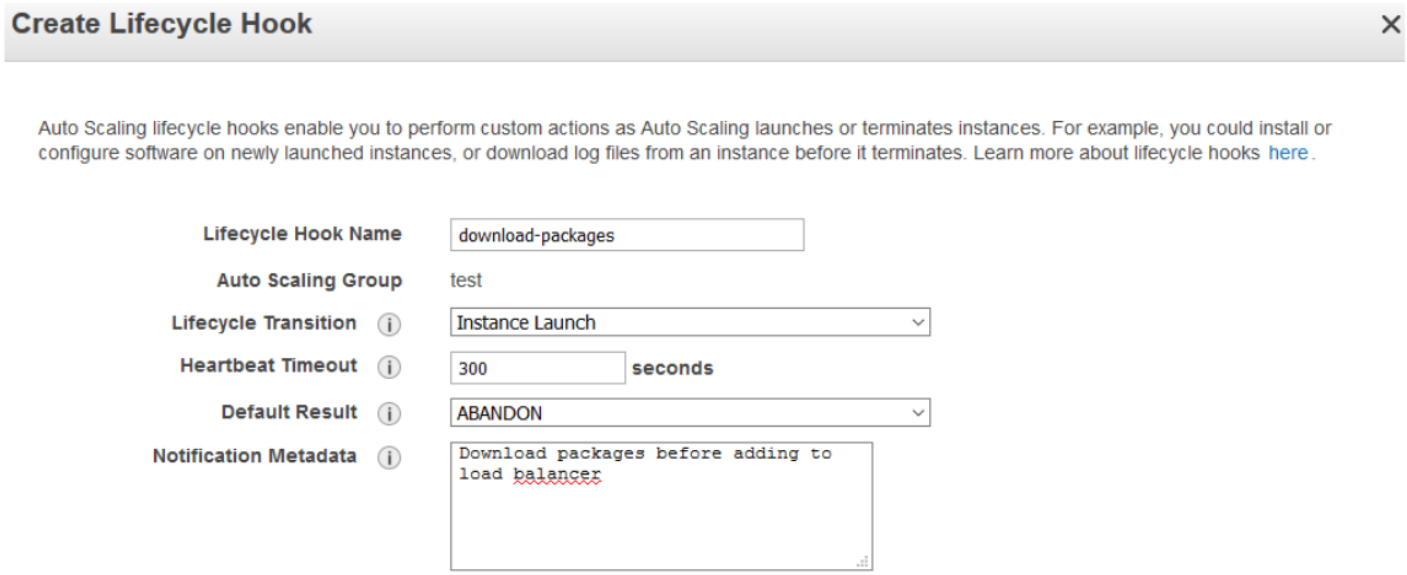
Configure Lifecycle Hooks on your Auto Scaling Groups

The following steps will show you how to configure lifecycle hooks for your Auto Scaling group.

1. On the Amazon EC2 Console, under Auto Scaling, choose Auto Scaling Group.
2. Select your Auto Scaling group.
3. Click the Lifecycle hooks tab then click the Create Lifecycle Hook button.



4. In the Create Lifecycle Hook box, do the following:



- Lifecycle Hook Name – then name for this lifecycle hook
- Lifecycle Transition – choose whether this lifecycle hook is for “Instance Launch” or “Instance Terminate” event. If you need a lifecycle hook for both events, you need to add another lifecycle hook.
- Heartbeat timeout – the amount of time (in seconds) for the instance to remain in the wait state. The range is between 30 seconds to 7200 seconds.
- Default Result – the action the Auto Scaling group takes when the lifecycle hook timeout elapses or if an unexpected error occurs.
  - If you choose CONTINUE and the instance is launching, the Auto Scaling group assumes that the actions are successful and proceeds to put the instance to InService state. If you choose CONTINUE and the instance is terminating, the Auto Scaling group will proceed with other lifecycle hooks before termination.
  - Choosing ABANDON on either state will terminate the instance immediately.
- Notification Metadata – additional information to include in messages to the notification target.

5. Click Create to apply the lifecycle hook for this Auto Scaling group.

References:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/lifecycle-hooks.html
https://docs.aws.amazon.com/cli/latest/reference/autoscaling/put-lifecycle-hook.html

Configuring Notifications for Lifecycle Hooks

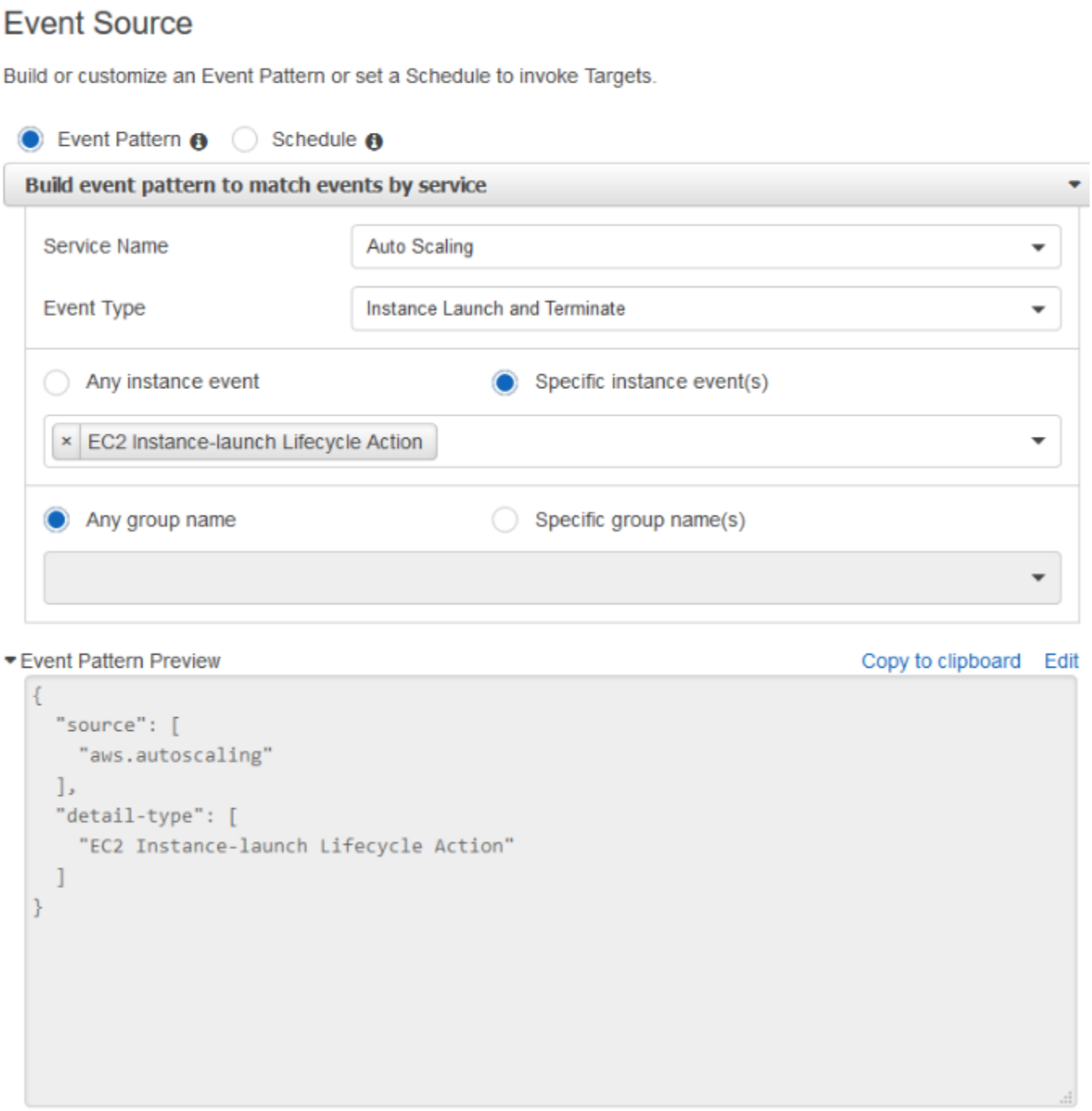
When a lifecycle hook occurs on an Auto Scaling group, it sends event logs to AWS CloudWatch Events (Amazon EventBridge), which in turn can be used to set up a rule and target to invoke a Lambda function.

The following steps assume that you have configured your Auto Scaling Lifecycle hook on the AWS Console.

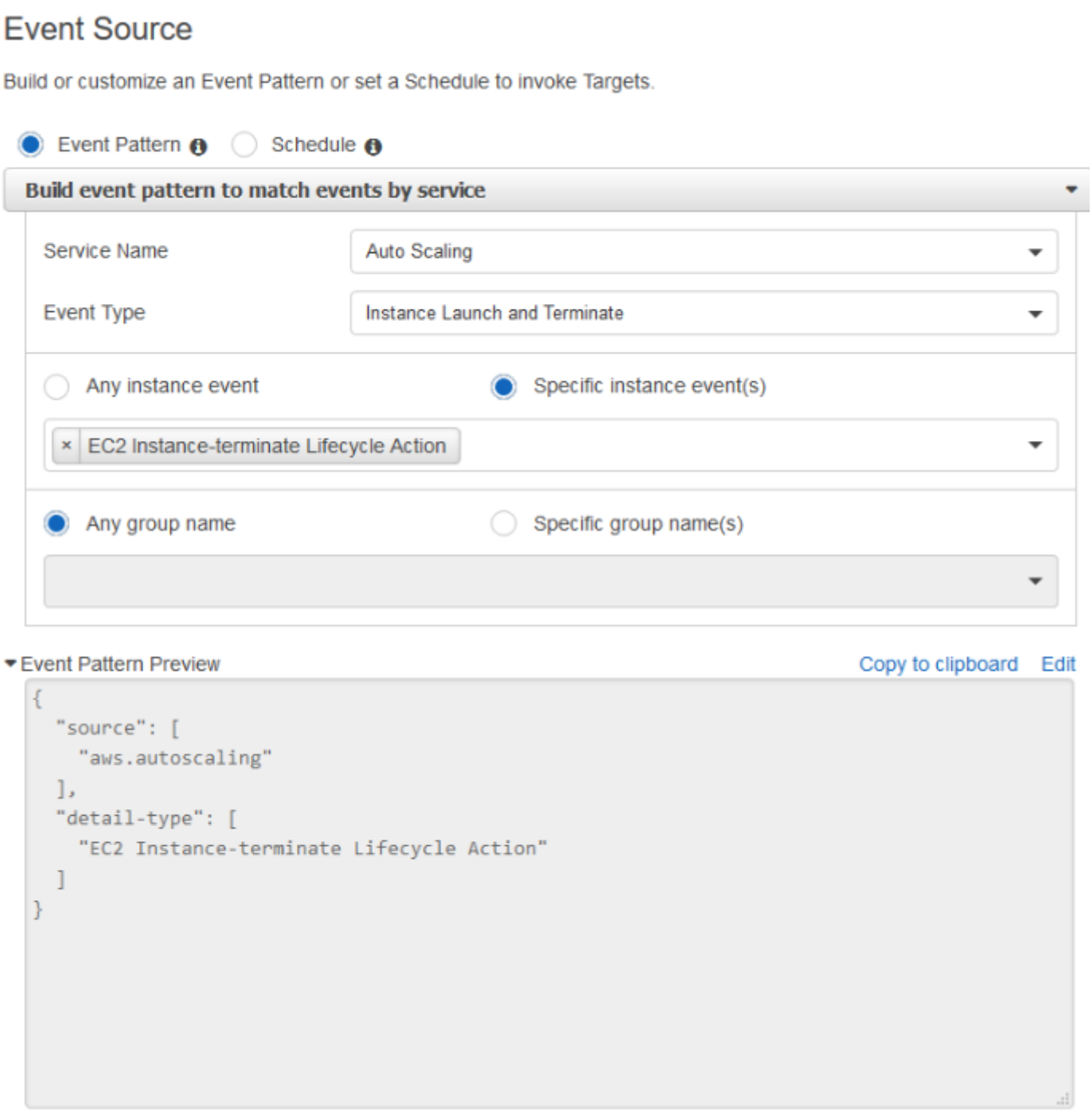
Route Notifications to Lambda using CloudWatch Events (Amazon EventBridge)

1. Create your Lambda function and take note of the ARN. To create your Lambda function, see this link.
2. Go to AWS **CloudWatch** > **Events** > **Rules** and click **Create rule**.
3. Choose the following options:
    a. **Event Pattern** – since you want this rule to filter AWS events
    b. **Service Name: Auto Scaling** – to filter from Auto Scaling service
    c. **Event type: Instance Launch and Terminate** – since the lifecycle hook happens on scale-out and scale-in event
    d. ***Specific Instance events*** *– Select this and you can choose whether you want this rule to trigger for the "Instance-launch Lifecycle Action" or the "Instance-terminate Lifecycle Action"*

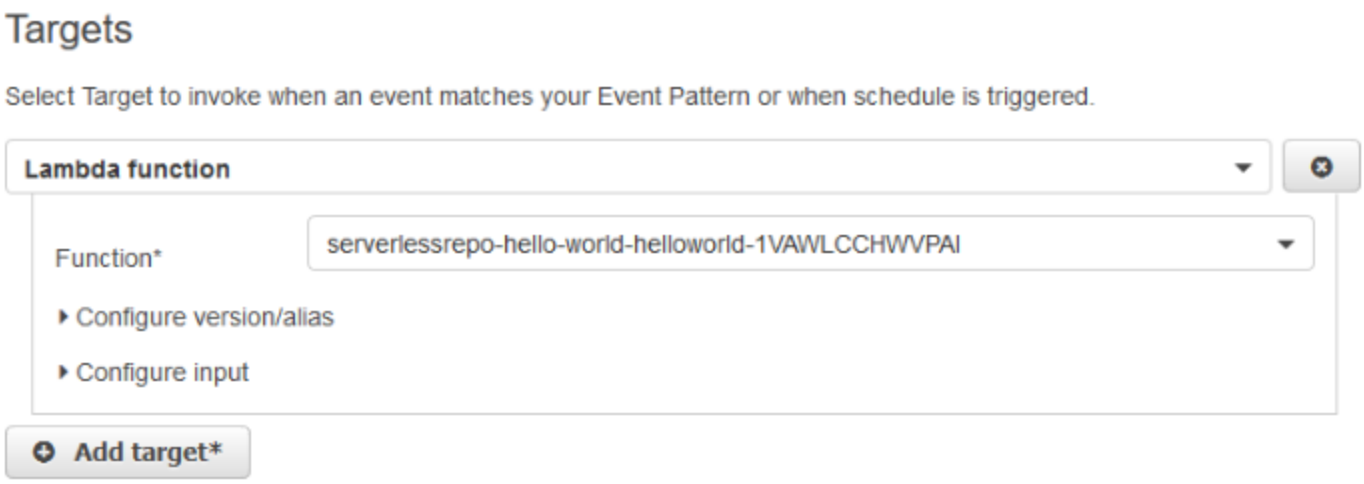
Your rule should be like the screenshot below for the *"Instance-launch Lifecycle Action"*.



Your rule should be like the screenshot below for the *"Instance-terminate Lifecycle Action"*.



4. Click on **"Add target"** on the right side of the page to add a target for this Rule.
5. Select **"Lambda function"** as target and select your Lambda function on the **"Function"** field. You can also add other targets here if you need to. Here's a screenshot for reference:



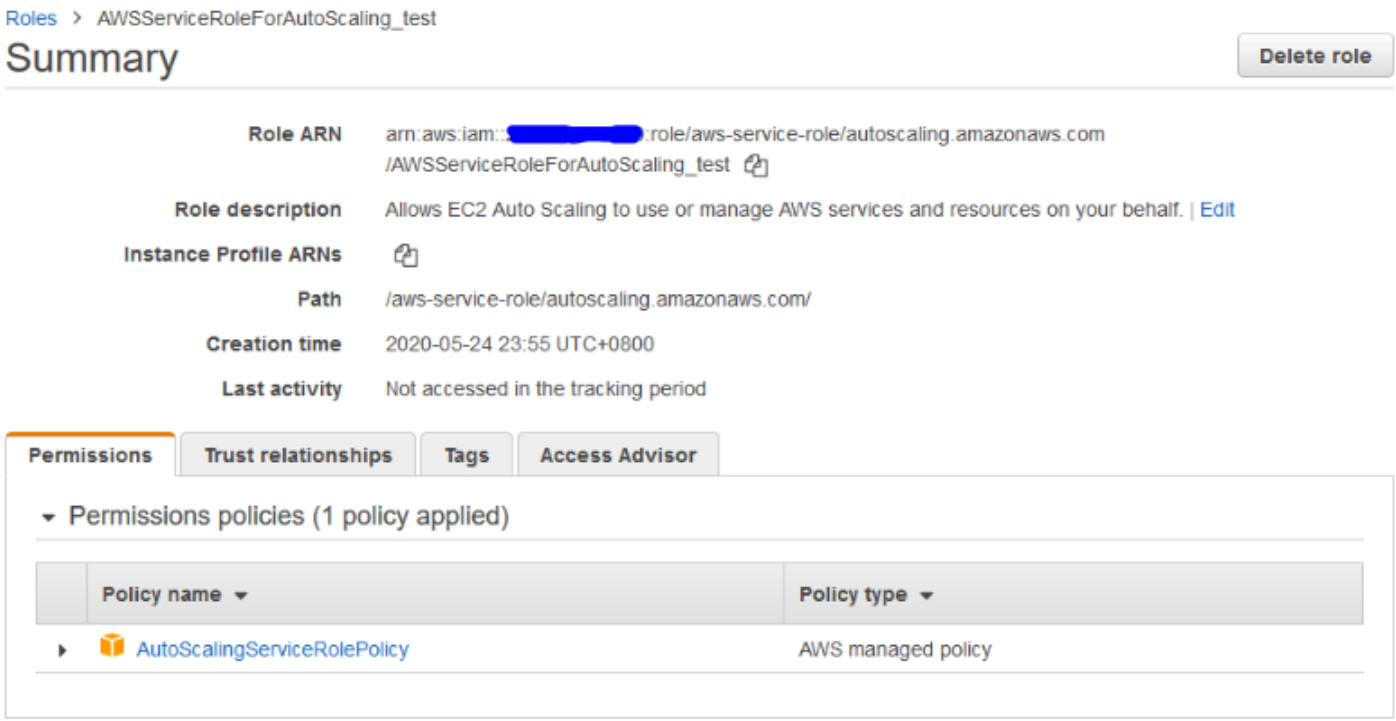
6. Click “Configure details” to proceed to the next step.
7. Add a name to your rule and add a description. You want to make sure the “State Enabled” is checked. Click **Create rule** to finally create your CloudWatch Events (Amazon EventBridge) rule.

That’s it, the CloudWatch permission to trigger the Lambda function is automatically taken care of. Now, when the Auto Scaling group scales-out or scales-in with a lifecycle hook, the Lambda function is triggered.

Receive Notification using Amazon SNS

To receive lifecycle hook notifications with Amazon SNS, you can use the AWS CLI to add a lifecycle hook. The key point here is that you need an SNS topic and an IAM role to allow publishing to that topic.

1. Create your SNS topic. Let’s assume the SNS topic ARN is arn:aws:sns:ap-northeast-1:1234457689123:test-topic. Make sure that your email is subscribed to this topic.
2. Create an IAM Role that you will associate to the lifecycle hook.
    a. Go to **IAM** > **Role** > **Create role**
    b. Select **AWS Service** under the **Select type of trusted entity**.
    c. Click **EC2 Auto Scaling** from the list under the **Choose a use case section**.
    d. Choose **EC2 Auto Scaling** on the **Select your use case** section.
    e. Click **Next: Permissions** to add permissions to this role. The **AutoScalingServiceRolePolicy** should already be added.
    f. Click **Next: Tags** to add tags to this role.
    g. Click **Next: Review** to add a name to this role
    h. Click **Create role**.



3. Get the ARN of this role. Let's assume the ARN is

   arn:aws:iam::123456789123:role/aws-service role/autoscaling.amazonaws.com/AWSServiceRoleForAutoScaling_test

4. Now we need to add a lifecycle hook and a notification to your Auto Scaling group. Change the values inside the brackets for the correct values.

For the scale-out action lifecycle hook, use the following **put-lifecycle-hook** command.

aws autoscaling put-lifecycle-hook --lifecycle-hook-name [lifecycle hook name] --auto-scaling-group-name [auto scaling group name] --lifecycle-transition autoscaling:EC2_INSTANCE_LAUNCHING --notification-target-arn [put sns topic arn here] --role-arn [put iam role arn here]

For the scale-in action lifecycle hook, use the following **put-lifecycle-hook** command.

aws autoscaling put-lifecycle-hook --lifecycle-hook-name [lifecycle hook name] --auto-scaling-group-name [auto scaling group name] --lifecycle-transition autoscaling:EC2_INSTANCE_TERMINATING --notification-target-arn [put sns topic arn here] --role-arn [put iam role arn here]

Once configured, the SNS topic receives a test notification with the following key-value pair:

"Event": "autoscaling:TEST_NOTIFICATION"

That's it. Your Auto Scaling lifecycle hook is configured with an SNS notification that will send out an email to you once the scale-out or scale-in event lifecycle hook puts the instance on the "wait" state.

References:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/configuring-lifecycle-hook-notifications.html

Suspending and Resuming Scaling Processes

Amazon EC2 Auto Scaling has two primary process types. It will either Launch or Terminate an EC2 instance. Other process types are related to specific scaling features :

- **AddToLoadBalancer** — Adds instances to the attached load balancer or target group when they are launched.
- **AlarmNotification** — Notifications from CloudWatch alarms that are associated with the group's scaling policies.
- **AZRebalance** — Balances the number of EC2 instances in the group evenly across all of the specified Availability Zones when the group becomes unbalanced.
- **HealthCheck** — Monitors the health of the instances and marks an instance as unhealthy if Amazon EC2 or AWS Elastic Load Balancing tells Amazon EC2 Auto Scaling that the instance is unhealthy.
- **ReplaceUnhealthy** — Terminates instances that are marked as unhealthy and then launches new instances to replace them.
- **ScheduledActions** — Performs scheduled scaling actions that you create or that are created by predictive scaling.

You can suspend/resume any of the process types above if you do not want them active in your auto scaling group. You would usually perform this if you are troubleshooting a scaling event and you don't want to impact system performance. When you suspend a primary process type, other process types may cease to function properly.

Reference:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/as-suspend-resume-processes.html

Some Limitations to Remember for Amazon EC2 Auto Scaling Group

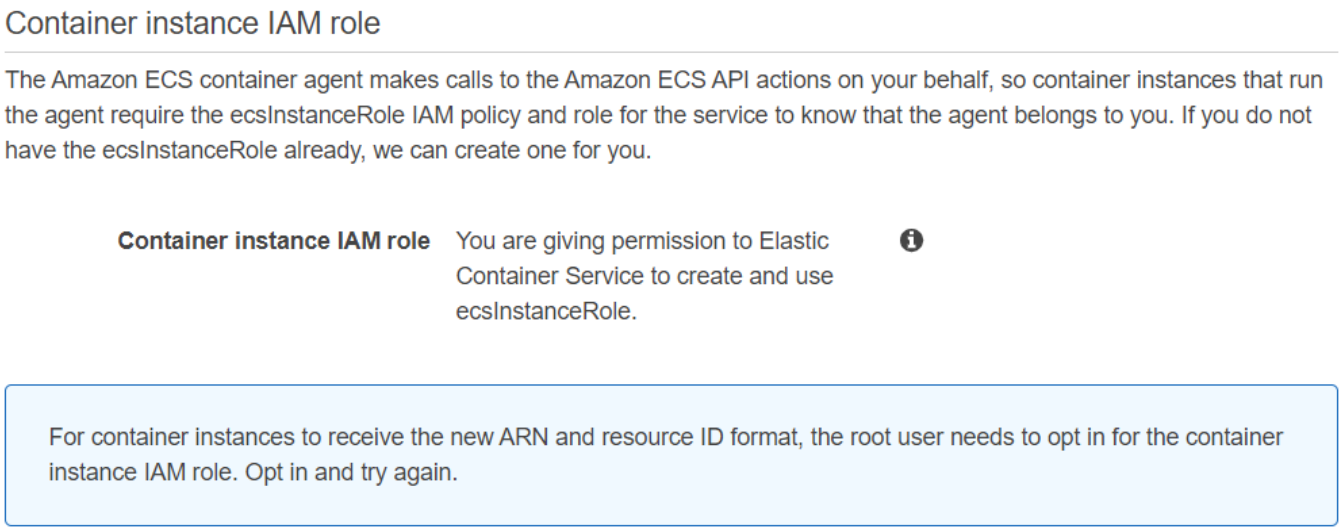
Keep in mind that auto scaling groups are regional services and do not span multiple AWS Regions. You can configure them to span multiple Availability Zones, since they were designed in the first place to help you

achieve high availability and fault tolerance. However, if you need to use multiple Regions for scaling horizontally, you will need to implement a different solution to achieve this result. The same goes for launch configurations and launch templates you create. They only exist within the Region you created them in. If you need to copy over your launch configurations and templates to another Region, simply recreate them in the desired target Region. Another thing to remember is when you've configured your EC2 Auto Scaling Group to spread your instances across multiple Availability Zones, you cannot use cluster placement groups in conjunction with this setup, since cluster placement groups cannot span multiple Availability Zones.

Amazon Elastic Container Service

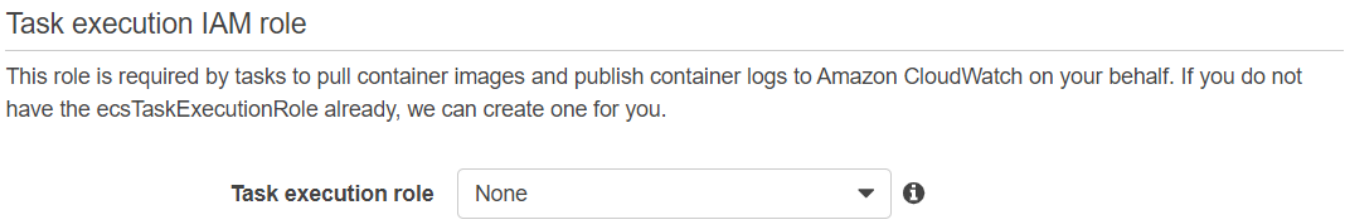
Amazon ECS Container Instance Role vs Task Execution Role vs Task Role

An ECS cluster is the very first resource you create in Amazon ECS. You define your cluster's underlying infrastructure, instance provisioning model (on-demand or spot), instance configuration (AMI, type, size, volumes, key pair, number of instances to launch), cluster network and container instance role. The container instance role allows the Amazon ECS container agent running in your container instances to call ECS API actions on your behalf. This role attaches the *ecsInstanceRole* IAM policy.

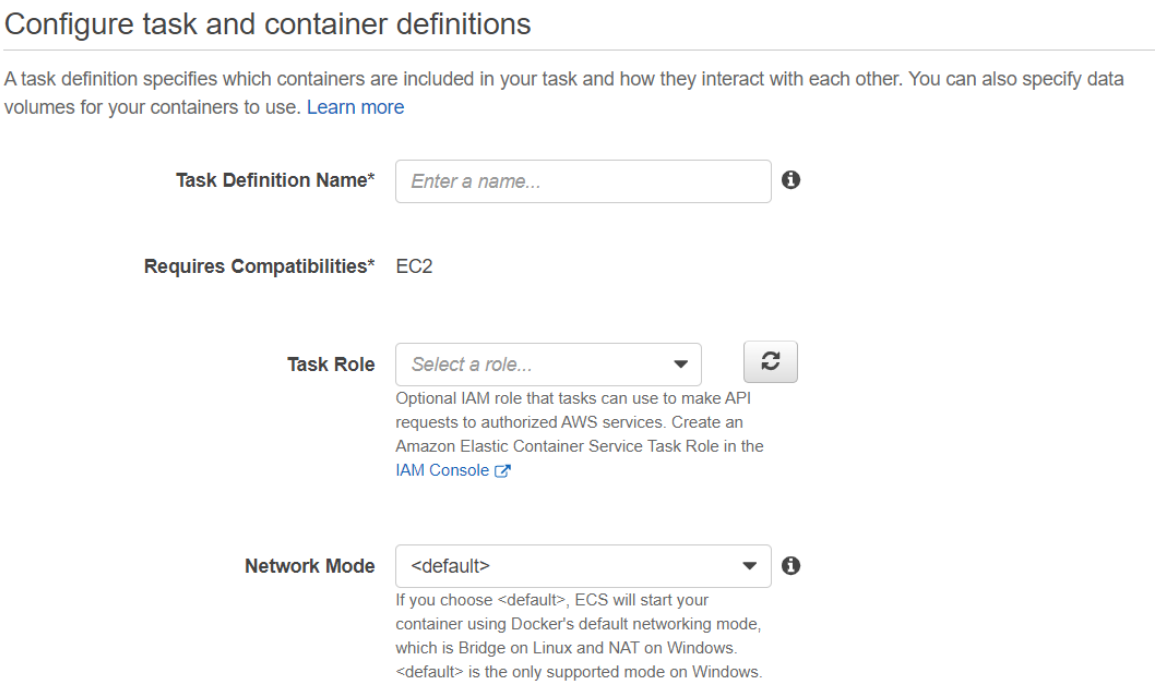


After creating your ECS cluster, one of the very first things you'll do next is create your task definition. A task definition is like a spec sheet for the Docker containers that will be running in your ECS instances or *tasks*. The following are the parameters that are defined in a task definition:

- The Docker image to use with each container in your task
- CPU and memory allocation for each task or each container within a task
- The launch type to use (EC2 or Fargate)
- The Docker networking mode to use for the containers in your task
- The logging configuration to use (bridge, host, awsvpc, or none)
- Whether the task should continue to run if the container finishes or fails
- The command the container executes when it is started
- Volumes that should be mounted on the containers in a task
- The Task Execution IAM role that provides your tasks permissions to pull Docker images and publish container logs.



Lastly, since the containers running in your ECS tasks might need to make some AWS API calls themselves, they will need the appropriate permissions to do so. The task role provides your containers permissions to make API requests to authorized AWS services. In addition to the standard ECS permissions required to run tasks and services, IAM users also require iam:PassRole permissions to use IAM roles for tasks. Assigning a task role is optional.



References:
https://docs.aws.amazon.com/AmazonECS/latest/developerguide/task_execution_IAM_role.html
https://docs.aws.amazon.com/AmazonECS/latest/developerguide/task-iam-roles.html
https://tutorialsdojo.com/amazon-elastic-container-service-amazon-ecs/

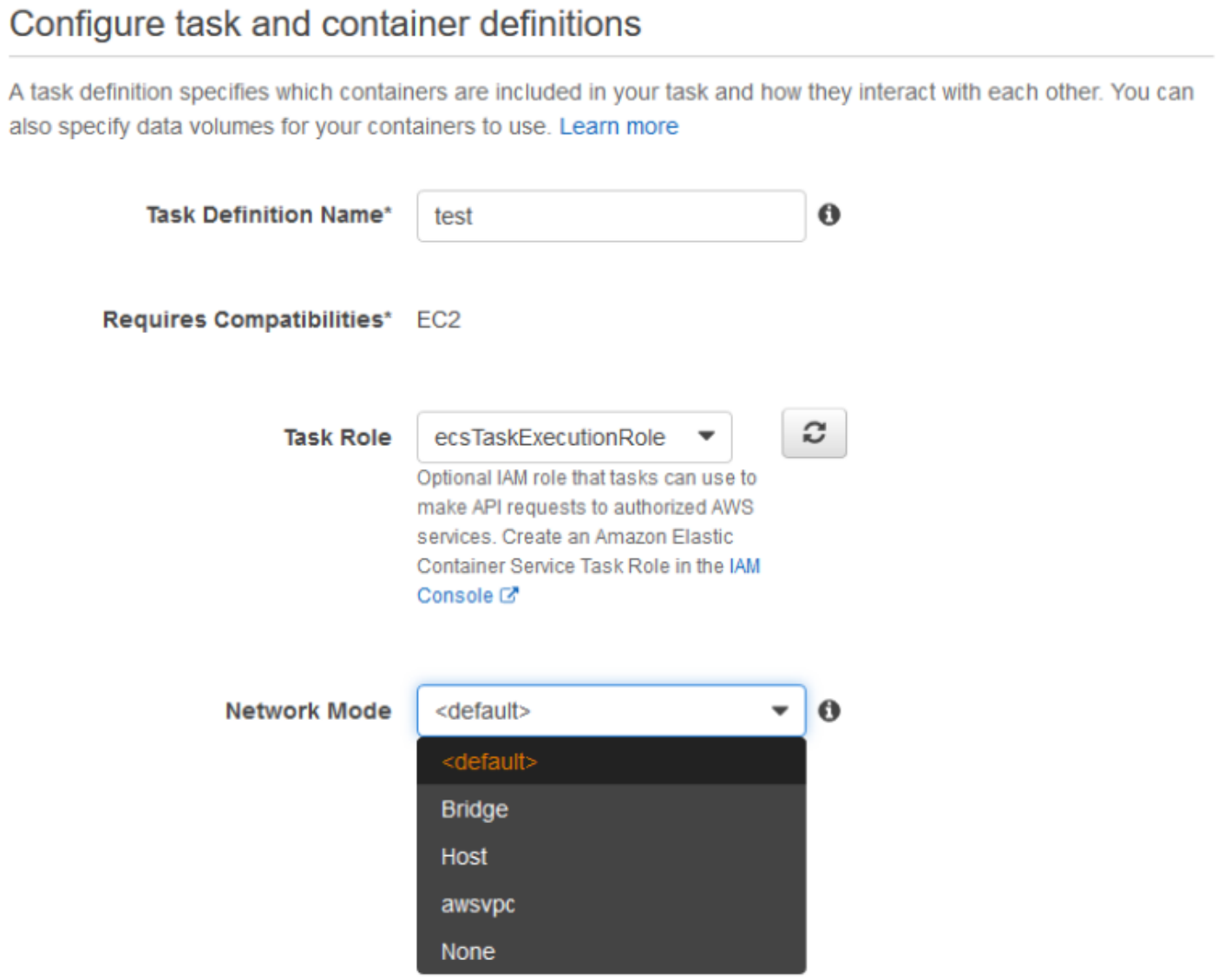
ECS Network Mode Comparison

Amazon Elastic Container Service (ECS) allows you to run Docker-based containers on the cloud. Amazon ECS has two launch types for operation: EC2 and Fargate. The EC2 launch type provides EC2 instances as hosts for your Docker containers. For the Fargate launch type, AWS manages the underlying hosts so you can focus on managing your containers instead. The details and configuration on how you want to run your containers are defined on the ECS Task Definition which includes options on networking mode.

In this post, we'll talk about the different networking modes supported by Amazon ECS and determine which mode to use for your given requirements.

ECS Network Modes

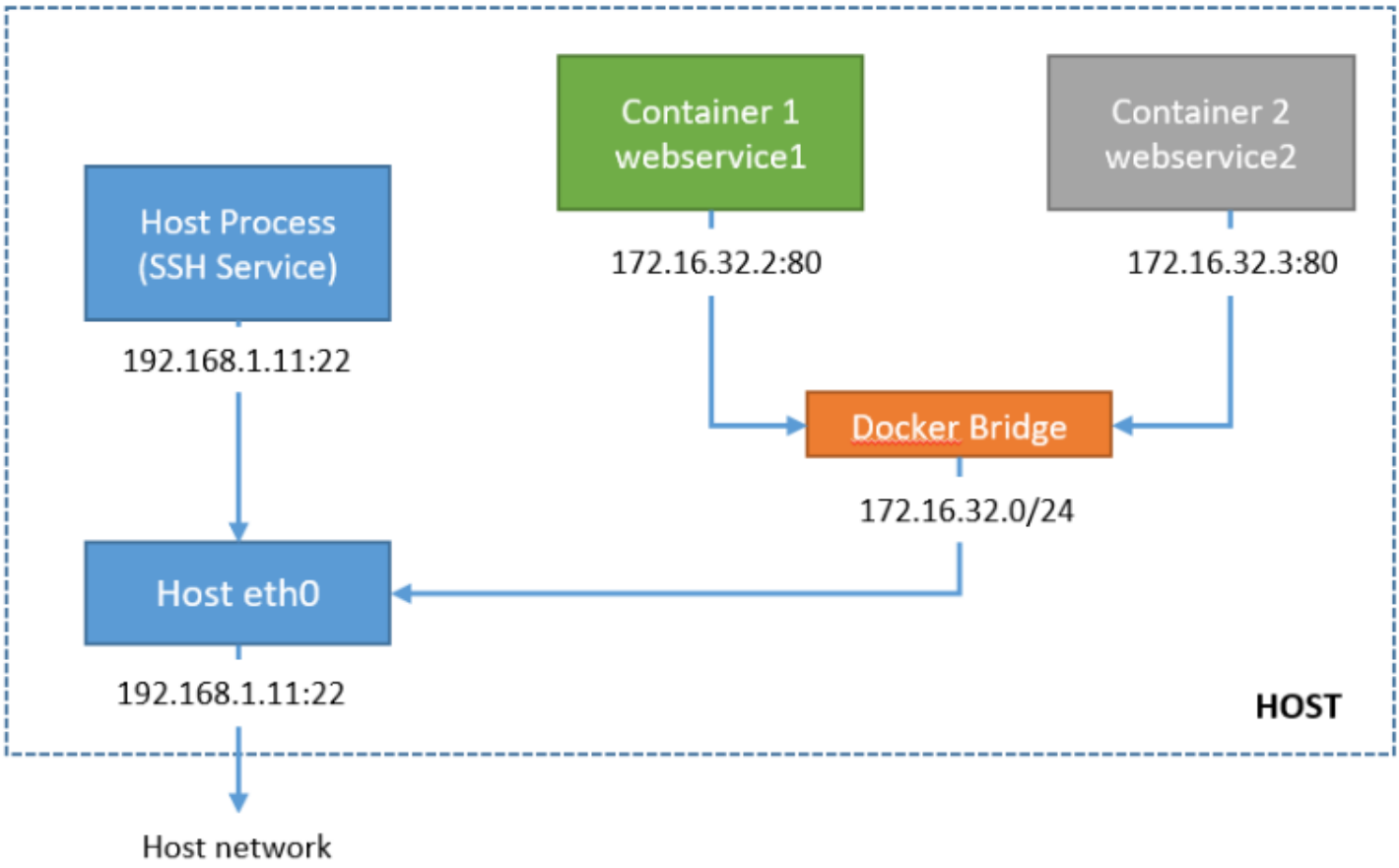
Amazon Elastic Container Service supports four networking modes: **Bridge**, **Host**, **awsvpc**, and **None**. This selection will be set as the Docker networking mode used by the containers on your ECS tasks.



Bridge network mode – Default

When you select the **<default>** network mode, you are selecting the **Bridge** network mode. This is the default mode for Linux containers. For Windows Docker containers, the **<default>** network mode is **NAT**. You must select **<default>** if you are going to register task definitions with Windows containers.

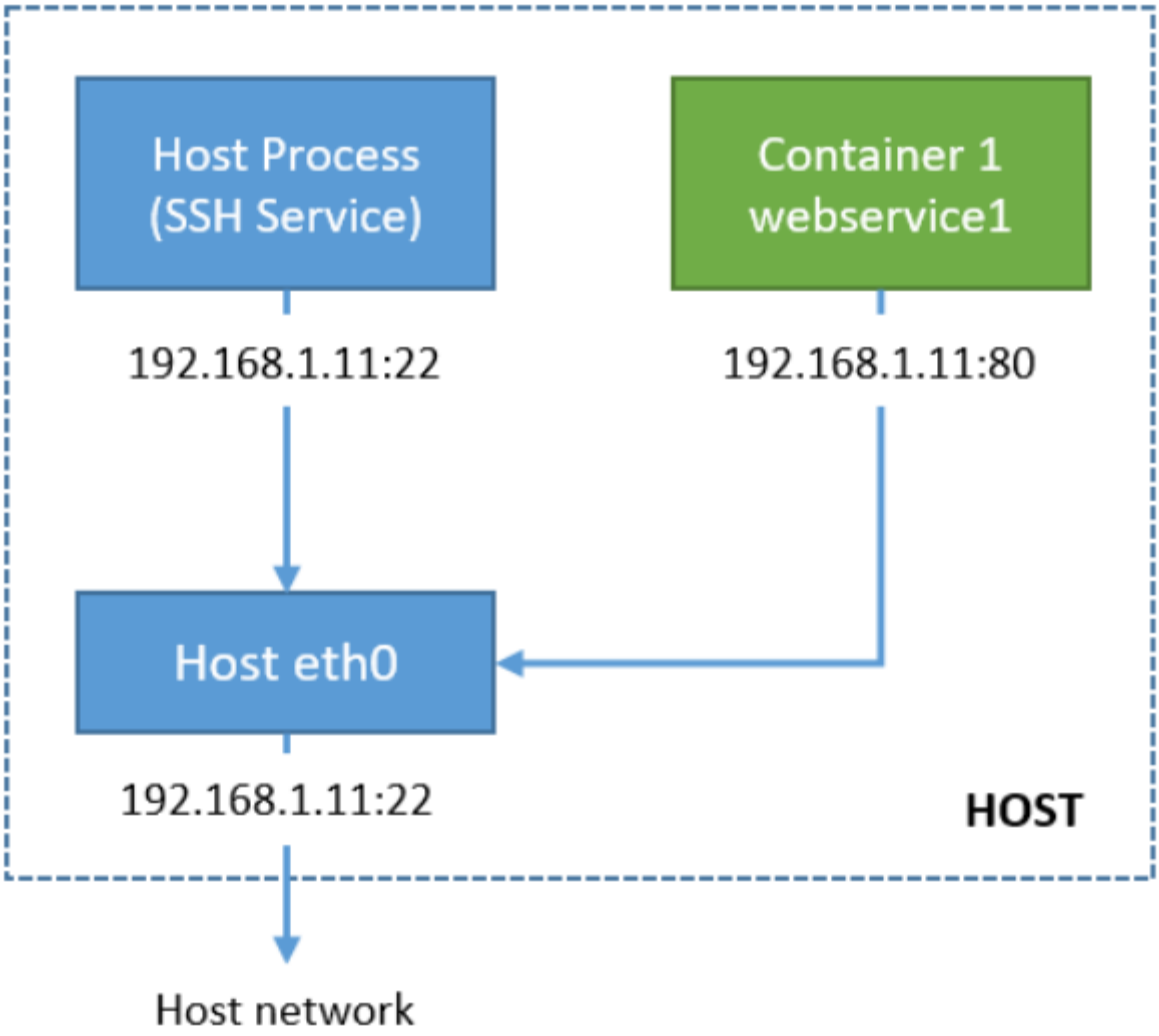
Bridge network mode utilizes Docker's built-in virtual network which runs inside each container. A bridge network is an internal network namespace in the host that allows all containers connected on the same bridge network to communicate. It provides isolation from other containers not connected to that bridge network. The Docker driver handles this isolation on the host machine so that containers on different bridge networks cannot communicate with each other.



This mode can take advantage of dynamic host port mappings as it allows you to run the same port (ex: port 80) on each container, and then map each container port to a different port on the host. However, this mode does not provide the best networking performance because the bridge network is virtualized and Docker software handles the traffic translations on traffic going in and out of the host.

Host network mode

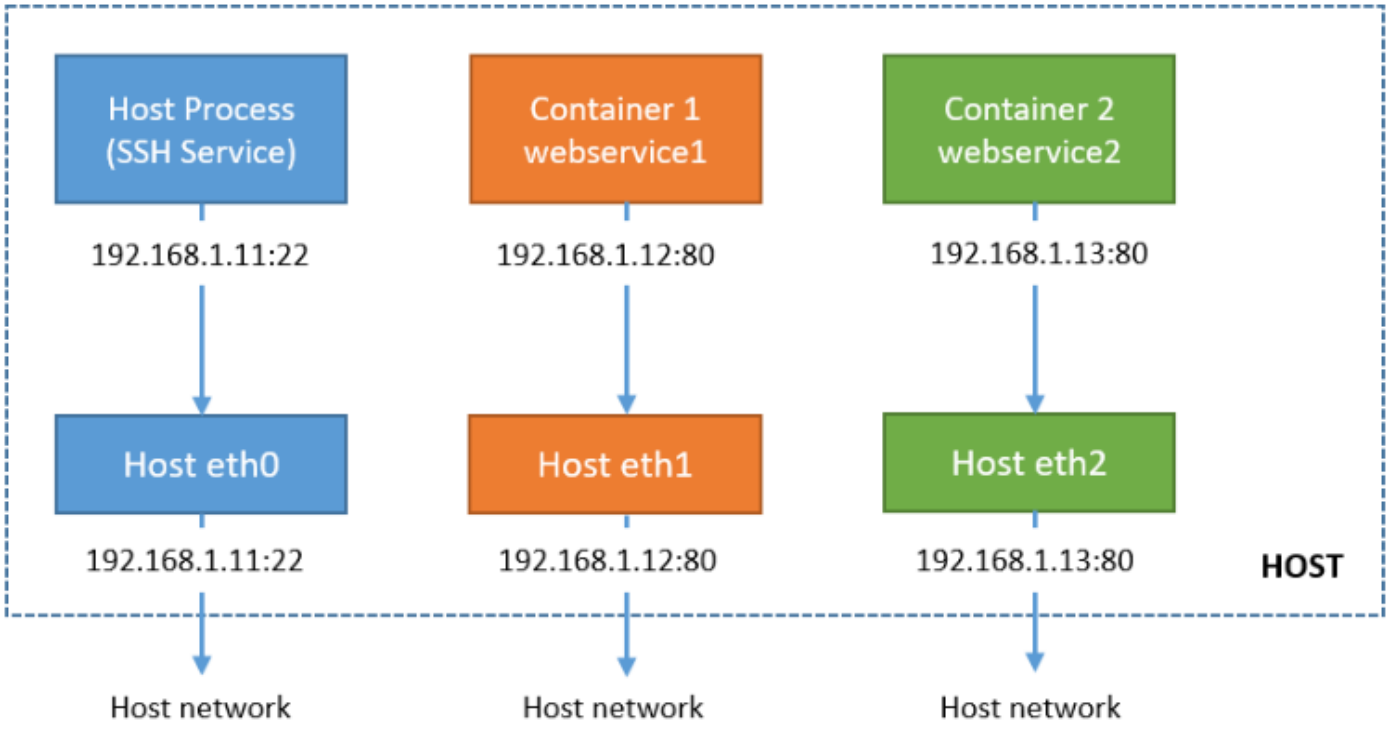
Host network mode bypasses the Docker's built-in virtual network and maps container ports directly to your EC2 instance's network interface. This mode shares the same network namespace of the host EC2 instance so your containers share the same IP with your host IP address. This also means that you can't have multiple containers on the host using the same port. A port used by one container on the host cannot be used by another container as this will cause conflict.



This mode offers faster performance than the bridge network mode since it uses the EC2 network stack instead of the virtual Docker network.

awsvpc mode

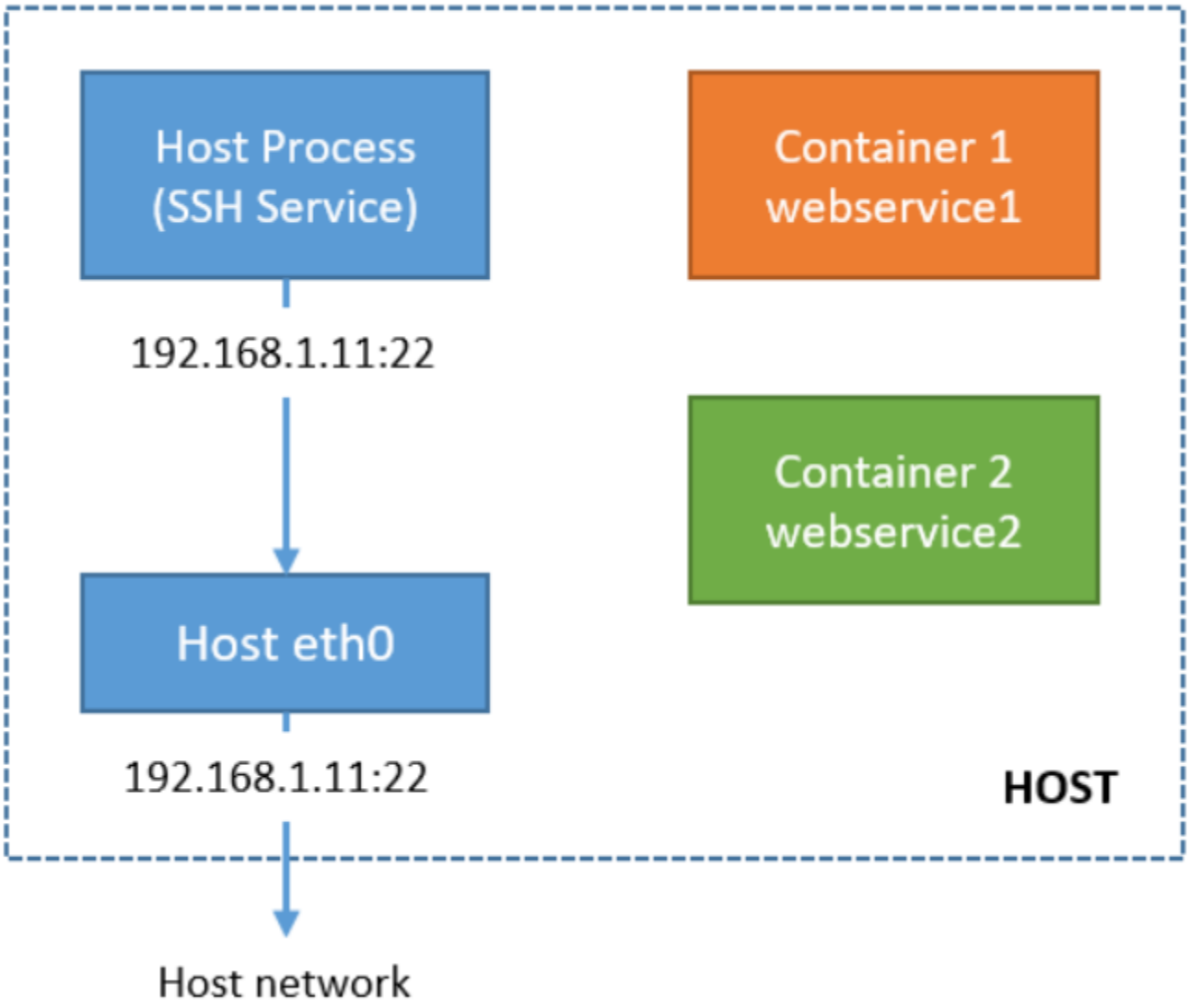
The **awsvpc** mode provides an elastic network interface for each task definition. If you have one container per task definition, each container will have its own elastic network interface and will get its own IP address from your VPC subnet IP address pool. This offers faster performance than the bridge network since it uses the EC2 network stack, too. This essentially makes each task act like their own EC2 instance within the VPC with their own ENI, even though the tasks actually reside on an EC2 host.



Awsvpc mode is recommended if your cluster will contain several tasks and containers as each can communicate with their own network interface. This is the only supported mode by the ECS Fargate service. Since you don't manage any EC2 hosts on ECS Fargate, you can only use awsvpc network mode so that each task gets its own network interface and IP address.

None network mode

This mode completely disables the networking stack inside the ECS task. The loopback network interface is the only one present inside each container since the loopback interface is essential for Linux operations. You can't specify port mappings on this mode as the containers do not have external connectivity.

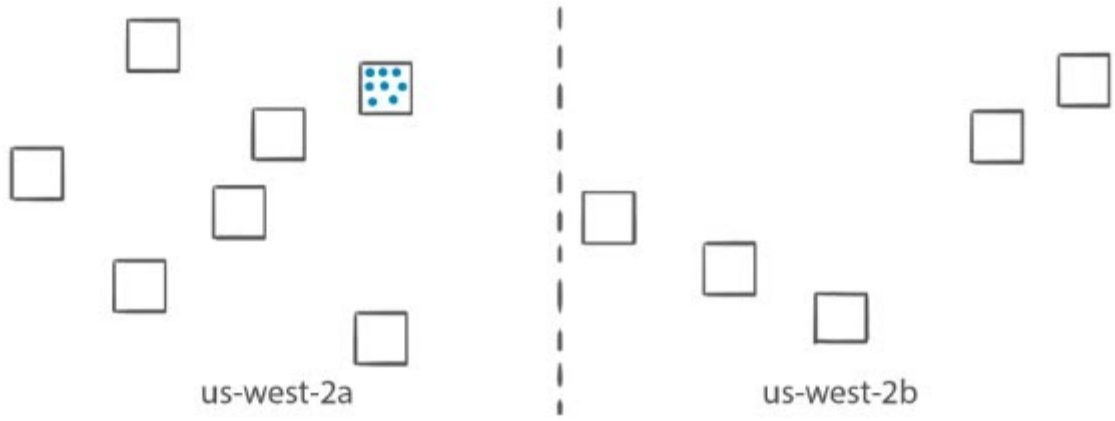


You can use this mode if you don't want your containers to access the host network, or if you want to use a custom network driver other than the built-in driver from Docker. You can only access the container from inside the EC2 host with the Docker command.

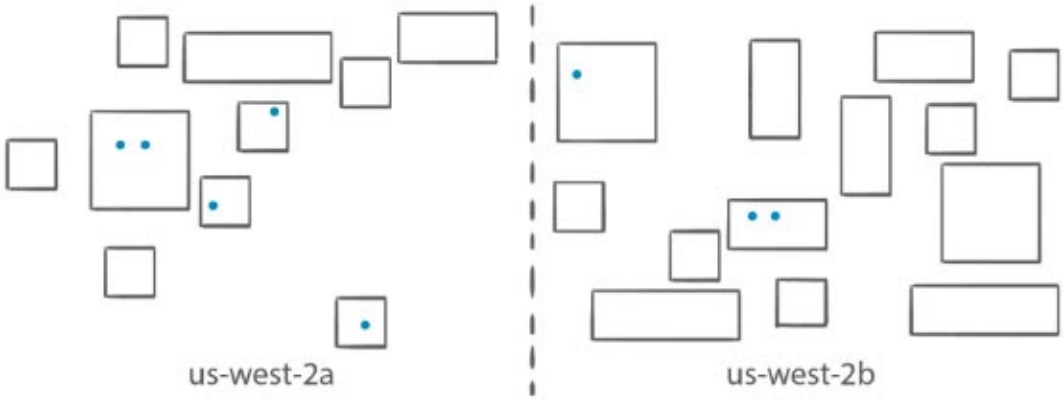
References:
https://docs.aws.amazon.com/AmazonECS/latest/developerguide/task_definition_parameters.html#network_mode
https://docs.aws.amazon.com/AmazonECS/latest/developerguide/task-networking.html

ECS Task Placement Strategies

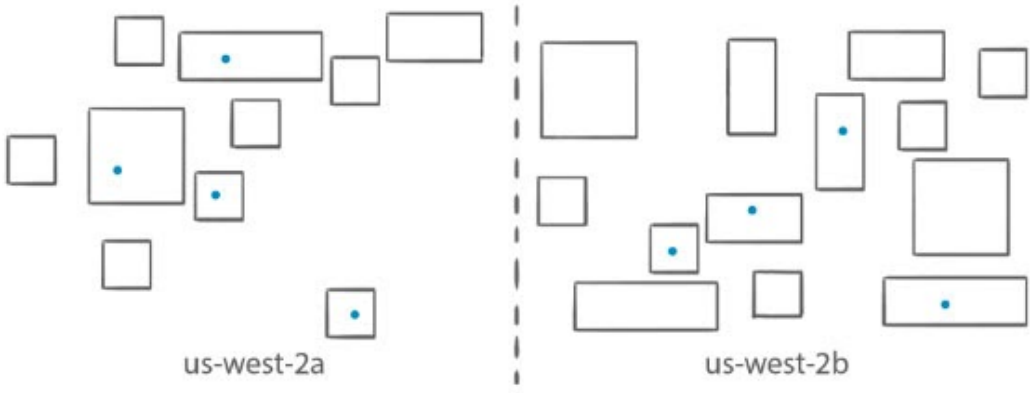
- A *task placement strategy* is an algorithm for selecting instances for task placement or tasks for termination. When a task that uses the EC2 launch type is launched, Amazon ECS must determine where to place the task based on the requirements specified in the task definition, such as CPU and memory. Similarly, when you scale down the task count, Amazon ECS must determine which tasks to terminate.
- A *task placement constraint* is a rule that is considered during task placement.
    - You can use constraints to place tasks based on Availability Zone or instance type.
    - You can also associate attributes, which are name/value pairs, with your container instances and then use a constraint to place tasks based on attribute.
- Task placement strategy types:
    - **Binpack** – Place tasks based on the least available amount of CPU or memory. This minimizes the number of instances in use and allows you to be cost-efficient. For example, you have running tasks in c5.2xlarge instances that are known to be CPU intensive but are not memory consuming. You can maximize your instances' memory allocation by launching tasks in them instead of spawning a new instance.



    - **Random** – Place tasks randomly. You use this strategy when task placement or termination does not matter.



- **Spread** – Place tasks evenly based on the specified value. Accepted values are attribute key-value pairs, instanceId, or host. Spread is typically used to achieve high availability by making sure that multiple copies of a task are scheduled across multiple instances. **Spread across Availability Zones** is the default placement strategy used for services.



- You can combine different strategy types to suit your application needs.
- Task placement strategies are a best effort.
- By default, Fargate tasks are spread across Availability Zones.
- By default, ECS uses the following placement strategies:
  - When you run tasks with the RunTask API action, tasks are placed randomly in a cluster.
  - When you launch and terminate tasks with the CreateService API action, the service scheduler spreads the tasks across the Availability Zones (and the instances within the zones) in a cluster.

References:
https://docs.aws.amazon.com/AmazonECS/latest/developerguide/task-placement.html
https://aws.amazon.com/blogs/compute/amazon-ecs-task-placement/

Amazon Elastic Kubernetes Service

Remain Cloud Agnostic with Kubernetes

Amazon EKS lets you easily run and scale Kubernetes applications in the AWS cloud or on-premises. Kubernetes is not an AWS native service. Kubernetes is an open-source container-orchestration tool used for deployment and management of containerized applications. Amazon EKS just builds additional features on top of this platform so you can run Kubernetes in AWS much easier. If you have containerized applications running on-premises that you would like to move into AWS, but you wish to keep your applications as cloud agnostic as possible then EKS is a great choice for your workload. All the Kubernetes-supported tools and plugins you use on-premises will also work in EKS. You do not need to make any code changes when replatforming your applications.

An EKS cluster consists of two components:

- The Amazon EKS control plane
- And the Amazon EKS nodes that are registered with the control plane

The Amazon EKS control plane consists of control plane nodes that run the Kubernetes software, such as *etcd* and the Kubernetes API server. The control plane runs in an account managed by AWS, and the Kubernetes API is exposed via the cluster's EKS endpoint. Amazon EKS nodes run in your AWS account and connect to your cluster's control plane via the API server endpoint and a certificate file that is created for your cluster.

To join worker nodes to your Amazon EKS cluster, you must complete the following:

1. Enable DNS support for your cluster's VPC
2. Provide sufficient IAM permissions for your instance profile's worker nodes
3. Configure the user data for your worker nodes
4. Launch your worker nodes in a subnet belonging to your cluster's VPC
5. Update the *aws-auth* ConfigMap with the *NodeInstanceRole* of your worker nodes
6. Add in the required security group rules of your worker nodes
7. Set the tags for your worker nodes
8. Verify that your worker nodes can reach the API server endpoint for your EKS cluster
9. Connect to a worker node's EC2 instance via SSH and review the kubelet agent logs for any errors

References:
https://docs.aws.amazon.com/eks/latest/userguide/clusters.html
https://aws.amazon.com/premiumsupport/knowledge-center/eks-worker-nodes-cluster/

AWS Lambda

Concurrency Limits

AWS Lambda is a blessing for developers who do not want to maintain any infrastructure. You don't need to worry about things like sizing, scaling, patching, and other management operations that you would normally have on servers such as EC2 instances. In Lambda, you just need to choose a runtime environment, provide your code, and configure other basic settings like the memory size available for each function call, the timeout of each function run, function triggers if applicable, etc. Although AWS Lambda is serverless, this doesn't mean that you don't have anything to manage on your end. If left unchecked, you'll be surprised how each function execution can add to your monthly bill. Your other Lambda functions might not even execute properly if one of your functions is hogging all the compute resources available to you. As with everything that scales automatically, you should be placing hard limits on the scalability so it will not explode all over the place. In AWS Lambda, this limit is known as **concurrency limit**.

Concurrency is the number of requests that your function is serving at any given time. When your function is invoked, Lambda allocates an instance of it to process the event. By default, your AWS account has a default quota of 1000 concurrent Lambda executions per Region. All your Lambda functions count against this limit. By setting a concurrency limit for your Lambda function, you reserve a portion of your concurrency limit for that given function. This allows you to throttle the given function once it reaches the maximum number of concurrent executions you've set for it.

There are two types of concurrency:

- **Reserved concurrency** – A pool of requests that can only be used by the function that reserved the capacity, and also prevents the function from using unreserved concurrency. A function cannot utilize another function's reserved concurrency, so other functions can't prevent your function from scaling.
- **Provisioned concurrency** – Initializes a requested number of execution environments so that they are prepared to respond to your function's invocations without any fluctuations.

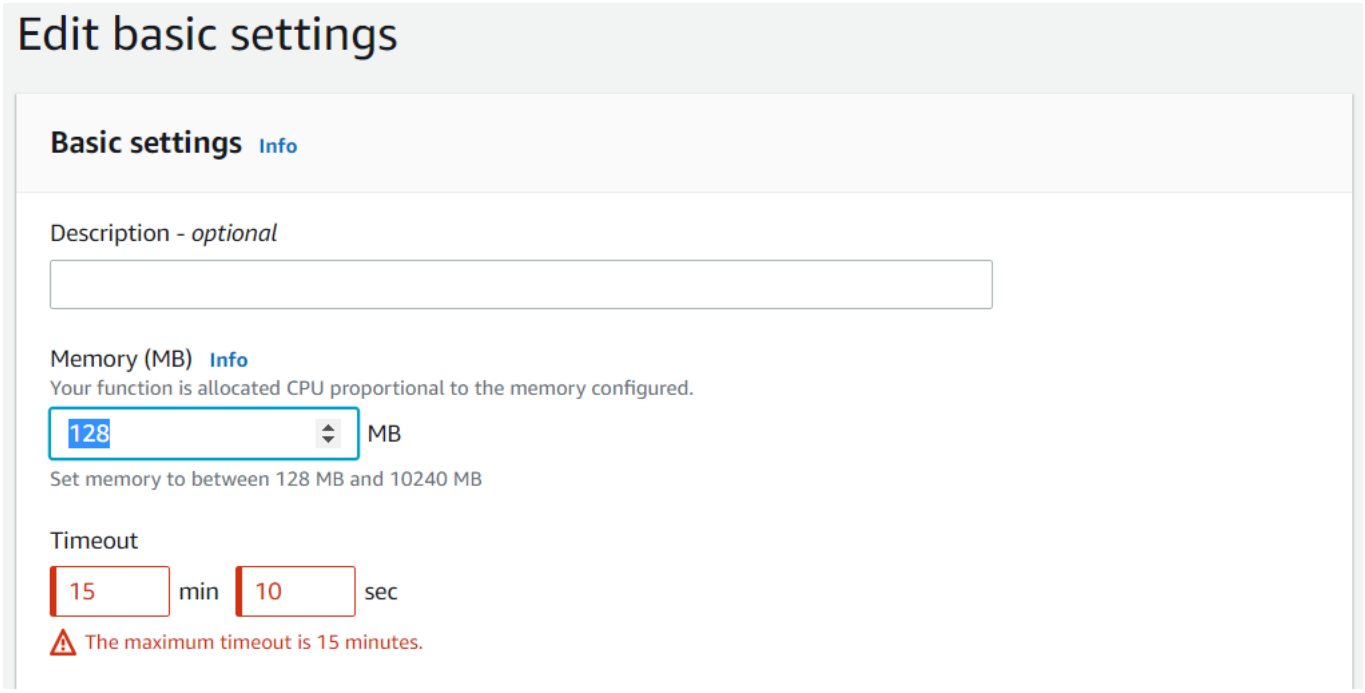
Both of these concurrency plans can be used together, but your provisioned concurrency cannot exceed your maximum reserved concurrency. Furthermore, Lambda integrates with Application Auto Scaling which lets you manage provisioned concurrency for your functions based on a schedule or on utilization. Managing your concurrency limits makes sure that your Lambda functions will run properly, and that they don't scale out of control.

References:
https://docs.aws.amazon.com/lambda/latest/dg/configuration-concurrency.html
https://aws.amazon.com/about-aws/whats-new/2017/11/set-concurrency-limits-on-individual-aws-lambda-functions/
https://tutorialsdojo.com/aws-lambda/

Maximum Memory Allocation and Timeout Duration

AWS Lambda allocates CPU power in proportion to the amount of memory you configure for a single function. And each function also has a timeout setting, which is the amount of time a single function execution is allowed to complete before a timeout is returned. For every Lambda function, you can indicate the maximum memory you'd like to allocate for a single execution as well as the execution duration of the function before timing out. The amount of memory you can allocate for a function is between 128 MB and 10,240 MB in 1-MB increments. At 1,769 MB, a function has the equivalent of one vCPU. For the timeout, the default is three seconds, and the maximum allowed value is 900 seconds or 15 mins.

Knowing this, some might think "*Why not just allocate the maximum memory and timeout for all Lambda functions*?" Well, first of all, allocating large amounts of memory when you don't need it will result in an increase in cost. You are charged an amount corresponding to your memory allocation for every 1ms that your function runs per execution. Same goes with your timeout settings. Aside from being billed for the duration of your function executions, there are cases where an application should fail fast. Choosing the optimal memory and timeout settings can be difficult to gauge for a new function, but with a few test runs and metric data in CloudWatch, you should be able to determine what works best for you.



References:
https://docs.aws.amazon.com/lambda/latest/dg/configuration-console.html
https://docs.aws.amazon.com/lambda/latest/dg/configuration-memory.html
https://docs.aws.amazon.com/whitepapers/latest/serverless-architectures-lambda/timeout.html

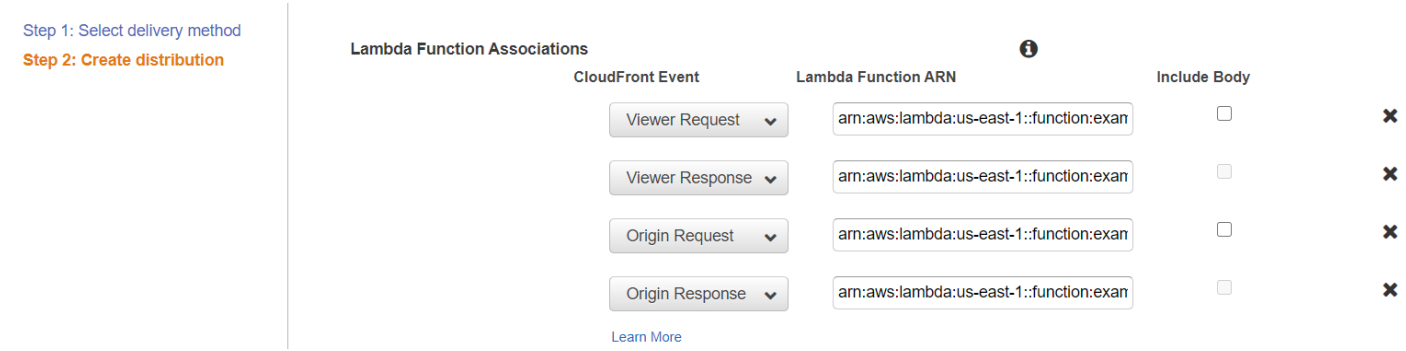
Lambda@Edge Computing

Lambda@Edge is a feature of Amazon CloudFront that lets you run Lambda code at edge locations around the world. Since this is a feature powered by both Lambda and CloudFront, there is no infrastructure to maintain or deploy. You only need to provide your Node JS or Python code and configure the type of CloudFront requests that your function will respond to, and AWS handles the provisioning and scaling of everything else needed by your code.

Your Lambda@Edge functions can be triggered in response to certain types of CloudFront requests:

- After CloudFront receives a request from an end user or device (**viewer request**)
- Before CloudFront forwards the request to the origin (**origin request**)
- After CloudFront receives the response from the origin (**origin response**)
- Before CloudFront forwards the response to an end user or device (**viewer response**)

A CloudFront distribution can have multiple Lambda functions associated with it. Lambda@Edge simplifies and speeds up a lot of basic tasks since the code execution does not need to be routed all the way to your application's location before it can send back a response. Associating a Lambda function to your CloudFront distribution is fairly straightforward. You just need to choose the type of trigger for your Lambda function, and input the corresponding Lambda function ARN. You can associate your Lambda functions during the creation of your CloudFront distribution, or modify an existing distribution.



A few examples on how you can use Lambda@Edge include:

1) Send different objects to your users based on the User-Agent header, which contains information about the device that submitted the request.
2) Inspect headers or authorized tokens, inserting a corresponding header and allowing access control before forwarding a request to the origin.
3) Add, delete, and modify headers, and rewrite the URL path to direct users to different objects in the cache.
4) Generate new HTTP responses to do things like redirect unauthenticated users to login pages, or create and deliver static web pages.

The difference between Lambda@Edge and Lambda with an API Gateway solution is that API Gateway and Lambda are regional services. Using Lambda@Edge and Amazon CloudFront allows you to execute logic across multiple AWS locations based on where your end viewers are located.

References:
https://docs.aws.amazon.com/lambda/latest/dg/lambda-edge.html
https://aws.amazon.com/lambda/edge/
https://tutorialsdojo.com/aws-lambda/

Connecting Your Lambda Function To Your VPC

There are some cases when your Lambda functions need to interact with your AWS resources. This is fairly easy to do if they are accessible via the public internet such as an Amazon S3 bucket or a public EC2 instance. But for private resources, you need to take some extra steps. By default, AWS Lambda is not able to access resources in a VPC. A Lambda function cannot properly resolve network traffic to your private subnets. This is especially frustrating when you need your Lambda function to connect to an RDS database for example. To grant VPC connectivity to your Lambda functions, you must join them to your VPC, choose the subnets that your functions should have access to, and specify the necessary security groups that will allow communication between your VPC resources.

When you connect a function to a VPC, Lambda creates an elastic network interface for each subnet you included in your function's VPC configuration. Multiple functions connected to the same subnets share network interfaces. Lambda uses your function's permissions to create and manage network interfaces. Therefore, your function's execution role must have the same permissions under the **AWSLambdaVPCAccessExecutionRole** IAM Role. Once you've connected your functions to a VPC, your functions will cease to have public internet access unless your VPC has an internet gateway and/or a NAT (depending on which subnets you link your functions). You can also utilize VPC endpoints to connect to certain AWS services if NAT is an expensive option.

You can configure a Lambda function to be part of a VPC immediately at creation, or edit the VPC settings of an existing function. AWS recommends that you choose at least two subnets for high availability. If the AZ of a subnet becomes unavailable, and your Lambda function is running in this subnet, then your function cannot be invoked.

References:
https://docs.aws.amazon.com/lambda/latest/dg/configuration-vpc.html
https://aws.amazon.com/blogs/compute/announcing-improved-vpc-networking-for-aws-lambda-functions/

Amazon Simple Storage Service (S3)

S3 Standard vs S3 Standard-IA vs S3 One Zone-IA vs S3 Intelligent Tiering

	S3 Standard	S3 Standard-Infrequent Access (IA)	S3 One Zone-Infrequent Access (IA)	S3 Intelligent Tiering
Features	General-purpose storage of frequently accessed data	For long-lived, rapid but less frequently accessed data; data is stored redundantly in multiple AZs	For long-lived, rapid but less frequently accessed data; data is stored redundantly in only one AZ of your choice	For long-lived data that have unpredictable access patterns
Durability	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)
Availability	99.99%	99.9%	99.5%	99.9%
Availability SLA	99.9%	99%	99%	99%
Number of Availability Zones	At least 3	At least 3	Only 1	At least 3
Minimum capacity charge per object	N/A	128KB	128KB	N/A
Minimum storage duration charge	N/A	30 days	30 days	30 days
Inserting data	Directly PUT into S3 Standard	Directly PUT into S3 Standard-IA or set Lifecycle policies to transition objects from the S3 Standard to the S3 Standard-IA storage class.	Directly PUT into S3 One Zone-IA or set Lifecycle policies to transition objects from the S3 Standard to the S3 One Zone-IA storage class.	Directly PUT into S3 Intelligent-Tiering or set Lifecycle policies to transition objects from the S3 Standard to the S3 Intelligent-Tiering storage class.
Retrieval fee	N/A	per GB retrieved	per GB retrieved	N/A
First byte latency	milliseconds	milliseconds	milliseconds	milliseconds
Storage transition	S3 Standard to all other S3 storage types including Glacier	S3 Standard-IA to S3 One Zone-IA or S3 Glacier	S3 One Zone-IA to S3 Glacier	S3 Intelligent to S3 One Zone-IA or S3 Glacier
Use Cases	Cloud applications, dynamic websites, content distribution, mobile and gaming applications, and big data analytics.	Ideally suited for long-term file storage, older sync and share storage, and other aging data.	For infrequently-accessed storage, like backup copies, disaster recovery copies, or other easily recreatable data.	Data with unknown or changing access patterns, optimize storage costs automatically, and unpredictable workloads

Additional Notes:

- Data stored in the S3 One Zone-IA storage class will be lost in the event of AZ destruction.
- S3 Standard-IA costs less than S3 Standard in terms of storage price, while still providing the same high durability, throughput, and low latency of S3 Standard.
- S3 One Zone-IA has 20% less cost than Standard-IA.
- It is recommended to use multipart upload for objects larger than 100MB.

Accessing S3 Buckets Publicly and Privately

By default, a newly created S3 bucket and the objects you upload in it will not be publicly accessible. Users who need access to your S3 bucket and objects will need to be granted explicit permissions from the bucket owner or from an administrator. To provide access to users and other services, you can create resource-based policies such as bucket policies and access control policies that define who has access to what. AWS users

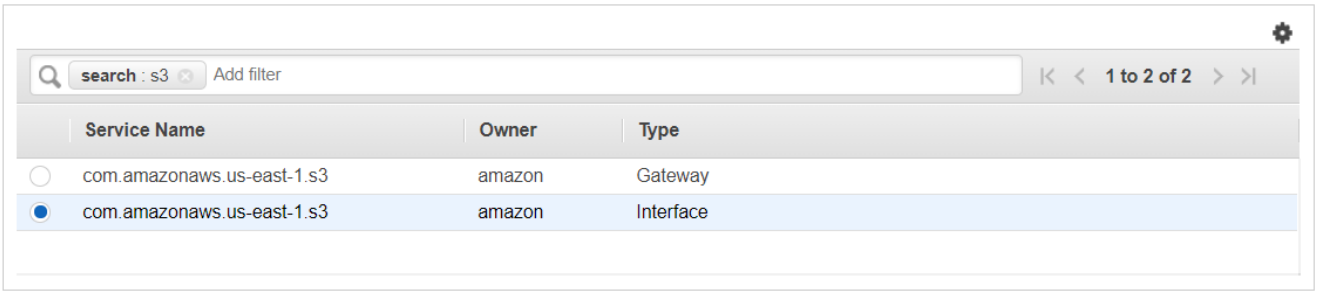
will also need the appropriate IAM permissions before they can perform any actions on your bucket and objects.

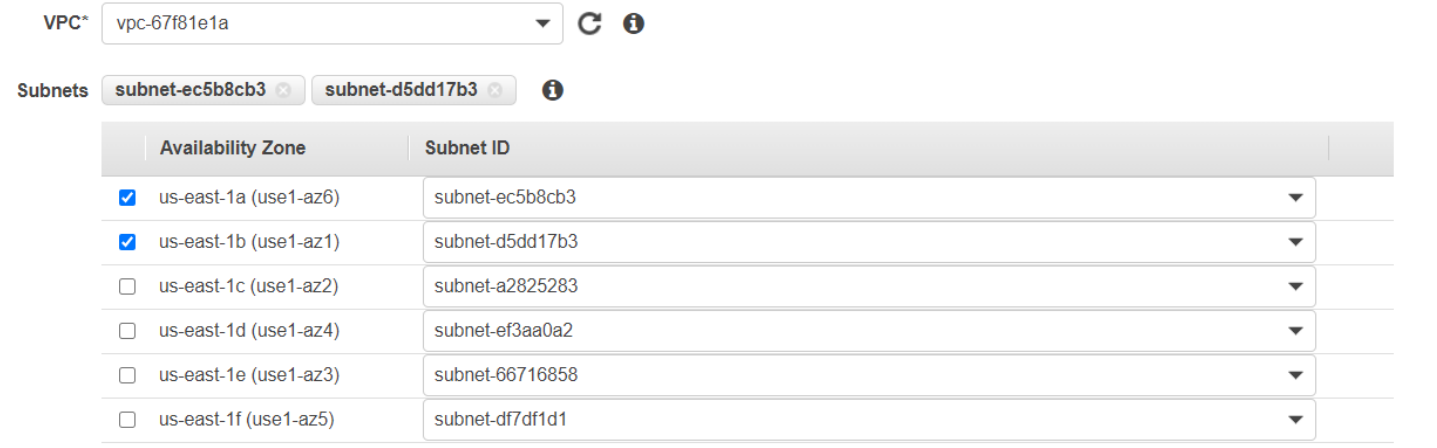
We know that once a user is provided access to an S3 bucket and its contents, all API activity on this bucket will pass through the public internet. This is true whether the request originates from within an AWS VPC or not. That is why your S3 bucket requires a unique name, to uniquely identify it with a publicly accessible S3 URL. But what if you prefer accessing S3 privately from within your VPC? What if you cannot afford having the data pass through the public internet? The first thing you'll need to do is create a VPC endpoint.

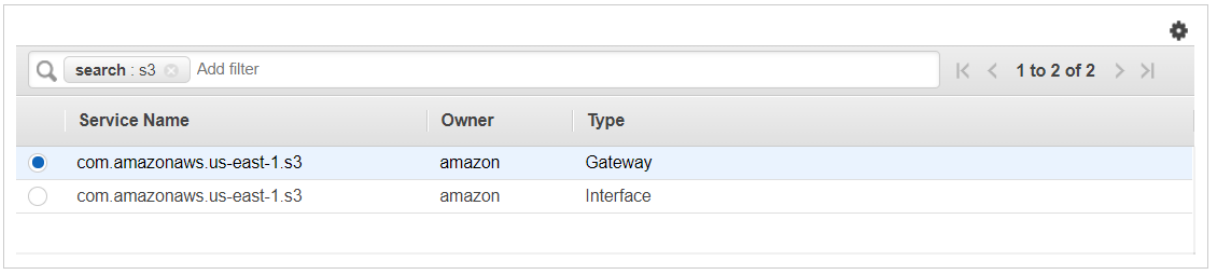
A VPC endpoint is a virtual device that allows your VPC resources to access AWS services directly without leaving the AWS network. VPC endpoints are powered by AWS PrivateLink, which enables you to privately access services by using their private IP addresses. Your VPC resources do not need to have public IP addresses to connect to Amazon S3 when using a VPC endpoint. To create a VPC endpoint, you first choose what type of endpoint you wish to use to access Amazon S3:

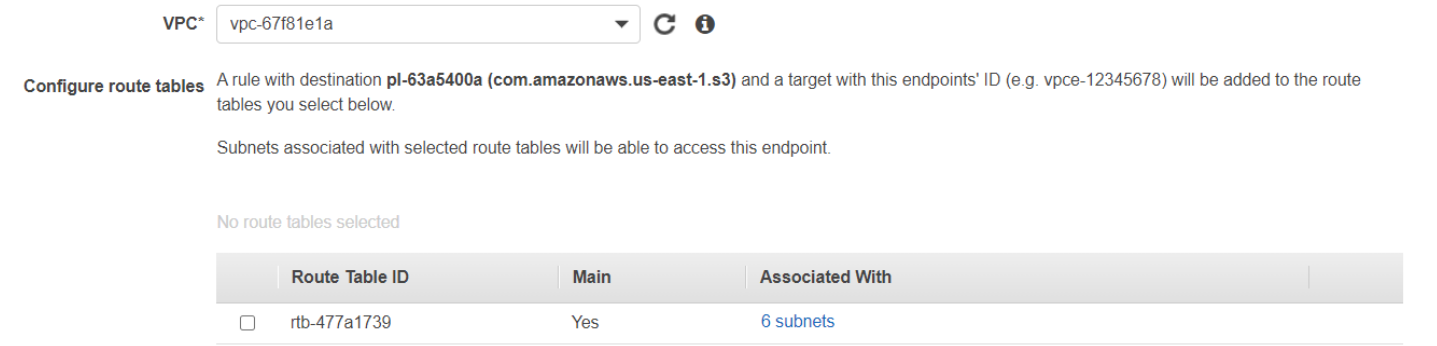
- An **interface endpoint** is an elastic network interface with a private IP address from the IP address range of the subnet(s) where you choose to deploy the ENI(s). Interface endpoints allow access from on-premises if it is connected to your VPC. It also allows access from resources that belong in a different region from your S3 bucket. You are billed for each interface endpoint you create.
- A **gateway endpoint** is a gateway that you specify in your route table(s) to direct traffic to S3. Gateway endpoints do not allow access from on-premises networks, and do not support cross-region access. Gateway endpoints are free of charge.

Next, you select the VPC you wish to associate your endpoint with. If you choose the interface endpoint option, you indicate which AZs and subnets to launch your endpoints in. You also select the security groups that are going to be attached to the ENIs. If you choose the gateway endpoint option, you indicate the route tables that will have a route to the endpoint.

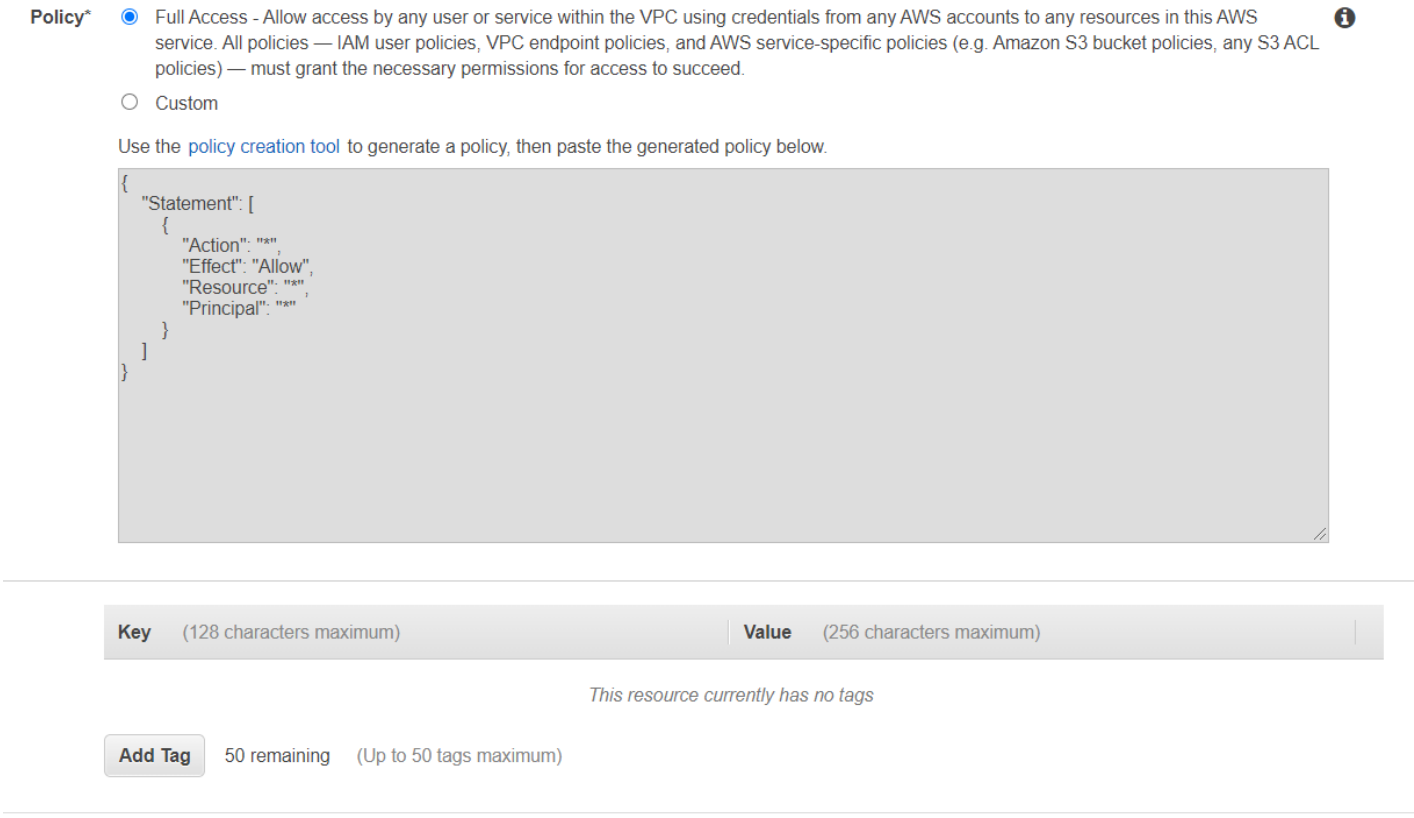








Optionally, you can create an access policy specifying the S3 buckets your endpoint will have access to, the principals that will be able to use your endpoint, and the actions they can make through your endpoint. You can also add tags to your endpoints.



Once you have created your endpoint, be sure to update your bucket policy with a condition that allows users to access the S3 bucket when the request is from the VPC endpoint.

References:
https://docs.aws.amazon.com/AmazonS3/latest/userguide/access-control-overview.html
https://docs.aws.amazon.com/AmazonS3/latest/userguide/privatelink-interface-endpoints.html
https://tutorialsdojo.com/amazon-s3/

Amazon S3 Bucket Features

In this section, we will tackle the features available in an S3 Bucket:

Lifecycle policies — These policies determine how your objects are stored in your S3 bucket. As you know, there are many S3 storage tiers to choose from. Lifecycle policies let you transition your objects from one storage tier to another, usually to reduce storage cost or to archive an object. Lifecycle policies are also used to

expire versioned objects and permanently delete them from your bucket. When creating a lifecycle policy, you configure two parameters for each transition or deletion action:

- Whether the policy should apply to all objects in the bucket or only a group of objects with matching prefix
- The number of days after object creation before the action is applied

S3 Bucket Policies and ACLs — S3 bucket policies are JSON-based policies used for access control. They work similarly to IAM policies, but are instead applied onto your S3 buckets rather than individual IAM users. You add a bucket policy to a bucket to grant other AWS accounts or IAM users access permissions for the bucket and the objects in it. Access control lists (ACLs), on the other hand, are preset options that you can enable to allow read and/or write access for other AWS accounts, users or the public.

Object Ownership — If you have external users uploading objects to a bucket you own, you can enable bucket-owner-full-control canned access control list (ACL) to automatically assume full ownership over the objects they upload.

Multipart Upload — For objects larger than 100MB, you can use S3's multipart upload feature to divide your file into parts and upload them individually. After all parts of your object are uploaded, S3 assembles these parts and creates the object. Multipart upload offers multiple benefits such as faster throughput thanks to parallel upload, retransmission for failed uploads, pause and resume upload capabilities, and better stability for uploading files with unknown file sizes.

S3 Transfer Acceleration — S3 TA leverages Amazon CloudFront's globally distributed edge locations to optimize long distance transfers from your client to Amazon S3. Although there is no guarantee that you will experience faster transfer speeds, S3 TA only bills you when there is an improvement compared to a regular S3 transfer. Using S3 TA is as simple as enabling it in your S3 bucket. S3 Transfer Acceleration also supports all bucket level features including multipart upload.

Static Web Hosting — An S3 bucket can be made to host static files such as images and webpages. Since an S3 bucket is public, you can configure it as a website, using the S3 URL as your domain name. This feature is convenient if you only need a simple and cost-effective webpage to get you going. When you configure your S3 bucket as a static website, make sure to set your objects as publicly available too. Amazon S3 website endpoints do not support HTTPS or access points. You will need to add a CloudFront to use HTTPS. You can also provide your static website a custom domain name using a DNS record in Route 53 pointing to your S3 bucket URL. For this matter, the domain name and the name of the S3 bucket must be an exact match.

Versioning — Versioning lets you keep a copy of an object whenever it is overwritten as its *versions*. You can preserve and restore back to a specific version of an object if you need to. This feature also protects your objects from accidental deletions, since versioning places deletion markers on an object version to mark it as removed, rather than permanently deleting it from your S3 bucket. By default, versioning is disabled on buckets, and you must explicitly enable it. Once it has been enabled, it cannot be disabled, but it can be suspended.

When you suspend versioning, any future updates on your objects will not create a new version, but existing versions will still be retained. Since a version of an object also takes up storage space, versioning will incur additional S3 costs, so only use this feature if you need it.

MFA Delete — MFA delete is a security feature that is used together with S3 Versioning to prevent unauthorized or accidental deletions in your S3 bucket. When enabled, the bucket owner must include two forms of authentication in any request to delete an object version or change the versioning state of the bucket. These two forms of authentication are his/her security credentials and the concatenation of a valid serial number, a space, and the six-digit MFA code.

Cross-Region Replication and Same-Region Replication — Replication is a feature that allows you to replicate objects from an S3 bucket in one region to another bucket in the same region or in another region. Buckets that are configured for object replication can be owned by the same AWS account or by different accounts. Objects can be replicated to multiple destination buckets. By default, S3 replication does not replicate existing objects, only objects that have been uploaded after replication was enabled. You must contact AWS Support Center if you intend to replicate existing objects.

Object Lock — Allows you to store objects using a write-once-read-many (WORM) model. Object lock prevents an object from being deleted or overwritten for a fixed amount of time or indefinitely.

S3 Event Notifications — This lets you receive notifications on certain events that occur in your S3 bucket. To enable notifications, you must first add a notification configuration that identifies the events you want S3 to publish and the destinations (SNS, SQS, Lambda) where you want the notifications to be sent. Amazon S3 can publish notifications for the following events:

- New object created events
- Object removal events
- Restore object events
- Replication events

Cross-origin Resource Sharing (CORS) — CORS is a way for client applications that are loaded in one domain to interact with resources in a different domain. When this feature is disabled, requests directed to a different domain will not work properly. If your S3 bucket is used for web hosting, verify if you need to enable CORS. To configure your bucket to allow cross-origin requests, you create a CORS configuration document. This is a document with rules that identify the origins that you will allow to access your bucket, the operations (HTTP methods) that will support each origin, and other operation-specific information.

Presigned URLs - By default, all S3 buckets and objects are private, and can only be accessed by the object owner. Object owners can share objects with other users or enable users to upload objects to their S3 buckets using a presigned URL. A presigned URL grants others time-limited permission to download or upload objects from and to the owner's S3 buckets. When object owners create presigned URLs, they need to specify their security credentials, the bucket name and object key, the HTTP method (GET to download the object), and

expiration date and time. The bucket owner then shares these URLs to those who need access to the objects or to the buckets. A presigned URL can be used many times, as long as it has not expired.

References:
https://docs.aws.amazon.com/AmazonS3/latest/userguide/Welcome.html
https://tutorialsdojo.com/amazon-s3/

Amazon S3 Pricing Details

Some storage tiers in Amazon S3 have minimum usage requirements that may affect your billing if you are unaware of them.

Storage Tier	S3 Standard	S3 Intelligent Tiering	S3 Infrequent Access	S3 One Zone-IA	S3 Glacier	S3 Glacier Deep Archive
Minimum capacity charge per object	None	None	128 KB	128 KB	40 KB	40 KB
Minimum storage duration charge	None	30 days	30 days	30 days	90 days	180 days
Retrieval fee	None	None	per GB retrieved	per GB retrieved	per GB retrieved	per GB retrieved

Minimum capacity charge per object means that an object should meet the specified minimum size once stored in the corresponding storage tier. If the object is less than the specified minimum then the object is billed according to the minimum size requirement. For example, if the minimum capacity charge is 128KB and your object is 40KB only then it is billed as a 128KB object by Amazon S3.

Minimum storage duration charge is the amount of time that the object should be stored in the corresponding storage tier. If the object is deleted before the duration passes then the object is billed as if it was stored for the whole minimum duration. For example, if you have a 128KB object stored in S3 IA for 15 days and you delete it the next day, Amazon S3 will continue to charge you an equivalent of storing a 128KB file for the next 15 days.

References:

https://aws.amazon.com/s3/storage-classes/
https://tutorialsdojo.com/amazon-s3/

Amazon S3 Encryption Methods

When you are using Amazon S3, it is always important to know how you can protect your data, especially if it contains sensitive information. Amazon S3 offers both Server-Side encryption and Client-Side encryption to secure your objects at rest and in-transit.

- **With Server-Side encryption (SSE)**, Amazon S3 encrypts your object before saving it on disks in its data centers and then decrypts it when you download the objects. You have three different options on how you choose to manage the encryption keys.
    - **With Amazon S3-Managed Keys (SSE-S3)** — S3 uses AES-256 encryption keys to encrypt your objects, and each object is encrypted with a unique key.
    - **With Customer Master Keys (CMKs) stored in AWS Key Management Service (SSE-KMS)** — Similar to SSE-S3, but your key is managed in a different service, which is AWS KMS. SSE-KMS provides you with an audit trail that shows when your CMK was used and by whom. Additionally, you can create and manage customer managed CMKs or use AWS managed CMKs that are unique to you, your service, and your Region.
    - **With Customer-Provided Keys (SSE-C)** — You manage the encryption keys and S3 manages the encryption and decryption process.
- **With Client-Side encryption (CSE)**, data is first encrypted on the client-side before uploaded to Amazon S3. You manage the encryption process, the encryption keys, and related tools. The encryption key you use can be any of the following:
    - Customer master key (CMK) stored in AWS KMS.
    - Master key that you store within your application.

References:
https://docs.aws.amazon.com/AmazonS3/latest/userguide/UsingEncryption.html
https://tutorialsdojo.com/amazon-s3/

Amazon S3 Glacier

Amazon S3 Glacier vs Amazon S3 Glacier Deep Archive

Amazon S3 Glacier Deep Archive is similar to Amazon S3 Glacier in that they are both storage classes built for archiving objects that you won't need again for a long time. Deep Archive offers a more competitive price point than S3 Glacier if your primary requirement is a durable and secure long-term storage for large amounts of data, but the tradeoff is that retrieval times take longer to finish. To make the comparison of these two storage classes simpler, we'll list down the key similarities and differences in two parts.

Similarities:

- Low cost storage option for archiving cold data that won't be retrieved often.
- Supports lifecycle policies to transition objects from S3 Standard, Standard-IA, OneZone-IA and Intelligent Tiering to Glacier and Glacier Deep Archive.
- Offers durability of 99.999999999% of objects across three or more Availability Zones with 99.99% availability.
- You may use the S3 API to directly upload objects to these storage classes.
- Objects that are stored in the S3 Glacier or S3 Glacier Deep Archive storage classes are not available in real time.
- When you initiate a restore request, a temporary copy of the object is made available for the duration that you specify in the request.
- Support for Object Lock and Cross-Region Replication features.
- Supports backing up tape drives through AWS Storage Gateway Tape Gateway and Amazon Snow devices.
- To maximize cost savings, objects to be archived should be at least 40 KB in size.
- You are billed for the number of retrieval requests you make and the size of your data retrievals per GB.
- Both are backed by Amazon S3 SLA.

Differences:

- You can transition objects from S3 Glacier to S3 Glacier Deep Archive but not the other way around.
- S3 Glacier offers three types of retrieval options: **Expedited** (takes 1–5 minutes to finish but only if AWS has enough retrieval capacity), **Standard** (3–5 hours) and **Bulk** (5–12 hours).
- S3 Glacier Deep Archive offers two types of retrieval options: **Standard** (finishes within 12 hours) and **Bulk** (within 48 hours).
- To maximize cost savings, you need to keep your objects archived in Glacier for at least 90 days, while Glacier Deep Archive requires at least 180 days.

References:
https://docs.amazonaws.cn/en_us/AmazonS3/latest/userguide/storage-class-intro.html
https://aws.amazon.com/s3/pricing/

AWS Storage Gateway

Moving Data From AWS Storage Gateway to Amazon S3 Glacier

We already know that you can transition objects in Amazon S3 to a different storage tier such as Amazon S3 Glacier using lifecycle policies. What you might not know is that you can also move data from AWS Storage Gateway to Amazon S3 Glacier. AWS Storage Gateway is a service that connects your on-premises access to virtually unlimited storage with S3. You just need the AWS Storage Gateway VM or physical device to act as a literal gateway. Data transfers are encrypted with SSL so you can rest assured that the transport is secure.

There are three types of Storage Gateway types that you can use: **File Gateway**, **Volume Gateway**, and **Tape Gateway**. File Gateway lets you access your S3 buckets via a file interface using SMB or NFS protocol, as if S3 was a file share you can mount. Volume Gateway provides an iSCSI target, which enables you to create block storage volumes and mount them as iSCSI devices. You can take snapshots of your volumes and use them to create new EBS volumes. Lastly, Tape Gateway is a cloud-based Virtual Tape Library. Your backup application can read data from or write data to virtual tapes by mounting them to virtual tape drives using the virtual media changer. Tape Gateway is usually used for archival purposes.

In this section, we'll be discussing File Gateway and Tape Gateway, which are the two services that can store data to Amazon Glacier.

Tape Gateway has the more obvious explanation. Since Tape Gateway is primarily used for archival, your archived tapes are sent to S3 Glacier or S3 Glacier Deep Archive, but not immediately. Data on your virtual tapes are first stored in a virtual tape library in S3 Standard while your backup application is writing data to tapes. After you eject the tapes from the backup application, they are then archived to S3 Glacier or S3 Glacier Deep Archive depending on what you choose. You can also store your tapes in S3 Glacier first then move them to Deep Archive later on.

File Gateway has an indirect approach to storing data in S3 Glacier. As mentioned earlier, File Gateway presents S3 via a file interface. You can move files between your application and S3 easily through this interface. File Gateway can use S3 Standard, S3 Standard-IA, or S3 One Zone-IA storage classes. Once you have stored your files in your S3 bucket, you can configure a bucket lifecycle policy to move your files to S3 Glacier or S3 Glacier Deep Archive. However, doing so will prevent you from retrieving the file through File Gateway again. You must restore the file from S3 Glacier first before you can retrieve it.

References:
https://aws.amazon.com/storagegateway/faqs/
https://tutorialsdojo.com/aws-storage-gateway/

Integrating AWS Storage Gateway to an Active Directory

AWS Storage Gateway File Gateway allows you to create an SMB file share that can be mounted on your Windows instances. You can configure either Microsoft Active Directory (AD) or guest access for authentication. To set up your SMB file share Microsoft AD access settings, perform the following:

1. Go to the Active Directory settings of your SMB file share.
2. Enter the Domain Name of the domain that you want the gateway to join. You can connect to your self-managed AD (running in the cloud or on-prem) or connect to AWS Directory Service.
3. Enter a set of domain credentials that has permissions to join a server to a domain.
4. You can optionally specify an organizational unit to place your SMB file share.
5. You can optionally indicate a set of domain controllers.
6. Finish the process by saving your changes.

Connecting your File Gateway file share to an Active Directory has many uses. First, the feature allows your users to authenticate with your AD before they can access the file share. Furthermore, you can create a list of AD users and groups that will have administrator rights to the file share. Lastly, you can provide a list of AD users or groups that you want to allow or deny file share access.

References:
https://docs.aws.amazon.com/storagegateway/latest/userguide/managing-gateway-file.html
https://tutorialsdojo.com/aws-storage-gateway/

Amazon Elastic Block Store (EBS)

SSD vs HDD Type Volumes

On a given volume configuration, certain I/O characteristics drive the performance behavior for your EBS volumes. SSD-backed volumes, such as General Purpose SSD (gp2, gp3) and Provisioned IOPS SSD (io1,io2), deliver consistent performance whether an I/O operation is random or sequential. HDD-backed volumes like Throughput Optimized HDD (st1) and Cold HDD (sc1) deliver optimal performance only when I/O operations are large and sequential.

In the exam, always consider the difference between SSD and HDD as shown on the table below. This will allow you to easily eliminate specific EBS-types in the options which are not SSD or not HDD, depending on whether the question asks for a storage type which has ***small, random*** I/O operations or ***large, sequential*** I/O operations.

FEATURES	SSD Solid State Drive	HDD Hard Disk Drive
Best for workloads with:	*small, random* I/O operations	*large, sequential* I/O operations
Can be used as a bootable volume?	Yes	No
Suitable Use Cases	- Best for transactional workloads - Critical business applications that require sustained IOPS performance - Large database workloads such as MongoDB, Oracle, Microsoft SQL Server and many others…	- Best for *large streaming workloads* requiring consistent, fast throughput at a low price - Big data, Data warehouses, Log processing - Throughput-oriented storage for large volumes of data that is *infrequently* accessed
Cost	moderate / high	low
Dominant Performance Attribute	IOPS	Throughput (`MiB/s`)

Provisioned IOPS SSD (io1,io2) volumes are designed to meet the needs of I/O-intensive workloads, particularly database workloads, that are sensitive to storage performance and consistency. Unlike gp2, which uses a bucket and credit model to calculate performance, an io1 volume allows you to specify a consistent IOPS rate when you create the volume, and Amazon EBS delivers within 10 percent of the provisioned IOPS performance 99.9 percent of the time over a given year. Provisioned IOPS SSD io2 is an upgrade of Provisioned IOPS SSD io1. It offers higher 99.999% durability and higher IOPS per GiB ratio with 500 IOPS per GiB, all at the same cost as io1 volumes.

Volume Name	General Purpose SSD		Provisioned IOPS SSD	
Volume type	gp3	gp2	io2	io1
Description	General Purpose SSD volume that balances price performance for a wide variety of transactional workloads	General Purpose SSD volume that balances price performance for a wide variety of transactional workloads	High performance SSD volume designed for **business-critical** latency-sensitive applications	High performance SSD volume designed for latency-sensitive transactional workloads
Use Cases	Virtual desktops, medium sized single instance databases such as MSFT SQL Server and Oracle DB, low-latency interactive apps, dev & test, boot volumes	Boot volumes, low-latency interactive apps, dev & test	Workloads that require sub-millisecond latency, and sustained IOPS performance or more than 64,000 IOPS or 1,000 MiB/s of throughput	Workloads that require sustained IOPS performance or more than 16,000 IOPS and I/O-intensive database workloads
Volume Size	1 GB – 16 TB	1 GB – 16 TB	4 GB – 16 TB	4 GB – 16 TB
Durability	99.8% – 99.9% durability	99.8% – 99.9% durability	99.999%	99.8% – 99.9%

Max IOPS / Volume	16,000	16,000	64,000	64,000
Max Throughput / Volume	1000 MB/s	250 MB/s	1,000 MB/s	1,000 MB/s
Max IOPS / Instance	260,000	260,000	160,000	260,000
Max IOPS / GB	N/A	N/A	500 IOPS/GB	50 IOPS/GB
Max Throughput / Instance	7,500 MB/s	7,500 MB/s	4,750 MB/s	7,500 MB/s
Latency	single digit millisecond	single digit millisecond	single digit millisecond	single digit millisecond
Multi-Attach	No	No	Yes	Yes

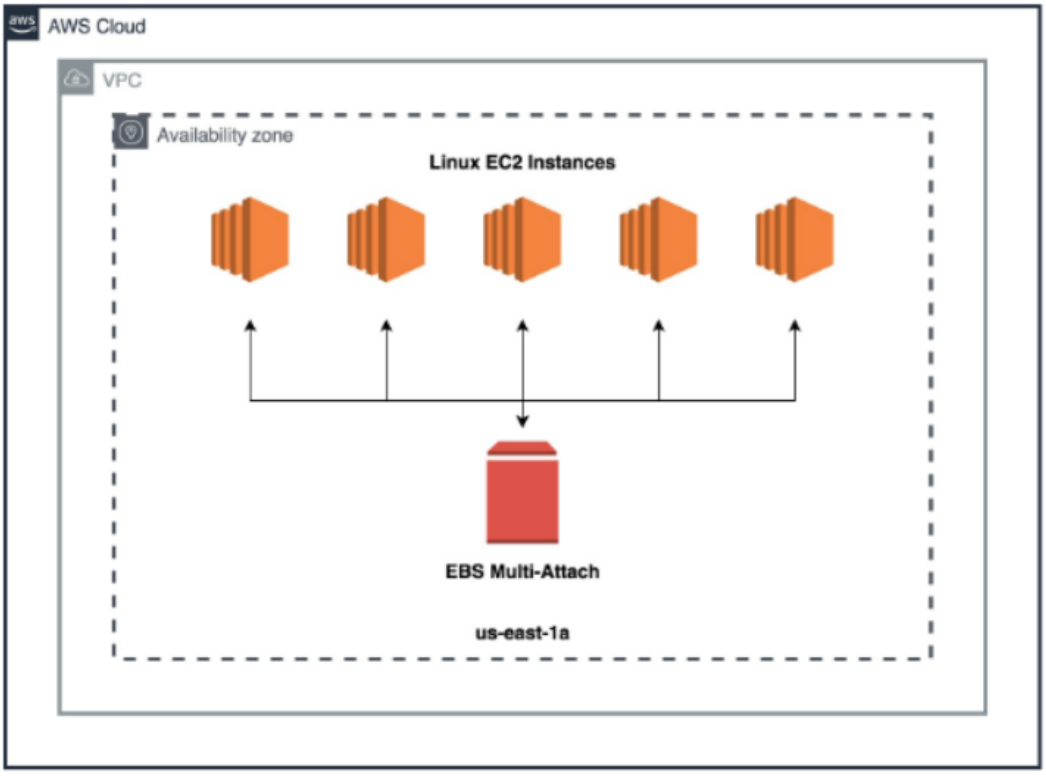
Volume Name	Throughput Optimized HDD	Cold HDD
Volume type	st1	sc1
Description	Low cost HDD volume designed for frequently accessed, throughput-intensive workloads	Throughput-oriented storage for data that is infrequently accessed Scenarios where the lowest storage cost is important
Use Cases	Big data, data warehouses, log processing	Colder data requiring fewer scans per day
Volume Size	125 GB – 16 TB	125 GB – 16 TB
Durability	99.8% – 99.9% durability	99.8% – 99.9% durability
Max IOPS / Volume	500	250
Max Throughput / Volume	500 MB/s	250 MB/s
Max IOPS / Instance	260,000	260,000
Max IOPS / GB	N/A	N/A
Max Throughput / Instance	7,500 MB/s	7,500 MB/s
Multi-Attach	No	No

Amazon EBS Multi-Attach Feature

Our understanding on Amazon EBS volumes is that they are virtual block devices that need to be attached to an Amazon EC2 instance before they can be used. While this is true, did you know that there is a type of EBS volume that you can attach to many EC2 instances simultaneously? Amazon EBS Provisioned IOPS (io1 and io2) volumes are currently the types that support EBS Multi-Attach. Multi-Attach lets you share access to an EBS data volume between up to 16 Nitro-based EC2 instances within the same Availability Zone (AZ). Each attached instance has full read and write permissions to the shared volume.

EBS Multi-Attach is primarily used with Amazon Linux instances. You may also use Multi-Attach with Windows instances, however, Windows does not recognize the data on the volume that is shared between the instances, which can result in data inconsistency. The Multi-Attach feature is not enabled by default. You will have to enable it during volume creation or modify your volume when it has been created already.

Multi-Attach volumes can't be created as boot volumes. Also, for io1 volumes, Multi-Attach can’t be disabled once enabled. You can disable Multi-Attach for io2 volumes but only if it is attached to no more than one instance. If you’d like to modify the volume type of a Multi-Attach enabled volume, you must first disable the feature. Lastly, Multi-Attach enabled volumes are deleted on instance termination if the last attached instance is terminated and if that instance is configured to delete the volume on termination. If the volume is attached to multiple instances that have different delete on termination settings, the last attached instance's setting determines the delete on termination behavior.



AWS sometimes creates solutions that draw a fine line between one service and another to use for your needs. In this case, EBS Multi-Attach closely resembles Amazon EFS in that you can create shared file systems that multiple instances can use concurrently.

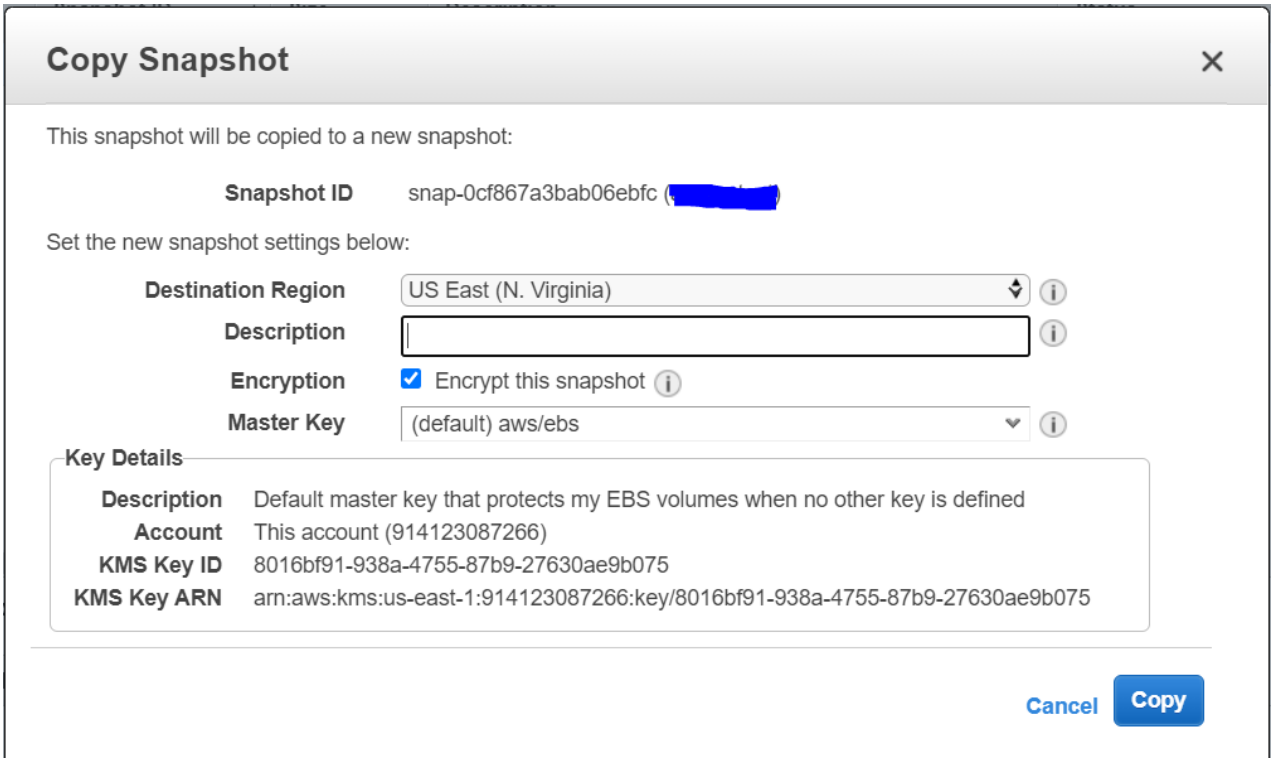
In the exams, whenever you are made to choose between EBS Multi-Attach and Amazon EFS, recall the limitations of EBS Multi-Attach. An example is that Multi-Attach enabled volumes do not support I/O fencing. Your applications must provide write ordering for the attached instances to maintain data consistency. Amazon EFS is more appropriate when you need a filesystem that needs to be concurrently accessed by hundreds to thousands of instances, and more so when these instances belong to different Availability Zones. There are also no limitations to the instance types that can mount EFS filesystems. EFS automatically scales in storage size and performance, unlike in EBS where manual intervention is required. Lastly, Amazon EFS by default provides traditional file permissions model, file locking capabilities, and hierarchical directory structure.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-volumes-multi.html
https://tutorialsdojo.com/amazon-ebs-multi-attach/

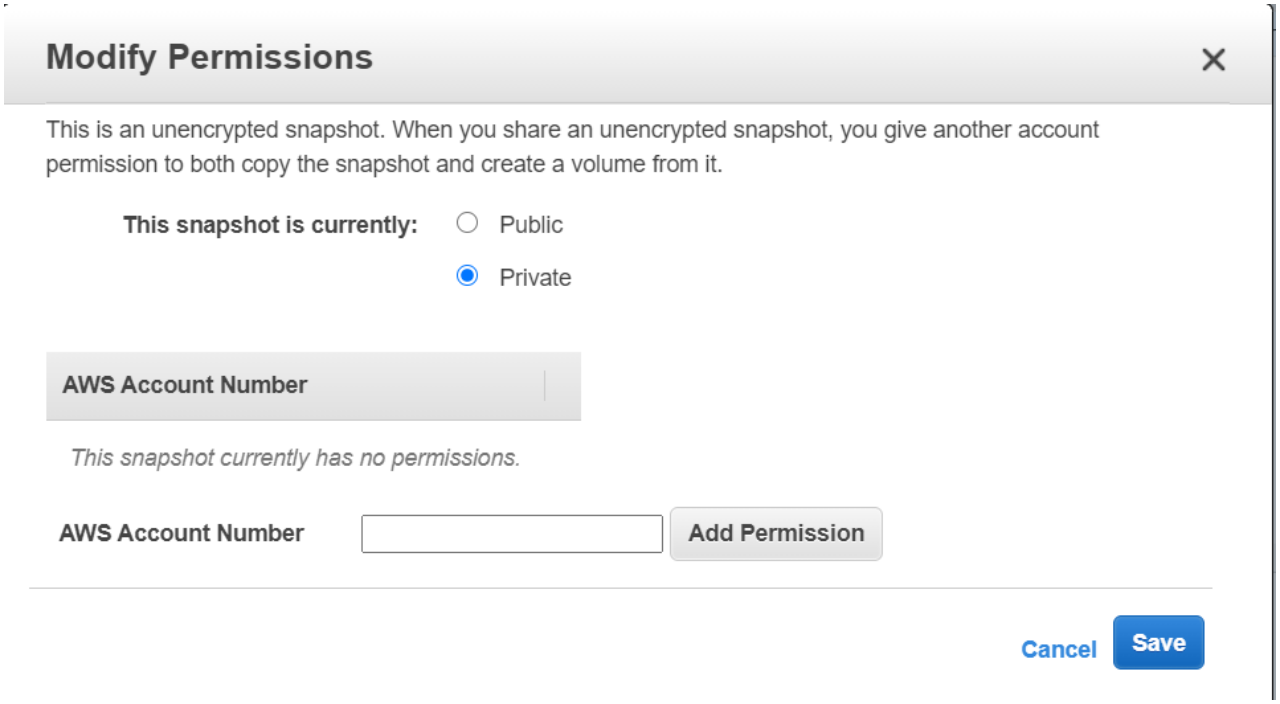
Amazon EBS Copy Snapshots

EBS Snapshots are a very simple but efficient way of taking backups of your EBS volumes in AWS. Snapshots are part of almost every disaster recovery plan, so making sure that they are available and usable when you need them is necessary. Your point-in-time snapshots are kept durably in Amazon S3, which we know is a service that's designed for durability. However, if one needed to restore a snapshot in another region or another AWS account, he/she would not be able to do so. An EBS snapshot is only available in the AWS Region it was created in, and only the account owner has access to the snapshot. If a regional disaster were to occur, you won't be able to use your EBS snapshots to rebuild your infrastructure in your DR region, not unless you copied them over previously.

Amazon EBS lets you copy snapshots from one region to another, or from within the same region. Amazon S3 server-side encryption protects a snapshot's data in transit during a copy operation. Copying snapshots lets you add or modify the encryption settings of that snapshot. This means that you can create copies of a backup with each having a different encryption key.



If you would like another account to be able to copy your snapshot, you can either modify the snapshot permissions to provide access to that account or make the snapshot public so that any AWS account can copy it.



Using snapshot copy within a single account and region does create a new copy of the data and therefore is cost-free as long as the encryption status of the snapshot copy does not change. Though if you copy a snapshot to a new region, or encrypt it with a new encryption key, the resulting snapshot is a complete, non-incremental copy of the original snapshot, which will incur additional storage costs. When you modify the encryption settings during your snapshot copy operation, you must ensure that the target account and/or target instance has permissions to use the encryption key.

Some use cases of copying snapshots include:

1. Regional disaster recovery
2. Data migration
3. Creating a base volume for different applications
4. Create a new volume with new encryption settings
5. Data retention and compliance requirements

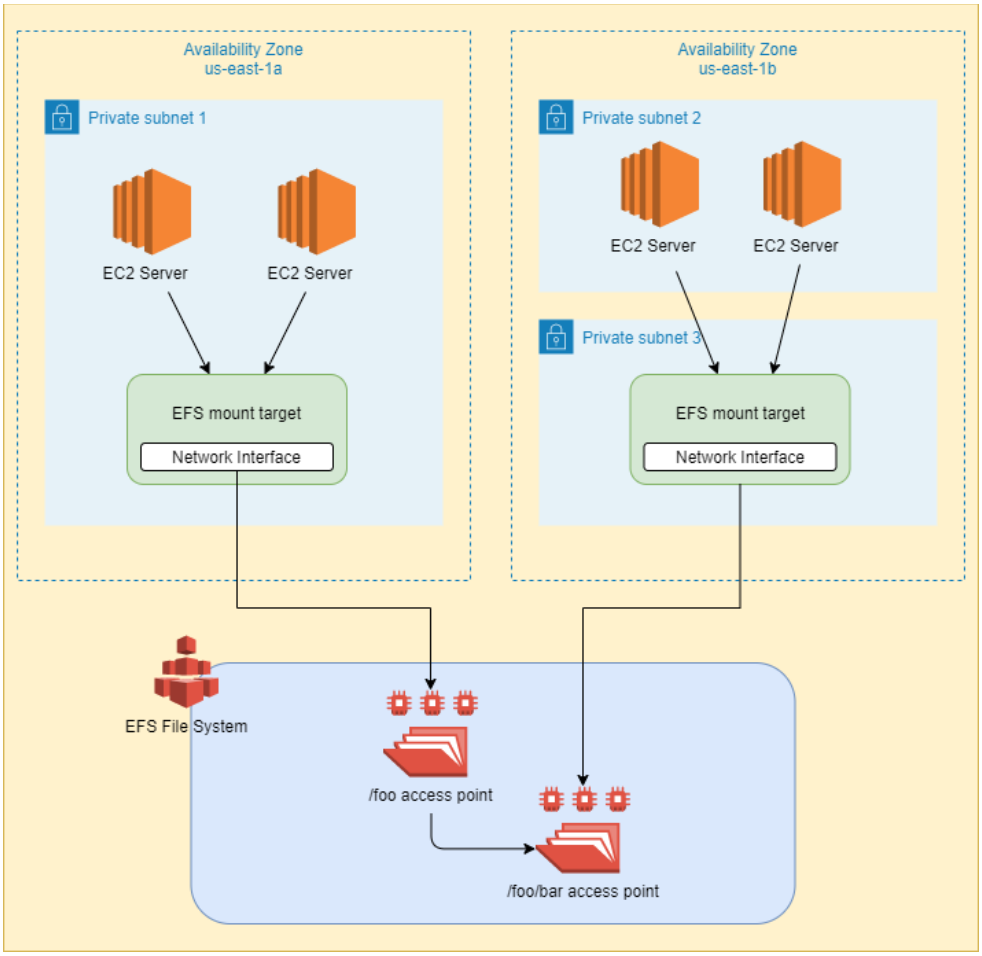
References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-copy-snapshot.html
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-modifying-snapshot-permissions.html

Amazon Elastic File System (EFS)

How To Mount An Amazon EFS File System

Before we dive in on how to mount an EFS file system, let's first go through what composes an EFS file system. Each file system has its own unique identifier, creation token, creation time, file system size in bytes, number of mount targets created for the file system, and the file system lifecycle state. To access your file system from a Linux EC2 instance, ECS container or a Lambda function, you must create mount targets in your VPC. When creating a mount target, you must indicate the Availability Zone at which the mount target will be created and add security groups to control access to your file system. Once done, you will be provided an IP address and a DNS name which you can use in your mount commands.

Another file system property you should know is your access point. An access point applies an operating system user, group, and file system path to any file system request made using the access point. Think of it as the directory where your requests are routed to, and this directory enforces specific access permissions similar to any Linux subdirectory. Access points ensure that an application always uses the correct operating system identity and the correct directory when reading from or writing to the file system.



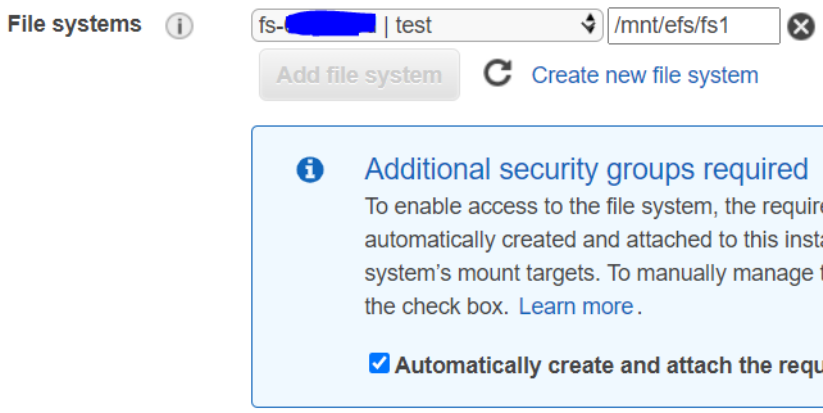
When mounting an EFS file system onto a Linux EC2 instance, the primary tool for this job is the **Amazon EFS mount helper**. To use the mount helper, you simply need to provide the following:

1. The file system ID of the EFS file system to mount
2. An Amazon EFS mount target

You may use any mount target, but if your EC2 instance is running in an AZ different from the mount target, you will incur data transfer charges. You might also experience increased latencies for file system operations. Furthermore, there are multiple ways to mount a mount target:

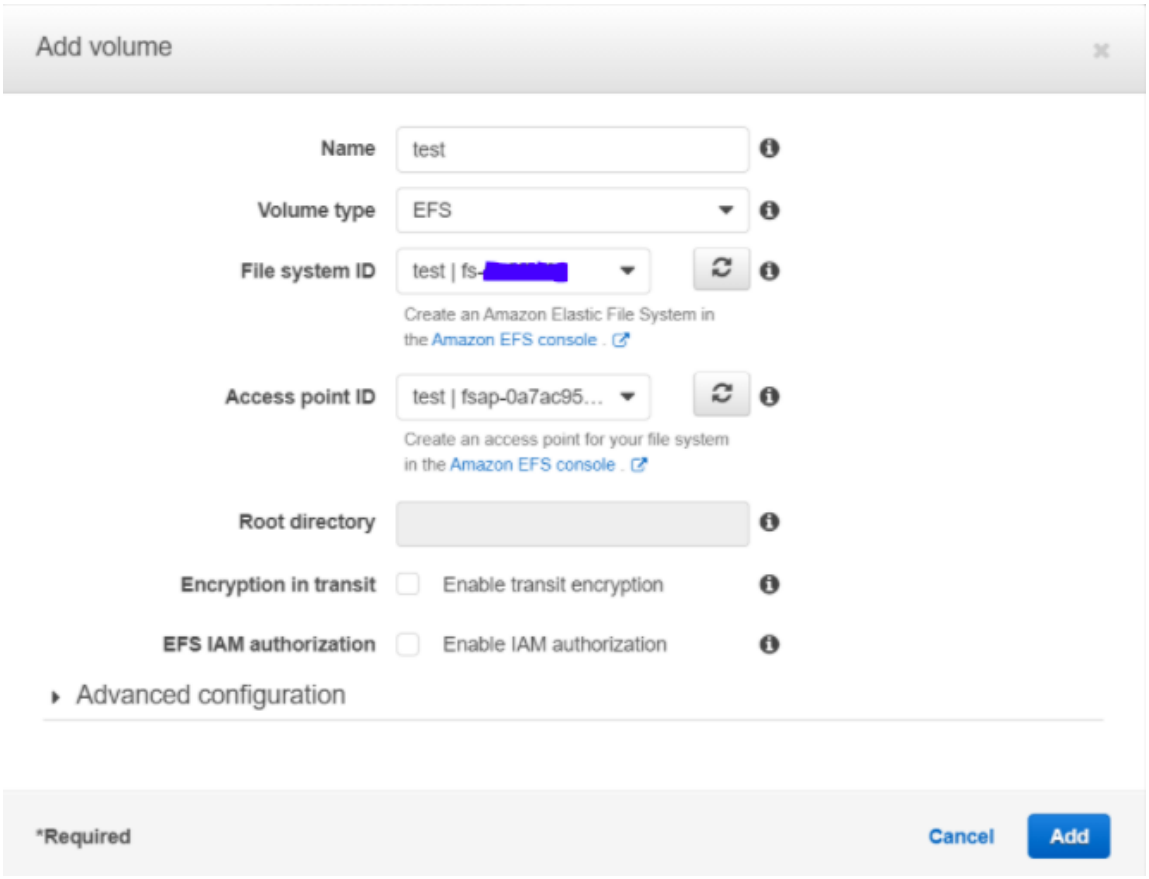
1. You can mount your target as is after you SSH into your instance using the mount command.
2. You can mount your target with a TLS parameter to enable encryption in-transit.
3. You can mount your target with IAM authorization (instance profile or named profile).
4. You can specify an EFS access point in your mount parameters.

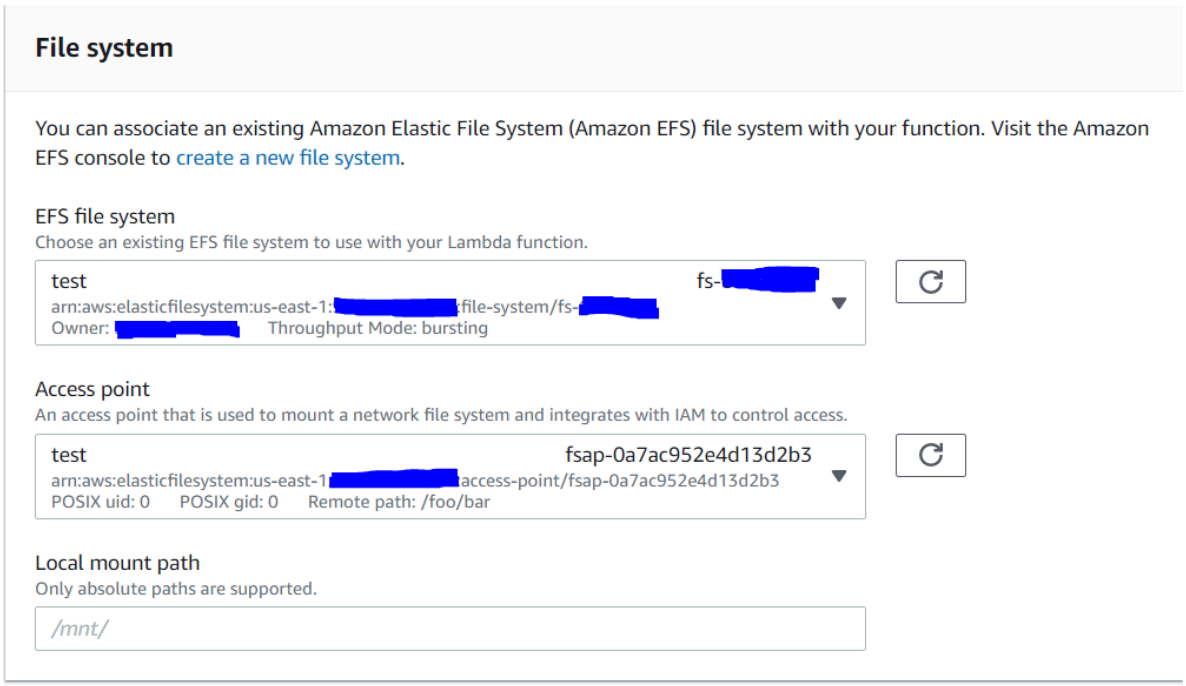
If you prefer to mount your file system immediately at instance launch, you can specify in the configuration details the file system you wish to mount and the mount target that your EC2 instance will use. You can also automatically remount your filesystem after reboots by adding your mount command in /etc/fstab.



Lastly, if you would like to mount your file system without having to SSH into an instance or into multiple EC2 instances, you can use AWS Systems Manager Run Command to execute a shell script for you, and just specify the targets of the script.

For ECS containers and Lambda functions, mounting an EFS file system is as easy as specifying mount points in the ECS task definition's *Add volume* or Lambda function configuration.


Add volume
Name
test
Volume type
EFS
File system ID
test | fs-[redacted]
Create an Amazon Elastic File System in the Amazon EFS console .
Access point ID
test | fsap-0a7ac95...
Create an access point for your file system in the Amazon EFS console .
Root directory
Encryption in transit
Enable transit encryption
EFS IAM authorization
Enable IAM authorization
Advanced configuration
*Required
Cancel
Add


File system
You can associate an existing Amazon Elastic File System (Amazon EFS) file system with your function. Visit the Amazon EFS console to create a new file system.
EFS file system
Choose an existing EFS file system to use with your Lambda function.
test
fs-[redacted]
arn:aws:elasticfilesystem:us-east-1:[redacted]:file-system/fs-[redacted]
Owner: [redacted] Throughput Mode: bursting
Access point
An access point that is used to mount a network file system and integrates with IAM to control access.
test
fsap-0a7ac952e4d13d2b3
arn:aws:elasticfilesystem:us-east-1:[redacted]:access-point/fsap-0a7ac952e4d13d2b3
POSIX uid: 0 POSIX gid: 0 Remote path: /foo/bar
Local mount path
Only absolute paths are supported.
/mnt/

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https://docs.aws.amazon.com/efs/latest/ug/mounting-fs.html
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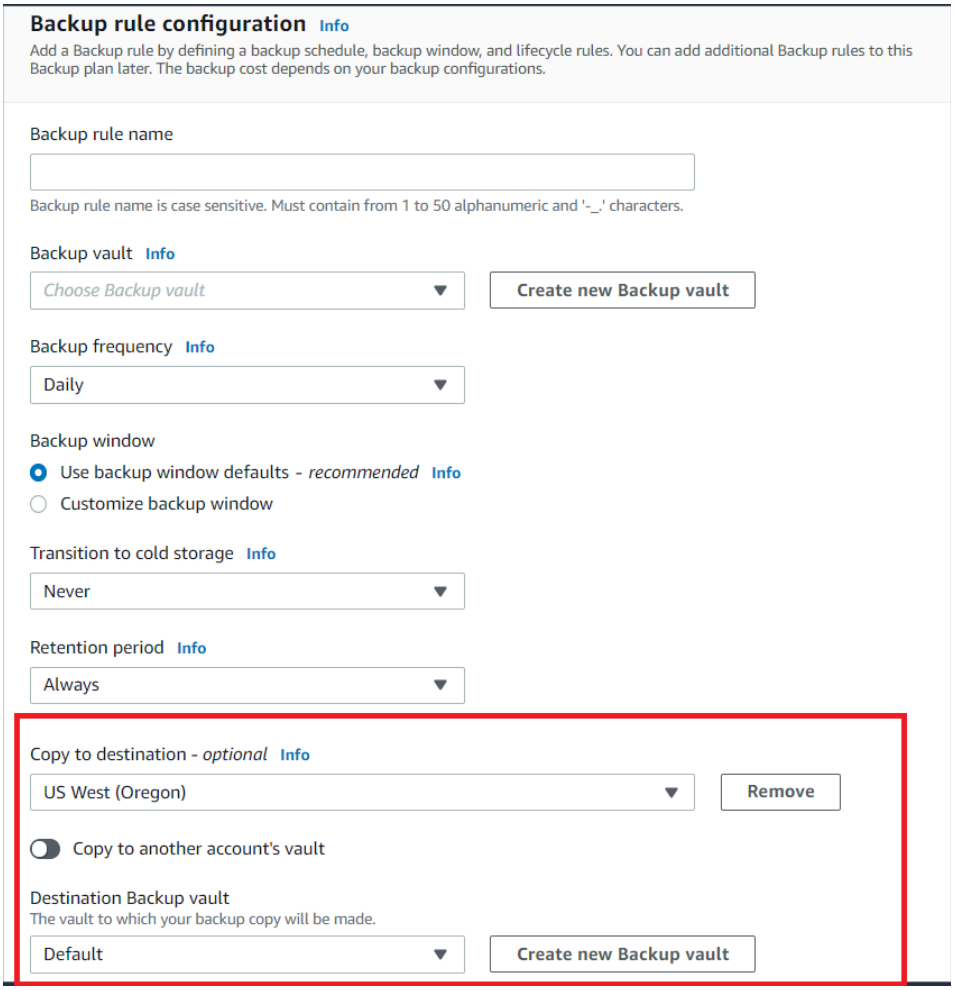
EFS-to-EFS Regional Data Transfer

There are times when you need to copy over some data from one AWS Region to another. Your reasons may be for DR purposes or data retention policies imposed by your organization. Nevertheless, in AWS, there are usually straightforward ways to do so. For example, for EBS volumes, you can create a snapshot of your volume and copy it over to your destination region. For S3 objects, you simply create a new bucket in your destination region and configure replication in the origin bucket. But for Amazon EFS, there is no native feature to handle this process. You need the help of other AWS services to successfully migrate your EFS data from one region to another. In this deep dive, we'll be taking a look at the services that will help you do so.

If your goal is to recreate an entire file system in another region, you can use **AWS Backup** to take a backup of your EFS file system and have it copy the backup over to a destination region. During your initial backup, AWS Backup takes a full copy of your entire file system and stores it in a durable vault. Succeeding backups on your file system are incremental, meaning that only changes made after your latest backup will be taken. AWS Backup is able to backup your file system no matter the storage class you are using, but restoring a backup restores your files to the Standard storage class. If you've configured your backup plan to copy backup files to another region then AWS Backup copies your backups to a destination vault in the other region. Other settings you can define for your backup plan include whether to transition your backups to cold storage to lower storage costs, and the retention duration of your backups.



If your goal is to migrate or replicate data from one EFS file system to another, then you can use AWS DataSync for this purpose. AWS DataSync is able to copy files between two EFS file systems even if they belong to different regions and/or AWS accounts. To start copying data using AWS DataSync, first deploy the DataSync agent as an EC2 instance inside a VPC with access to your source file system. Once you activate the DataSync agent using a web browser, you select Amazon EFS as your destination AWS storage, enter your file system details, and start moving data. One advantage of using AWS DataSync is that you can copy your files over a private AWS network. To do so, simply follow these steps:

1. Create a VPC peering connection between your source EFS VPC and destination EFS VPC.
2. Add a rule in the security group of your source and destination EFS that would allow them to communicate with each other.
3. Create a VPC endpoint for AWS DataSync in the region of the destination EFS.
4. Initialize a DataSync Agent and choose the VPC endpoint as your service endpoint.
5. Start the agent and begin a transfer task.

References:

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https://aws.amazon.com/premiumsupport/knowledge-center/datasync-transfer-efs-cross-region/
https://aws.amazon.com/about-aws/whats-new/2019/05/aws-datasync-now-supports-efs-to-efs-transfer/
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Amazon EFS Storage Lifecycle

Amazon EFS is not exactly the cheapest storage service in AWS. If left unmanaged, it WILL hit you in the wallet. Although its price point is a reflection of its features and capabilities, we as Solutions Architects should always look for ways to lower cost. One such example is how you should optimize file storage in EFS. Amazon EFS has two storage classes: **Standard** (EFS-Standard) and **Infrequent Access** (EFS-IA). These storage classes are quite similar to the ones in Amazon S3. The Standard storage class offers a balance between cost and storage. This class is most suitable for storing frequently accessed files. You only need to pay for storage consumed by files in this class. The Infrequent Access storage class, on the other hand, brings you lower storage costs in exchange for retrieval fees. This class is most suited for files that you know won't be accessed very often. Although storage cost is lower in EFS-IA, overall costs can quickly ramp up if EFS-IA files are being accessed too often.

Lifecycle management policies control how your objects are stored in Amazon EFS. When enabled, lifecycle management migrates all your files that have not been accessed for a set period of time to the Infrequent Access storage class. You define the period of time from the selection below in your lifecycle policy:

- None
- 7 days since last access
- 14 days
- 30 days
- 60 days
- 90 days

Note that, as of the moment, you cannot set your own period. If in the exam there is a strict requirement that data should only be transitioned to IA storage after x number of days and x is not in the selection above, then consider your other options first.

To qualify for the transition to the IA storage class, files must at least be 128 KB in size. Files moved into the IA storage class remain there indefinitely. You can move files from the IA storage class back to the Standard storage class by copying them to another location on your file system. If you want your files to remain in the Standard storage class, disable Lifecycle Management by choosing None in the lifecycle policy and then copy your files to another location on your file system.

References:
https://docs.aws.amazon.com/efs/latest/ug/storage-classes.html

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https://tutorialsdojo.com/amazon-efs/

Amazon FSx

Amazon FSx for Lustre vs Amazon FSx for Windows File Server

	Amazon FSx for Lustre	Amazon FSx for Windows File Server
Short description	A high-performance, scalable storage service powered by Lustre.	A fully managed, highly reliable, and scalable file storage that is accessible over the Server Message Block (SMB) protocol. Lowest cost SMB file server in AWS.
Use cases	Machine learning, high performance computing (HPC), video rendering, and financial simulations	For applications requiring use of Windows shared storage through SMB protocol and requiring support for other Windows features such as AD integration or a lift-and-shift replacement for Sharepoint for example.
Accessible from these sources	Intended for thousands of concurrent access from Linux-based instances and devices, whether in AWS or on-premises. FSx for Lustre integrates with Amazon EC2, AWS Batch, Amazon EKS, and Amazon Parallel Cluster.	Can be concurrently accessed by thousands of Windows, Linux, and MacOS compute instances and devices, whether in AWS or on-premises. Compute instances include Amazon EC2, Amazon ECS, VMware Cloud on AWS, Amazon WorkSpaces, and Amazon AppStream 2.0 instances.
Deployment options	Scratch file systems - designed for temporary storage and shorter-term processing of data. Data is not replicated and does not persist if a file server fails. Persistent file systems - designed for longer-term storage and workloads. The file servers are highly available, and data is automatically replicated within the Availability Zone (AZ) of the file system. The data volumes attached to the file servers are replicated independently from the file servers to which they are attached.	Only has persistent file systems. Can run in single AZ or multi-AZ.
Storage options	SSD storage for latency-sensitive workloads or workloads requiring the high IOPS/throughput. HDD storage for throughput-focused workloads that aren't latency-sensitive. Amazon FSx also provides a fast, in-memory cache on the file server.	

Managing storage capacity	You can increase your file system's storage capacity every six hours. Throughput scales linearly as you increase storage.	Each file system can have up to 64 TB of data. Amazon FSx grows the storage capacity of your existing file system without any downtime impact to your applications and users.
How to mount	Install the open-source Lustre client on your Linux instance. Once it's installed, you can mount your file system using standard Linux commands.	In Windows, use the "Map Network Drive" feature to map a drive letter to a file share on your FSx file system. In Linux, use the cifs-utils tool to mount your file share.
Backups	Amazon FSx takes daily automatic backups of your file systems, and allows you to take manual backups at any point. Backups are incremental. Default backup retention is 7 days. You can only take a backup of a Lustre file system that has persistent storage and is not linked to an S3 bucket.	
Security	FSx for Lustre always encrypts your file system data and your backups using keys you manage through AWS KMS. Amazon FSx encrypts data-in-transit using SMB Kerberos session keys.	
	Encrypts data-in-transit when accessed from supported EC2 instances.	Encrypts data-in-transit using SMB Kerberos session keys.
Extra features	You can link your Lustre file system to an Amazon S3 bucket. You can also create multiple Lustre file systems linked to the same S3 bucket.	Amazon FSx for Windows File Server works with Microsoft Active Directory (AD) so you can easily integrate existing AD-based user identities. It also provides standard Windows permissions for files and folders. Data Deduplication is a feature in Windows Server that reduces costs by storing redundant data only once.

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Amazon Relational Database Service (RDS)

Amazon RDS High Availability and Fault Tolerance

When it comes to production databases, architecting a highly available, fault tolerant database infrastructure is key in making sure that your operations continue to run smoothly in the event of a failure. Since we can easily launch new resources in the AWS cloud, and tear them down as easily too, it is always a good practice to create redundant infrastructure in every part of your system when applicable; and yes, that includes databases.

Amazon RDS is a managed relational database service that supports multiple database engines and versions. As you may know, different database engines have different ways of implementing high availability in a traditional sense. In Amazon RDS, these capabilities are further improved thanks to the innovations brought forth by AWS. Two concepts we'll touch on in relation to HA/FT are **Multi-AZ Deployments** and **Read Replicas**.

Amazon RDS Multi-AZ deployment creates and maintains a standby replica of your RDS DB instance in a different Availability Zone, effectively providing high availability and failover support for situations that would cause the primary database to go offline. Multi-AZ spans at least two Availability Zones within a single region. Your primary DB instance is synchronously replicated across Availability Zones to a standby replica to provide data redundancy, eliminate I/O freezes, and minimize latency spikes during system backups. Amazon RDS uses several different technologies to provide failover support. Multi-AZ deployments for MariaDB, MySQL, Oracle, and PostgreSQL DB instances use Amazon's failover technology. SQL Server DB instances use SQL Server Database Mirroring (DBM) or Always On Availability Groups (AGs). You should remember that you cannot use the standby replica to serve read traffic. For this purpose, you should use a read replica, which we'll discuss later on.

When converting a Single-AZ deployment to a Multi-AZ deployment, Amazon RDS takes a snapshot of the primary DB instance and then restores the snapshot into another AZ. RDS then sets up synchronous replication between your primary DB instance and the new instance. In the event of a planned or unplanned outage of your DB instance, RDS automatically switches to your standby replica. The time it takes for the failover to complete depends on the database activity and other conditions at the time the primary DB instance became unavailable. Also, the failover mechanism automatically changes the Domain Name System (DNS) record of the DB instance to point to the standby DB instance.

Amazon RDS Read Replicas let you scale out your DB instances across multiple AZs if you have a read-heavy database workload. You can create one or more replicas from the DB instance and use those replicas as a source for read operations. Read replicas can be created in the same AZ as the primary, in a different AZ but in the same region as the primary, or even in AZs in different regions if the RDS DB engine supports it. Data between your DB instance and read replicas are replicated asynchronously, so replicas might return stale data when you do a read on them. Another benefit of read replicas is that they store redundant copies of your data, so in the event of a failure on the primary DB instance, read replicas can be manually promoted to become standalone DB instances. When you promote a read replica, the DB instance is rebooted before it becomes

available. Amazon RDS uses MariaDB, MySQL, Oracle, PostgreSQL, and Microsoft SQL Server DB engines' built-in replication functionality to create the read replicas. MySQL and MariaDB perform logical replication, while Oracle, PostgreSQL and Microsoft SQL Server perform physical replication.

Similar to how Multi-AZ deployments are created, Amazon RDS takes a snapshot of your source DB instance and creates a read-only instance from the snapshot. RDS then uses asynchronous replication to update the read replica whenever there is a change to the primary DB instance. One requirement when creating read replicas is that automatic backups should be enabled. Take note that read replicas, by default, allow only read-only connections, but MySQL and MariaDB replicas can be made writable. Also, by default, a read replica is created with the same storage type as the source DB instance. However, you can create a read replica that has a different storage type from the source DB instance depending on the configuration. If you delete a source DB instance without deleting its read replicas in the same AWS Region, each read replica is promoted to a standalone DB instance.

Lastly, a few final reminders for RDS read replicas. You can't configure a DB instance to serve as a replication source for an existing DB instance. You can only create a new read replica from an existing DB instance. Read Replicas for MySQL and MariaDB support Multi-AZ deployments, so you can combine these two features to build a resilient disaster recovery strategy. Read Replicas DO NOT CACHE DATA. You'll need to add a caching layer using services such as Amazon Elasticache for example.

References:
https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/Concepts.MultiAZ.html
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Amazon RDS Security

Amazon RDS is a database service hosted in AWS, and it is always a given that you do everything you can to protect your databases and the data stored in them, no matter the platform. In this section, we'll discuss the many ways you can apply security for your Amazon RDS instances.

Network Isolation and VPC Security

Your RDS instances reside in a VPC, which is an isolated piece of network that you own and manage in AWS. No one can gain access to your VPC network unless you allow them to. Furthermore, there are many VPC security features available for you to use which are very important in securing your database network. It is a good practice to run your RDS instances in private subnets, and more to the fact that these subnets should be isolated from the rest of your system. This way, you can configure firewall rules (both security group and network acl) as well as routing rules that are dedicated for your databases. You can further secure your database access by using an IPsec VPN solution, and allow users to connect to the database through the VPN

only. Lastly, you can set up intrusion detection systems to notify you immediately if there is a supposed threat to your databases. Endpoint protection services such as AWS WAF may come in handy too since you can create WAF rules that mitigate SQL injection attempts.

Encryption At Rest

I'm sure this is a given, but you must encrypt your database to prevent others from easily reading your data. Amazon RDS encrypts your databases using keys you manage in the AWS Key Management Service (KMS). On a database instance running with Amazon RDS encryption, data stored at rest in the underlying storage is encrypted, as are its automated backups, read replicas, and snapshots. RDS encryption uses the industry standard AES-256 encryption algorithm to encrypt your data on the server that hosts your RDS instance. Amazon RDS also supports Transparent Data Encryption (TDE) for SQL Server (SQL Server Enterprise Edition) and Oracle (Oracle Advanced Security option in Oracle Enterprise Edition). With TDE, the database server automatically encrypts data before it is written to storage and automatically decrypts data when it is read from storage.

You can only enable encryption for an Amazon RDS DB instance when you create it, not after the DB instance is created. Once you have created an encrypted DB instance, you can't change the AWS KMS key used by that DB instance. If you'd like to encrypt an existing DB instance, take a snapshot of it and then create a copy of that snapshot, encrypt the copy, and restore it to have an encrypted version of your database. You also cannot disable encryption on RDS after you've enabled it on your DB instance. If you'd like to change encryption keys, export the data from your encrypted DB instance and import it to an unencrypted one.

Encryption In-Transit

Although you encrypt the data at-rest in your database, this is not enough as database traffic also contains your data. You should encrypt your network traffic to protect it from sniffers and malicious attacks. If someone were to get hold of your traffic data, who knows what they can do with them. They can attempt to intercept requests and send fake responses. Encrypt the communications between your application and your RDS DB instances using SSL/TLS. Amazon RDS creates an SSL certificate and installs the certificate on the DB instance when the instance is provisioned. Different DB engines have different ways for you to retrieve the SSL public key. Remember that in the network security section above, you can enforce HTTPS connections with security groups. You can also require your DB instance to only accept encrypted connections.

Access Controls

Amazon RDS is tightly integrated with AWS IAM which allows you to manage who can access and modify your RDS DB instances through IAM policies. In addition, you can tag your resources and control the actions that your IAM users and groups can do on your resources that have those tags. There is also the IAM database authentication feature which works with Aurora MySQL and Aurora PostgreSQL. With this authentication

method, you don't need to use a password when you connect to a DB cluster. Instead, you use an authentication token.

When you first create a DB Instance, you need to enter the credentials of your master user account, which is used only within the context of Amazon RDS to control access to your DB Instances and will be provided database administrator privileges. Once you have created your DB Instance, you can connect to the database using the master user credentials and configure additional user accounts for your other users. You can also opt to disable the master account within the database settings (as a best practice), and use a separate account instead to perform administration work.

Logging and Monitoring

Although this is a given already, you should also enable logging for your database so you can monitor all activity that occurs within them. This will help you troubleshoot any security issues you might encounter in the future and prevent them from happening again. Logs that provide system activity are crucial in knowing the state of your databases and how well they are performing. Some users might even require them for auditing purposes, so be sure to store your logs somewhere durable such as Amazon S3 or Cloudwatch Logs.

References:
https://aws.amazon.com/rds/features/security/
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Amazon Aurora

Aurora Serverless Scaling

When you are using Amazon RDS or any relational database for your applications, and you notice that the database has varying usage patterns, wouldn't it be great having a database that automatically scales capacity based on demand? We already know that Amazon Aurora automatically scales its storage as your data grows, but how about CPU capacity and allowed number of connections? Amazon Aurora has a DB engine mode called Amazon Aurora Serverless, which is an on-demand, auto-scaling configuration for Amazon Aurora. You get most of the features and benefits that come with the standard Amazon Aurora, plus more. Amazon Aurora Serverless cluster automatically starts up, shuts down, and scales capacity up or down based on your application's needs. You do not need to keep monitoring and managing capacity yourself. And to prevent your Aurora Serverless from becoming too expensive, you can set a capacity range to prevent it from overscaling.

Amazon Aurora Serverless supports both MySQL and PostgreSQL, since it is just an extension of Amazon Aurora. If you'd like to move your data from Amazon Aurora to Amazon Aurora Serverless, simply take a snapshot from your existing Aurora provisioned cluster and restore it into an Aurora Serverless DB Cluster. One thing to note is that you can't give an Aurora Serverless DB cluster a public IP address, so you'll have to connect to it from within your VPC.

When configuring scaling options, you specify Aurora capacity units (ACUs). Each ACU is a combination of approximately 2 gigabytes (GB) of memory, corresponding CPU, and networking. Database storage automatically scales from 10 gibibytes (GiB) to 128 tebibytes (TiB). The minimum Aurora capacity unit is the lowest ACU to which the DB cluster can scale down. The maximum Aurora capacity unit is the highest ACU to which the DB cluster can scale up. Based on your settings, Aurora Serverless automatically creates scaling rules for thresholds for CPU utilization, connections, and available memory. A scaling point is a point in time at which the database can safely initiate the scaling operation.

Use Aurora Serverless for the following types of database workloads:

- Infrequently used applications
- Applications with variable workloads (high peaks and low dips)
- New applications with no benchmarked performance
- Applications with unpredictable workloads
- Development and test databases which can be shut down when not in use
- Multi-tenant applications

In Aurora Serverless, there are a few features that are not supported:

1. Aurora cloning
2. Aurora global databases
3. Aurora multi-master clusters
4. Aurora Replicas

5. AWS IAM database authentication
6. Backtracking in Aurora
7. Database activity streams
8. Performance Insights

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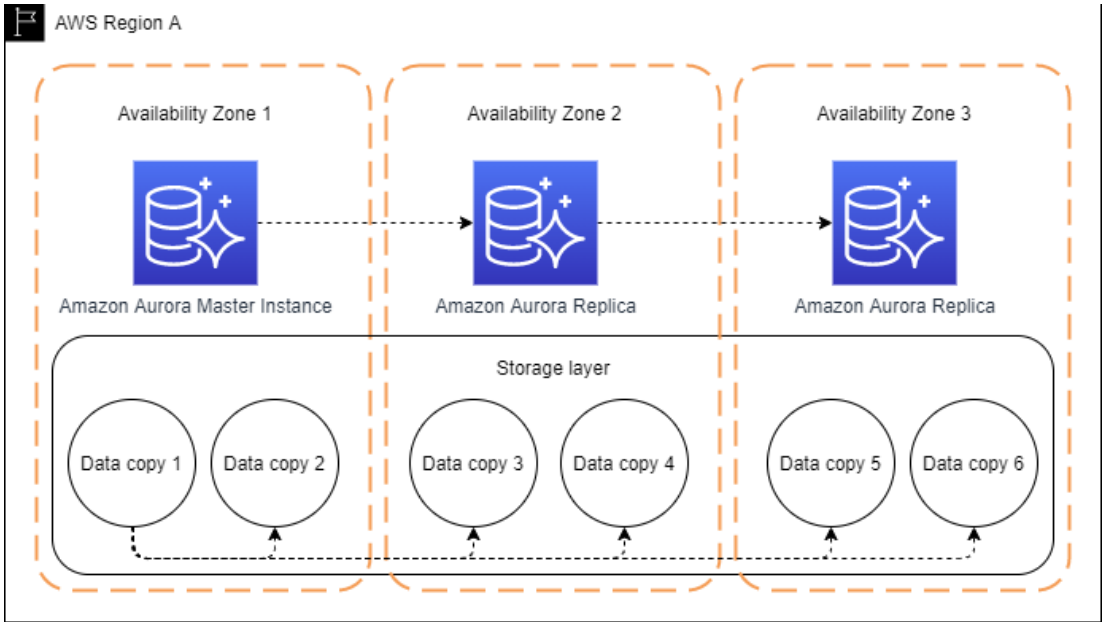
High Availability for Amazon Aurora

Although Amazon Aurora is a part of Amazon RDS, they do not share the same technology for implementing high availability and fault tolerance. The Amazon Aurora architecture separates storage hardware from compute hardware. Your data remains safe even if some or all of the DB instances in your Aurora cluster become unavailable. How Amazon Aurora achieves HA and FT are discussed below.

Amazon Aurora synchronously replicates your data six ways across three Availability Zones in a single AWS Region. Aurora stores these copies regardless of whether the instances in the DB cluster span multiple Availability Zones. For a cluster using single-master replication, after you create the primary instance, you can create up to 15 read-only Aurora Replicas in different AZs.

Aurora Replicas work similarly with Amazon RDS Read Replicas. You can offload your read operations to these replicas to reduce the burden on the primary database. When the primary instance encounters an issue and fails, one of the Aurora Replicas is promoted to primary via a failover. The cluster endpoint will then automatically point to this new primary database so you won't have to modify your connection strings. If you need multi-region DR, use Amazon Aurora Global Databases instead. Amazon Aurora Global Databases span multiple regions, and Amazon Aurora handles the replication between your DB instances with minimal replication lag. If you do not create Aurora Replicas nor Global Databases, in the event of a failure, Amazon Aurora recreates the primary instance using the data that is stored in other Availability Zones.



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Amazon Aurora Global Database and Replicas

Perhaps you have an Amazon RDS Multi-AZ database with read replicas located in multiple regions, and you know that your database experiences read-heavy operations, especially in your secondary regions. If retrieving stale data is unacceptable due to the asynchronous replication of Amazon RDS then you should consider migrating your database cluster onto Amazon Aurora instead, if possible.

Amazon Aurora has a feature called “Global Database”, which is primarily designed for these globally distributed application scenarios. Enabling this feature allows Amazon Aurora to replicate your data across regions with no impact on database performance, with fast local reads and low latency in each region, and provides disaster recovery from region-wide outages.

An Aurora global database has a primary DB cluster in one Region, and up to five secondary DB clusters in different Regions. Global Database uses storage-based replication with typical latency of less than 1 second. With this, the chances of retrieving stale data is minimized. Furthermore, if your primary region suffers a performance degradation or outage, you can promote one of the secondary regions to become the new primary. An Aurora cluster can recover in less than 1 minute even in the event of a complete regional outage. This provides you with a Recovery Point Objective (RPO) of 1 second and a Recovery Time Objective (RTO) of less than 1 minute. You can further scale your secondary clusters by adding more read-only instances or

Aurora Replicas to a secondary region. The secondary cluster is read-only, so it can support up to 16 Aurora Replica instances rather than the usual limit of 15 for a single Aurora cluster.

When Aurora Global Database feels like a bit overkill, or you'd like to utilize MySQL/PostgreSQL's native replication features, you can scale your Aurora cluster by configuring Aurora Replicas to serve read-only transactions. Aurora Replicas also help to increase availability. If the primary instance becomes unavailable, Aurora automatically promotes one of the replicas. An Aurora DB cluster can contain up to 15 Aurora Replicas. The Aurora Replicas can be distributed across Availability Zones in your cluster's region. Additionally, Aurora Replicas return the same data for query results with minimal replica lag.

Aside from these benefits, one feature of an Aurora MySQL DB cluster is that you can create a Read Replica of it in a different region, by using MySQL binary log (binlog) replication. Each cluster can have up to five Read Replicas created this way, each in a different region. You can also replicate two Aurora MySQL DB clusters in the same region, by using MySQL binary log (binlog) replication. Same goes with two Aurora PostgreSQL DB clusters in the same region, by using PostgreSQL's logical replication feature. Aurora PostgreSQL does not currently support cross-region replicas. Since the logical replication process is handled by the database, it might have an effect on its performance, unlike Aurora Global Database where the replication happens in the storage layer.

References:
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/aurora-global-database.html
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/Aurora.Replication.html

Amazon DynamoDB

Amazon DynamoDB Transactions

DynamoDB transactions is a feature that lets you fulfill atomicity, consistency, isolation, and durability (ACID) across one or more tables within a single AWS account and region. Use DynamoDB transactional read and write APIs if your applications require adding, updating, or deleting multiple items as a single, all-or-nothing operation. A DynamoDB transaction can include up to 25 unique items or up to 4 MB of data.

- With the transaction write API, you can group multiple Put, Update, Delete, and ConditionCheck actions. You can then submit the actions as a single TransactWriteItems operation that either succeeds or fails as a unit. TransactWriteItems is supported in DynamoDB Accelerator but not in Global Tables.
- With the transaction read API, you can group and submit multiple Get actions as a single TransactGetItems operation. If a TransactGetItems request is submitted on an item that is part of an active write transaction, the read transaction is cancelled. TransactGetItems is supported in DynamoDB Accelerator but not in Global Tables.

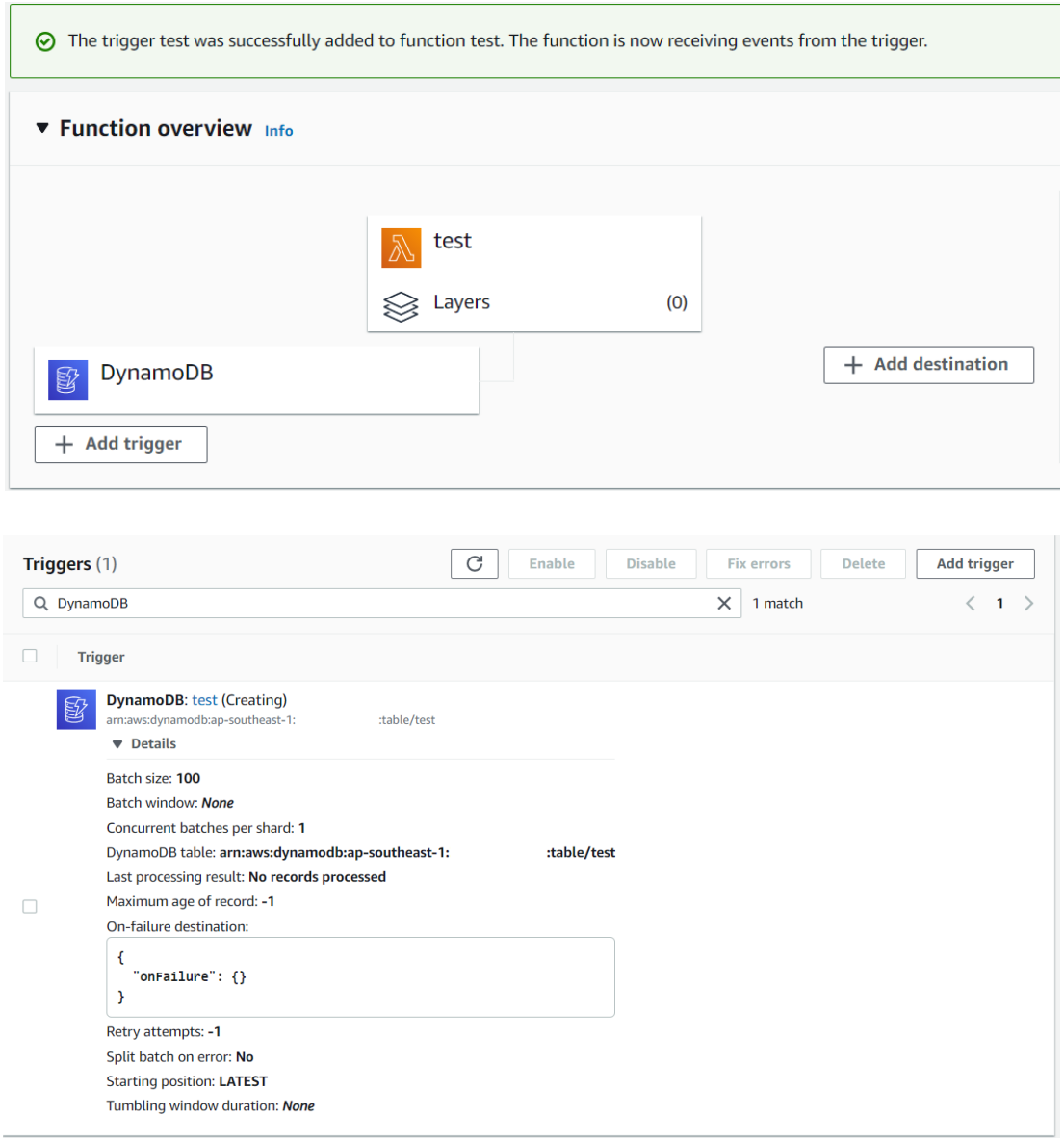
With the addition of DynamoDB transactions, you can choose among three options for read operations — eventual consistency, strong consistency, and transactional; and between two options for write operations — standard and transactional.

Know that transactional operations are different from batch operations. In batch operations, some queries may succeed while others do not. In transactional operations, it's all or nothing with your queries. You also can't target the same item with multiple operations within the same transaction.

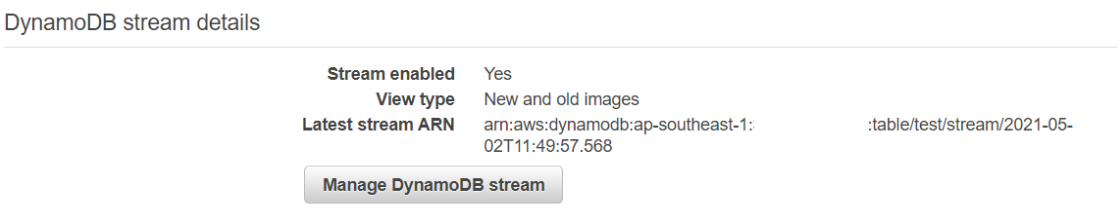
References:
https://aws.amazon.com/blogs/aws/new-amazon-dynamodb-transactions/
https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/transactions.html
https://tutorialsdojo.com/amazon-dynamodb/

AWS Lambda Integration with Amazon DynamoDB Streams

Amazon DynamoDB is integrated with AWS Lambda so you can create *triggers*, which are pieces of code that automatically respond to events in DynamoDB Streams. With triggers, you can build applications that react to data modifications in DynamoDB tables.

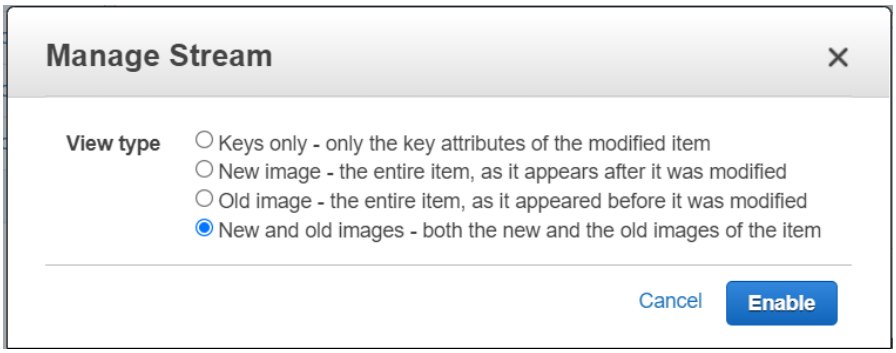


After you enable DynamoDB Streams on a table, associate the DynamoDB table with a Lambda function if AWS does not automatically associate it. AWS Lambda polls the stream and invokes your Lambda function synchronously when it detects new stream records.



Configure the StreamSpecification you want for your DynamoDB Streams:

- **StreamEnabled (Boolean)** – indicates whether DynamoDB Streams is enabled (true) or disabled (false) on the table.
- **StreamViewType (string)** – when an item in the table is modified, StreamViewType determines what information is written to the stream for this table. Valid values for StreamViewType are:
  - **KEYS_ONLY** – Only the key attributes of the modified items are written to the stream.
  - **NEW_IMAGE** – The entire item, as it appears after it was modified, is written to the stream.
  - **OLD_IMAGE** – The entire item, as it appeared before it was modified, is written to the stream.
  - **NEW_AND_OLD_IMAGES** – Both the new and the old item images of the items are written to the stream.



References:
https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/Streams.Lambda.html
https://docs.aws.amazon.com/amazondynamodb/latest/APIReference/API_StreamSpecification.html

Amazon DynamoDB Replication

In Amazon RDS, if you decided to replicate your databases to other AWS Regions, you would create Read Replicas in your desired region(s) and AWS will perform asynchronous replication between the primary instance and the read replicas. In Amazon DynamoDB, the concept of a read replica does not exist. Instead, to create copies of your DynamoDB tables across different regions, you will need to create a Global Table. A Global Table, in a basic sense, is just a collection of one or more DynamoDB replica tables. Each replica table has the same table name, stores the same data, and uses the same primary key schema as the primary table. A global table can only have one replica table per region.

With RDS read replicas, applications can only read data from them, so no write operations can be performed. When an application writes data to any DynamoDB replica table in one region, DynamoDB propagates the write to the other replica tables in the other regions within the same global table automatically. Because of this,

DynamoDB does not support strongly consistent reads across regions. To help ensure eventual consistency, DynamoDB global tables use a *last writer wins* reconciliation between concurrent updates.

When creating a global table, you first need to enable DynamoDB streams. DynamoDB streams will distribute the changes in one replica to all other replicas. Next, you select the region(s) where you would like to deploy a replica in. The *AWSServiceRoleForDynamoDBReplication* IAM role that is automatically created by DynamoDB allows the service to manage cross-region replication for global tables on your behalf.

References:
https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/V2globaltables_HowItWorks.html
https://aws.amazon.com/dynamodb/global-tables/
https://tutorialsdojo.com/amazon-dynamodb/

Caching with DynamoDB DAX

In most cases, the single digit millisecond performance of DynamoDB is sufficient for the user's needs. But for cases when single digit microsecond performance is required, you'll need to add a caching mechanism to your DynamoDB table. DynamoDB Accelerator (DAX) is a fully managed, write-through caching service that delivers fast response times for accessing eventually consistent data in DynamoDB. In the exam, unless there is a clear requirement to use Redis or Memcached, which in this case you'll use Amazon Elasticache instead, always choose DAX as your DynamoDB caching solution.

DAX is able to perform the following functions:

1. DAX reduces the response times of eventually consistent read workloads from single-digit milliseconds to microseconds.
2. DAX requires only minimal functional changes if your applications have already been using the DynamoDB API.
3. For read-heavy or bursty workloads, DAX provides increased throughput and potential cost savings by reducing the need to overprovision read capacity units.

If you need enhanced data security, DAX supports server-side encryption, but it does not support TLS. For high availability, configure a Multi-AZ DAX cluster. You can scale your DAX cluster by adding more nodes or by using larger node types. A DAX cluster in an AWS Region can only interact with DynamoDB tables that are in the same region. If you have tables in other regions, you must launch DAX clusters in those regions too.

DAX is not ideal for the following scenarios:

- Applications that require strongly consistent reads.
- Applications that do not require microsecond response times for reads, or that do not need to offload repeated read activity from underlying tables.
- Applications that are write-intensive, because the data in the cache will be frequently overwritten.

There are two caches available in DAX: **item cache** and **query cache**.

DAX maintains an item cache to store the results from GetItem and BatchGetItem operations. Cached items have a default cache TTL of 5 minutes. When a cache is full, DAX evicts older items (even if they haven't expired yet) to make room for new items.

DAX maintains a query cache to store the results from Query and Scan operations. These result sets are stored by their parameter values. You specify the TTL setting for the query cache when you create a new DAX cluster. If the query cache becomes full, DAX evicts older result sets (even if they haven't expired yet) to make room for new result sets.

References:
https://docs.amazonaws.cn/en_us/amazondynamodb/latest/developerguide/DAX.html
https://tutorialsdojo.com/amazon-dynamodb/

Amazon Redshift

Amazon Redshift High Availability, Fault Tolerance and Disaster Recovery

Amazon Redshift is similar to Amazon RDS where it is also a fully managed RDBMS. But where Amazon RDS is for OLTP, database-type workloads, Amazon Redshift is designed for OLAP, data warehouse-type workloads. An Amazon Redshift data warehouse consists of your cluster of nodes which run a specific Redshift engine. In each cluster, there is one leader node and one or more compute nodes. The leader node receives queries from client applications, parses the queries, and creates query execution plans. It then coordinates the parallel execution of these plans with the compute nodes and collects the results from these nodes. Finally, it then returns the results of the query back to the client applications. Compute nodes do bulk of the query execution work based on the execution plans from the leader node and transmit data among themselves to serve these queries. Query results are then sent to the leader node for aggregation.

When launching your cluster, Amazon Redshift provisions your cluster in a randomly selected Availability Zone within the AWS Region you are in, though you can optionally use a specific Availability Zone if Amazon Redshift is available in that zone. All the cluster nodes are provisioned in the same Availability Zone. There is no option in Amazon Redshift to deploy a multi-AZ cluster. Amazon Redshift only supports Single-AZ deployments. If your cluster's Availability Zone experiences an outage, Amazon Redshift will automatically move your cluster to another AZ within the same region without any data loss or application changes, but you must enable the relocation capability beforehand in your cluster configuration settings.

If you need high availability for your Redshift cluster then you must create a new secondary cluster that will continuously receive new data from the primary cluster through some pipeline, such as Amazon Kinesis. However, if you only need high availability for nodes within a cluster, Amazon Redshift already automatically detects and replaces any failed node it finds. During this period, the data warehouse cluster will be unavailable for queries and updates until a replacement node is provisioned and added in. Additionally, if the leader node fails, inflight queries are dropped. Data for the replacement node is retrieved from the continuous backups in S3 and the most frequently queried data is prioritized during restoration. Single node clusters do not support data replication, so you will have to restore the cluster from a snapshot.

For disaster recovery, Amazon Redshift replicates all your data within your data warehouse cluster when it is loaded, and also continuously backs it up to Amazon S3. The service maintains at least three copies of your data – the original and replica on the compute nodes, and a backup in S3. You can also configure Redshift to asynchronously replicate your snapshots to S3 in another region. Automated backups are only kept up to a maximum of 35 days, but manual backups can be retained for a longer period.

References:
https://aws.amazon.com/redshift/faqs/
https://tutorialsdojo.com/amazon-redshift/

Amazon Redshift Spectrum

Amazon Redshift Spectrum is a feature of Amazon Redshift that allows you to query structured and semistructured data stored on Amazon S3 without having to load and transform the data into Amazon Redshift tables. If you have pools of data stored in Amazon S3 or you are using Amazon S3 as a data lake, Amazon Redshift Spectrum is capable of executing SQL queries on them, such as pull data, filter, project, aggregate, group, and sort. Best of all, Redshift Spectrum is serverless, so there is no infrastructure to maintain from your end. Redshift Spectrum runs on dedicated servers that are independent from those of Redshift clusters, and Redshift Spectrum automatically scales query compute capacity based on the size of the S3 data being retrieved. This means Redshift Spectrum is capable of massive parallel processing. You pay only for the queries you run against the data that you actually scan.

How Redshift Spectrum works is as follows:

1) You create Redshift Spectrum tables by defining the structure for your files and registering them as tables in an external data catalog. The external data catalog can be AWS Glue, the data catalog that comes with Amazon Athena, or your own Apache Hive metastore. You can also partition the external tables on one or more columns to optimize query performance.
2) Redshift Spectrum queries are sent to the leader node of your Redshift cluster. The leader node creates and distributes the execution plan to the compute nodes in your cluster.
3) Then, the compute nodes obtain the information describing the external tables from your data catalog. The compute nodes also examine the data available locally in your cluster and scans only the objects in Amazon S3 that are not present locally.
4) The compute nodes then generate multiple requests depending on the number of objects that need to be processed, and submit them concurrently to Redshift Spectrum. Redshift Spectrum worker nodes scan, filter, and aggregate your data from S3, and stream the required data for processing back to your Redshift cluster.
5) Final join and merge operations are performed locally in your cluster and the results are returned to your client applications.

When using Redshift Spectrum, your Redshift cluster and the S3 bucket data source must be in the same AWS Region. You also can't perform update or delete operations on external tables. You must recreate them if there are any changes that need to be made.

Comparison of similar analytics tools in AWS:

Amazon Redshift Spectrum	Amazon Redshift	Amazon EMR	Amazon Athena
Use Amazon Redshift Spectrum if you are running complex queries on large amounts of data stored in Amazon S3 and Amazon Redshift, and you are planning on storing frequently accessed data in Amazon Redshift.	Use Amazon Redshift when you are pulling data from multiple different sources and joining them into one structured table for querying and analytics.	Use Amazon EMR if you use custom code to process and analyze extremely large datasets with big data processing frameworks such as Apache Spark, Hadoop, Presto, or Hbase	Use Amazon Athena if you only need a simple way to query data stored in Amazon S3. Data is returned in a table and can be exported into a csv file. Consecutive results are not stored in a structured format.

References:
https://aws.amazon.com/blogs/big-data/amazon-redshift-spectrum-extends-data-warehousing-out-to-exabytes-no-loading-required/
https://docs.aws.amazon.com/redshift/latest/dg/c-using-spectrum.html
https://tutorialsdojo.com/amazon-redshift/

AWS Backup

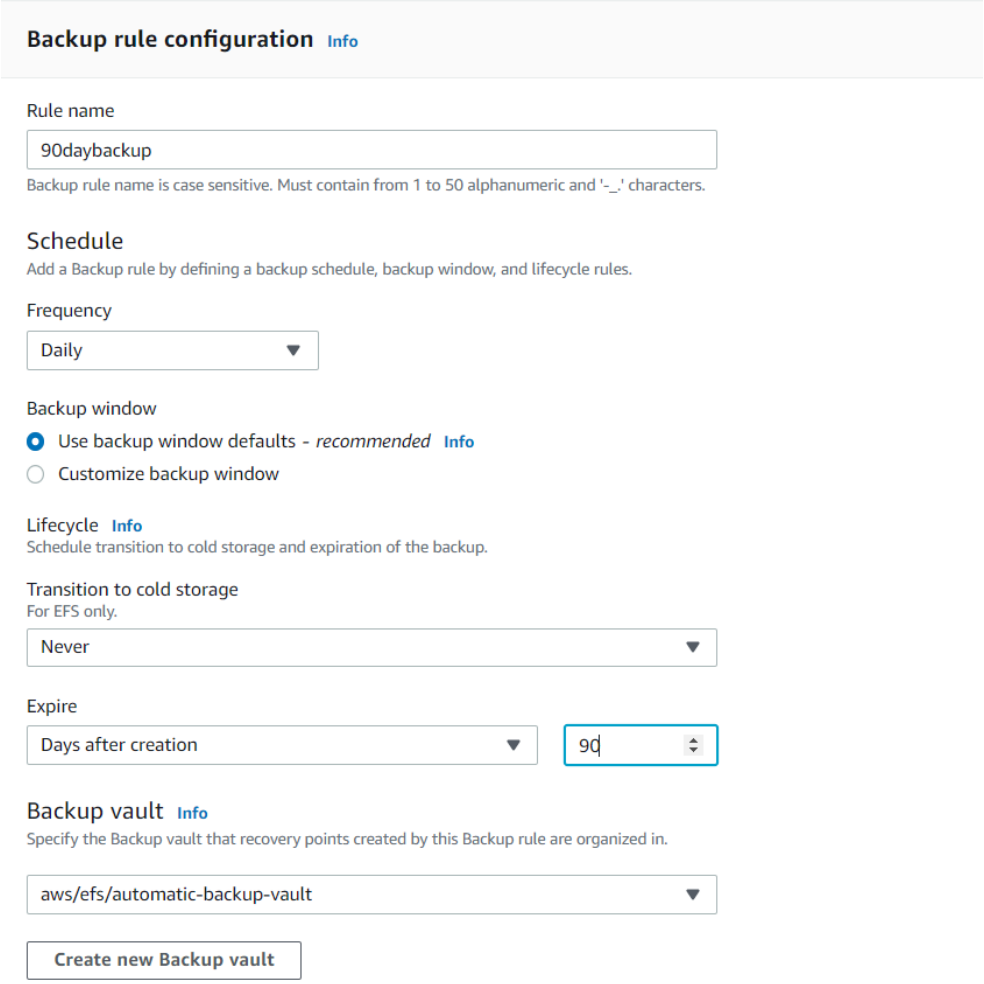
Backup Retention Period Too Short?

Backups are a necessity for any storage device that contains critical data. They are a lifesaver when something goes wrong and you need to restore something back. Backups are a requirement for any production database and file system. Most companies develop their own backup strategies, such as deciding what types of backups to take and how long to keep them for.

In AWS, services such as Amazon RDS, Amazon Aurora, Amazon EFS, and Amazon DynamoDB support automated backups, so you never have to worry about not having a backup available. However, and you might not know this, automated backups or automated snapshots for these services have a maximum retention period of only 35 days. For some companies, this period is too short. To keep your backups for longer periods of time, you should create manual backups; but why would you do a task that repeats manually when you can automate it?

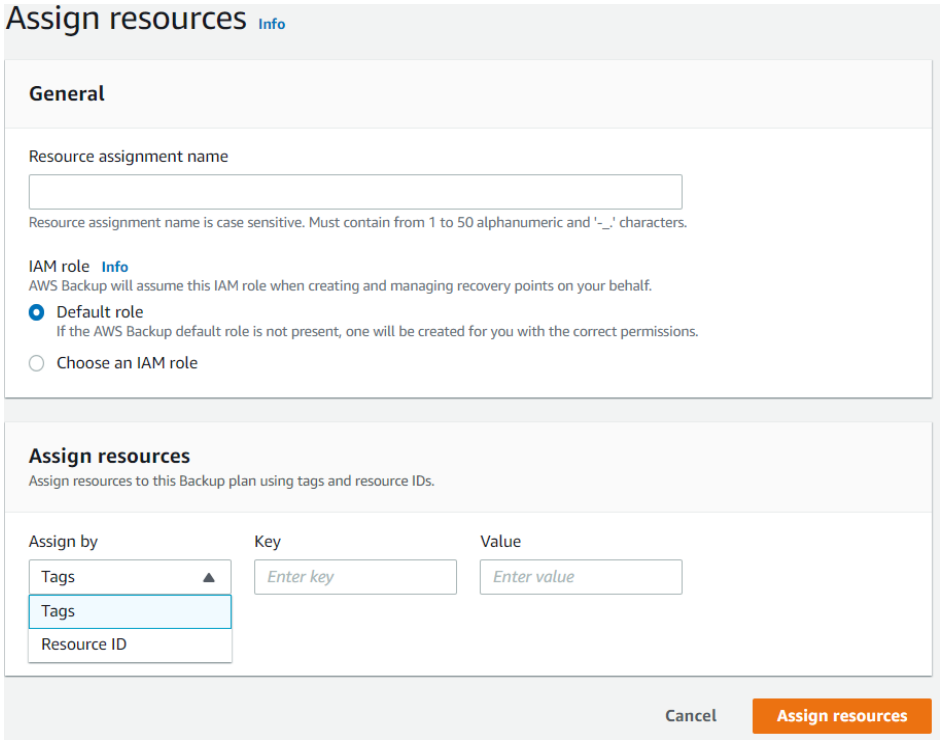
If you have a custom solution for taking manual backups programmatically because you need to process the backup, then there is nothing wrong with scripting your own automation. But if your only goal is to take recurring backups and keep them durably for an extended period of time, then you can use AWS Backup instead.

AWS Backup is a fully managed backup service that centralizes and automates backing up of data across different AWS services. With AWS Backup, you can create backup plans which define your backup requirements, such as how frequently to back up your data and how long to retain those backups. Your backups are then stored in what's called a backup vault. You can also specify in your backup plan if there should be a specific time window on when backups should run. Furthermore, AWS Backup supports on-demand backups if you only need to do a one-time backup.



To associate your AWS resources with your backup plans, simply list down the tags that would identify them or enter their resource IDs. In other words, every supported resource that has matching tags or resource IDs from those you entered will be included in the backup plan. You can choose which AWS services you'd like to opt-in with AWS Backup. Opting out a service means that even if a resource under that service matches a tag defined in one of your backup plans, AWS Backup will not take a backup of that resource. AWS Backup supports taking backups for the following services:

- Aurora
- DynamoDB
- EBS
- EC2
- EFS
- FSx
- RDS
- Storage Gateway



References:

https://docs.aws.amazon.com/aws-backup/latest/devguide/whatisbackup.html

Amazon VPC

Non-VPC Services

Not all compute, storage, and database services need to run in a VPC. It is important that you know these services so you can easily spot them out in the exam.

Services that do not require a VPC:

1) Amazon S3
2) Amazon DynamoDB
3) AWS Lambda (although you can configure Lambda to connect to a VPC to access resources in the VPC)

Security Group vs NACL

Security Group	Network Access Control List
Acts as a firewall for associated Amazon EC2 instances	Acts as a firewall for associated subnets
Controls both inbound and outbound traffic at the instance level	Controls both inbound and outbound traffic at the subnet level
You can secure your VPC instances using only security groups	Network ACLs are an additional layer of defense.
Supports allow rules only	Supports allow rules and deny rules
Stateful (Return traffic is automatically allowed, regardless of any rules)	Stateless (Return traffic must be explicitly allowed by rules)
Evaluates all rules before deciding whether to allow traffic	Evaluates rules in number order when deciding whether to allow traffic, starting with the lowest numbered rule.
Applies only to the instance that is associated to it	Applies to all instances in the subnet it is associated with
Has separate rules for inbound and outbound traffic	Has separate rules for inbound and outbound traffic
A newly created security group denies all inbound traffic by default	A newly created nACL denies all inbound traffic by default
A newly created security group has an outbound rule that allows all outbound traffic by default	A newly created nACL denies all outbound traffic default
Instances associated with a security group can't talk to each other unless you add rules allowing it	Each subnet in your VPC must be associated with a network ACL. If none is associated, the default nACL is selected.
Security groups are associated with network interfaces	You can associate a network ACL with multiple subnets; however, a subnet can be associated with only one network ACL at a time.

Your VPC has a default security group with the following rules:

1. Allow inbound traffic from instances assigned to the same security group.
2. Allow all outbound IPv4 traffic and IPv6 traffic if you have allocated an IPv6 CIDR block.

Your VPC has a default network ACL with the following rules:

1. Allows all inbound and outbound IPv4 traffic and, if applicable, IPv6 traffic.
2. Each network ACL also includes a non modifiable and non removable rule whose rule number is an asterisk. This rule ensures that if a packet doesn't match any of the other numbered rules, it's denied.

NAT Gateways and NAT Instances

NAT Gateways and NAT instances provide public internet connectivity to your private VPC resources without having to expose them to the public internet. NAT Gateways are managed NAT solutions, so you can easily provision and use them without having to maintain them. They also provide high bandwidth speeds and are highly available within a single subnet. NAT instances, on the other hand, give you more administrative control over your NAT workloads. They are EC2 instances that use a pre-configured AMI. NAT instances can be much cheaper if you do not totally need the benefits of a NAT Gateway.

Remember that when you launch a NAT Gateway or instance, you must place them in your public subnets and not your private subnets. They are literally a gateway between your public and private subnets, so mistakenly placing them in a private subnet will not provide you internet connectivity. Also note that a single NAT service can only run within a single subnet. For high availability and fault tolerance, you can use multiple public subnets and create a NAT service for each subnet. In this case, if one public subnet goes down, other private subnets would still have internet connectivity through their respective public subnets.

NAT Instance vs NAT Gateway

Attribute	NAT gateway	NAT instance
Availability	Highly available in the Availability Zone it is created in. But for true high availability, you should create a NAT gateway in a public subnet for each of your redundant private subnets or AZs.	Not highly available. You'll need a script to handle failover. For true high availability, you should launch a NAT instance in a public subnet for each of your redundant private subnets or AZs.
Bandwidth	Can scale up to 45 Gbps.	Depends on the bandwidth of the instance type you use.

Maintenance	Managed by AWS.	Managed by you, such as installing software updates or operating system patches on the instance.
Performance	Optimized for handling NAT traffic.	An Amazon Linux AMI that's configured to perform NAT.
Type and size	No available selection.	Select the instance type and size according to your predicted workload.
Cost	Charged on the number of NAT gateways you use, duration of usage, and amount of data that you send through the NAT gateways.	Charged on the number of NAT instances that you use, duration of usage, instance type and size, and storage. This option might be cheaper for some scenarios.
Public IP addresses	You need to associate an Elastic IP address to each NAT gateway at creation.	You may use an Elastic IP address or the automatically provided public IP address by AWS with the NAT instance.
Security groups	Cannot be associated with one. Control traffic using network ACLs.	Can be associated with one or more security groups.
Network ACLs	Use a network ACL to control the traffic to and from the subnet in which your NAT gateway resides.	Use a network ACL to control the traffic to and from the subnet in which your NAT instance resides.
Port forwarding	Not supported.	Manually customize the configuration to support port forwarding.
Bastion servers	Not supported.	Can be used as a bastion server.
Timeout behavior	When there is a connection timeout, a NAT gateway returns an RST packet to any resources behind the NAT gateway that attempt to continue the connection (it does not send a FIN packet).	When there is a connection timeout, a NAT instance sends a FIN packet to resources behind the NAT instance to close the connection.
IP fragmentation	Supports forwarding of IP fragmented packets for the UDP protocol. Does not support fragmentation for the TCP and ICMP protocols. Fragmented	Supports reassembly of IP fragmented packets for the UDP, TCP, and ICMP protocols

	packets for these protocols will get dropped.	

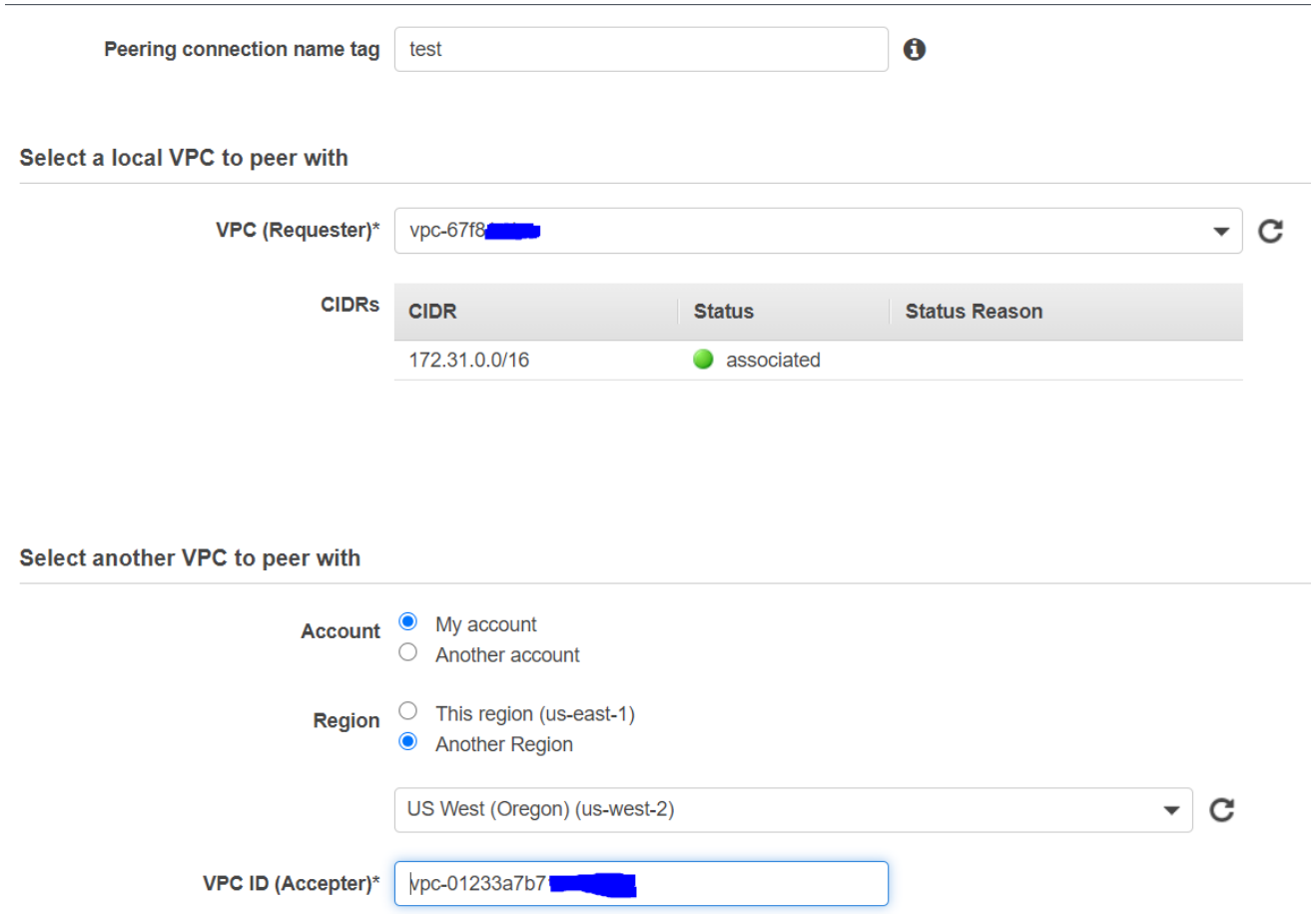
References:
https://docs.aws.amazon.com/vpc/latest/userguide/vpc-nat-comparison.html
https://docs.aws.amazon.com/vpc/latest/userguide/vpc-nat.html
https://tutorialsdojo.com/aws-cheat-sheet-amazon-vpc/

VPC Peering Setup

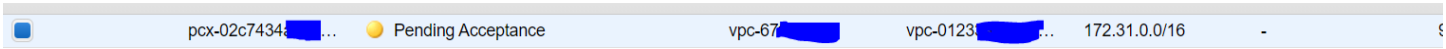
VPC peering is a common go-to solution for linking two VPC networks together. The solution is simple, effective, and does not cost anything to set up. Another advantage of VPC peering is that the connection is not a single point of failure and is not a bandwidth bottleneck unlike other VPC connection methods.

To create a VPC Peering connection with one of your VPCs, or another account's VPC, whether it be in the same region or another region, the steps are as follows:

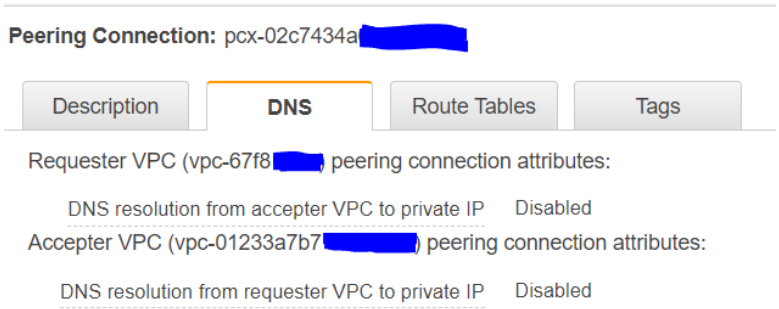
1) On your VPC console, create a peering request to your target VPC.
2) Indicate whether the target VPC is in the same account or another account, and whether in the same region or not.



3) Make sure that your target VPC CIDR does not overlap with your VPC.
4) Once the peering request is created, the target VPC will either accept or reject your peering request.



5) If you require DNS resolution between the two VPCs, you can enable them in your VPC peering settings.

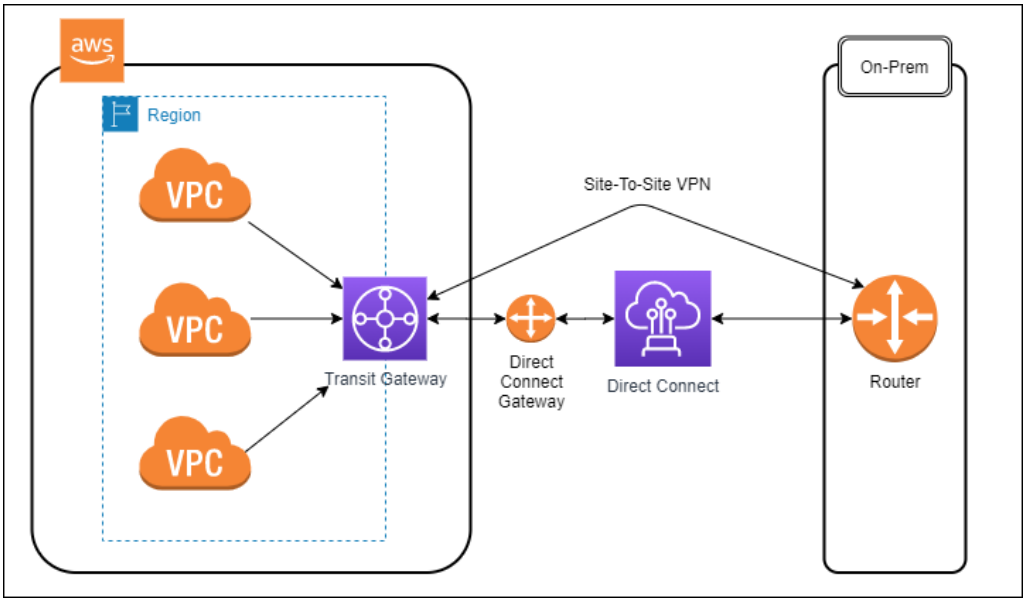


6) Once the target VPC accepts your peering request, you can now reference this connection in your route tables to specify which traffic needs to be routed over to the target VPC.

References:
https://docs.aws.amazon.com/vpc/latest/peering/create-vpc-peering-connection.html
https://tutorialsdojo.com/aws-cheat-sheet-amazon-vpc/

Utilizing Transit Gateway for Multi-VPC Connection

With VPC Peering, you can only connect two VPCs together. Managing multiple VPC Peering connections can be very troublesome when you have many interlinked VPCs. A better solution would be to use AWS Transit Gateway instead to handle these connections. AWS Transit Gateway requires little management overhead for managing multiple VPC connections. What's more, Transit Gateway lets you create Site-to-Site VPN solutions that are not possible with VPC Peering. Transit Gateway also works with Direct Connect line for hybrid environments, which would require a Direct Connect Gateway for it to work.



Adding CIDR Blocks to your VPC

When you create a VPC, you must provide a CIDR range that the VPC will use to allocate private IP addresses to your resources. In the event that you run out of IP addresses to allocate, you can expand your VPC by adding IPv4 CIDR blocks to it. When you associate a CIDR block with your VPC, a route is automatically added to your VPC route tables to enable routing within the VPC. Some restrictions to remember are:

- The CIDR block must not overlap with any existing CIDR block that's associated with the VPC.
- The allowed block size is between a /28 netmask and /16 netmask.
- You cannot increase or decrease the size of an existing CIDR block.
- You can disassociate secondary CIDR blocks that you've associated with your VPC; however, you cannot disassociate the primary CIDR block.

Reference:
https://docs.aws.amazon.com/vpc/latest/userguide/VPC_Subnets.html#vpc-resize

Amazon Route 53

Route 53 for DNS and Domain Routing

Amazon Route 53 is a Domain Name System (DNS) web service that works similarly to other DNS providers out there such as CloudFlare and GoDaddy, with a few extra functionalities. You aren't required to use Route 53 as your DNS provider if you are using the AWS cloud, but since Route 53 is tightly integrated with other AWS services, you can always move from your current provider to enjoy these benefits. Route 53's primary functions can be summarized into four sections:

1. Domain registration
2. DNS management
3. Traffic management
4. Availability monitoring

Domain Registration

Since Route 53 is a domain registrar, you can certainly purchase and register your custom domain(s) through the service. Route 53 supports multiple top-level domains (TLD) with each having a corresponding price. You can also specify how many years you'd like to own the domain(s) before finalizing your purchase. Route 53 will then request for your contact details to keep you updated on the status of your domain purchase. Lastly, there is an option for some TLDs that allows you to automatically renew your domains before every expiration so you won't suddenly lose ownership of them. Once you've successfully purchased a domain, it should appear as a registered domain in Route 53.

If you have already purchased a domain before from another registrar, you can just transfer the ownership to Route 53. But when doing so, you should take note of the following:

- You might incur a transfer fee depending on the TLD being transferred.
- Expiration date may stay the same or may be extended depending on your TLD.
- Some registrars require you to have your domain registered with them for at least 60 days. If the registration for a domain name expired and had to be restored, it must have been restored at least 60 days ago.
- Make sure that the domain is transferable.
- Route 53 does not support all types of TLDs. Verify if the TLD is supported first before you initiate a transfer.

Similarly, if you can transfer domains into Route 53, then you can also transfer domains out of Route 53.

DNS Management

You may use Route 53 as your DNS service even if your domains are registered with a different domain registrar. It is able to resolve DNS queries to targets that are running inside and outside of AWS. In DNS

management, everything starts at your hosted zones. A hosted zone is a container for DNS records, and these records contain information about how you want to route traffic for a specific domain. Hosted zones should have the same name as its associated domain. There are two types of hosted zones that you can create — **public hosted zone** and **private hosted zone**. The main difference between the two is, with public hosted zones, the records stored in them are publicly resolvable. On the other hand, private hosted zones contain records that are only resolvable within a VPC you associate, like if you want a record to resolve to a private EC2 instance for example.

In each public hosted zone, Route 53 automatically creates a name server (NS) record and a start of authority (SOA) record. Afterwards, you can create additional records in this hosted zone to point your domain and subdomains to their endpoints. If you are moving from an existing DNS service, you can also import a zone file instead to automatically populate your hosted zone. Be sure to modify the NS records of the DNS service to use the name servers of AWS. Once you've performed the actions above, just wait for DNS queries to come in (and wait for the DNS cache TTL to expire if the records were existing beforehand), and they should resolve to your designated targets.

For private hosted zones, DNS resolution is handled a bit differently. When you create a VPC, Route 53 Resolver automatically answers DNS queries for local VPC domain names of EC2 instances and records in private hosted zones. For all other domain names, Route 53 Resolver performs recursive lookups against public name servers. You can also integrate DNS resolution between Resolver and DNS resolvers on your network by configuring forwarding rules. Before you can start forwarding queries, you must create a Resolver inbound and/or outbound endpoint in the associated VPC.

- An inbound endpoint lets DNS resolvers on your network forward DNS queries to Route 53 Resolver via this endpoint.
- An outbound endpoint lets Route 53 Resolver conditionally forward queries to resolvers on your network via this endpoint.

There are multiple types of records that you can create in Route 53, but the most common ones you'll encounter are A record, AAAA record, and CNAME record. Furthermore, each of these records can be alias or non-alias records. A non-alias record means you just need to enter your targets' IP addresses or domain names and the TTL for the record. An alias record is a Route 53-specific feature that lets you specify your AWS resources as the target instead of an IP address or a domain name. When you use an alias record to route traffic to an AWS resource, there is no TTL to set; Route 53 automatically recognizes changes in the resource. Unlike a CNAME record, you can create an alias record at the zone apex. For example, an Alias A record can route traffic to the following targets:

1) Another A record in your hosted zone
2) API Gateway API
3) CloudFront distribution
4) Elastic Beanstalk environment
5) Application, Network and Classic Load Balancer
6) Global Accelerator

7) S3 web endpoint
8) VPC endpoint

Traffic Management

Each Route 53 DNS record also has its own routing policy. A routing policy determines how Route 53 responds to DNS queries. Different routing policies achieve different results:

- **Simple routing policy** – Resolves your DNS to a resource as is.
- **Failover routing policy** – Use for configuring active-passive routing failover. You can specify two DNS records with the same DNS name and have them point to two different targets. If your primary target becomes unavailable, Route 53 automatically routes succeeding incoming requests to your secondary target.
- **Geolocation routing policy** – Use when you want to route traffic based on the location of your users. This policy helps you serve geolocation-specific content to your users.
- **Geoproximity routing policy** – Use when you want to route traffic based on the location of your resources and, optionally, shift traffic from resources in one location to resources in another.
- **Latency routing policy** – Use when you have resources in multiple AWS Regions and you want to route traffic to the region that provides the best latency.
- **Weighted routing policy** – Use to route traffic to multiple resources in proportion to the weights you assign for each target. The greater the weight, the greater the traffic portion it receives. This policy can be used when you've deployed a new version of an application and you only want to route a percentage of your user traffic to it.
- **Multivalue answer routing policy** – Use when you want Route 53 to respond to DNS queries with up to eight healthy records selected at random. Users who query this type of record can choose a target from the DNS response to connect to.

Some of these routing policies can actually be used together, such as latency and weighted records, to produce a more complex routing system.

Availability Monitoring

The last primary feature of Route 53 is monitoring the health of your endpoints and taking the necessary steps in reducing DNS resolution downtime. A Route 53 health check can monitor any of the following:

- The health of a resource, such as a web server
- The status of other health checks
- The status of an Amazon CloudWatch alarm

Route 53 health check supports multiple types of network protocols for monitoring your targets. If you are familiar with the health check of an elastic load balancer, it's pretty much the same as a Route 53 health check. You indicate the network protocol, port, target and path of the health check, and optionally the check interval, failure threshold, and originating Regions of the health check requests.

You can use HTTP, HTTPS, or TCP for the network protocol, and even configure Route 53 to search for a specific string in the response body to determine if the response is good or not. Furthermore, you can invert the status of a health check, meaning Route 53 considers health checks to be unhealthy when the status is healthy and vice versa. After you create a health check, you can view the status of the health check, get notifications when the status changes via SNS and Cloudwatch Alarms, and configure DNS failover in response to a failed health check.

References:
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/registrar.html
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/dns-configuring.html
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/dns-failover.html

Latency Routing vs Geoproximity Routing vs Geolocation Routing

Latency Routing	
Definition	Lets Route 53 serve user requests from the AWS Region that provides the lowest latency. It does not, however, guarantee that users in the same geographic region will be served from the same location. Latency-based routing is based on latency measurements performed over a period of time, and the measurements reflect changes in network connectivity and routing.
How it works	To use latency-based routing, you create **latency records** for your resources in multiple AWS Regions. When Route 53 receives a DNS query for your domain or subdomain, it determines which AWS Regions you've created latency records for, determines which region gives the user the lowest latency, and then selects a latency record for that region. Route 53 responds with the value from the selected record, such as the IP address for a web server. Record sets can be created using any record type supported by Route 53, except NS or SOA records.
Use Case	Use when you have **resources in multiple AWS Regions** and you want to route traffic to the **region that provides the best latency**

Geoproximity Routing

Definition	Lets Amazon Route 53 route traffic to your resources based on the geographic location of your users and your resources. You can also optionally choose to route more traffic or less to a given resource by specifying a value, known as a bias. A bias expands or shrinks the size of the geographic region from which traffic is routed to a resource.
How it works	To use geoproximity routing, you must use **Route 53 traffic flow**. You create traffic flow policies for your resources and specify one of the following values for each policy: - If you're using AWS resources, you can set the AWS Region where your resource is created - If you're using non-AWS resources, you can enter the latitude and longitude of the resource
Use Case	Use when you want to route traffic **based on the location of** your resources and, optionally, shift traffic from resources in one location to resources in another.

Geolocation Routing

Definition	Resources serve traffic based on the geographic location of your users, meaning the location that DNS queries originate from.
How it works	Geolocation works by **mapping IP addresses to locations.** Some IP addresses aren't mapped to geographic locations, so Amazon Route 53 will receive some DNS queries from locations that it can't identify. You can create a default record that handles both queries from IP addresses that aren't mapped to any location and queries that come from locations that you haven't created geolocation records for. If you don't create a **default record**, Route 53 returns a "no answer" response for queries from those locations. No two records should specify the same geographic location.
Use Case	Use when you want to route traffic **based on the location of your users.** - You can localize your content and present some or all of your website in the language of your users. - You can restrict distribution of content to only the locations in which you have distribution rights. - Useful for balancing load across endpoints in a predictable, easy-to-manage way, so that each user location is consistently routed to the same endpoint.

Tutorials Dojo

Active-Active Failover and Active-Passive Failover

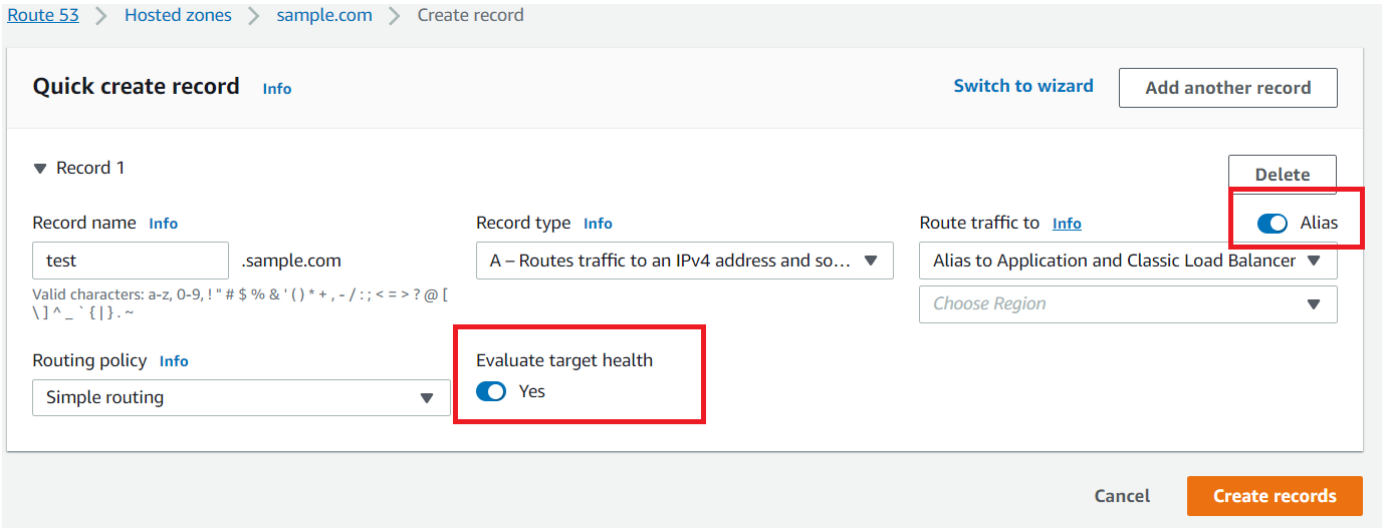
All types of systems nowadays need to implement some sort of redundancy and high availability to ensure business continuity. We'll never know when the next outage might occur, so by planning beforehand and developing solutions that consider the worst possible scenarios, we can create a highly resilient architecture that can achieve near 100% uptime.

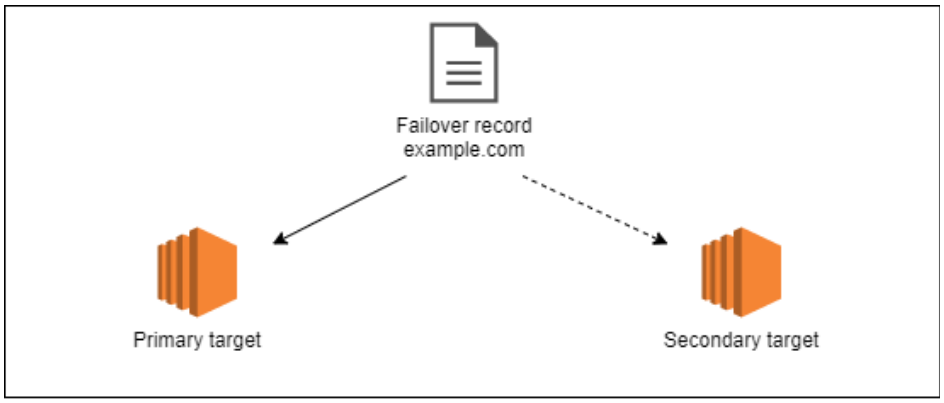
Hence, you should have a failover plan for every component of your system, and that includes your DNS services. AWS makes it very convenient for us to create solutions that focus on high availability and fault tolerance. In Route 53, AWS handles the availability of the service while you manage the policies that ensure your website's availability. Route 53 uses health checks to monitor the availability of your DNS targets. And there are two ways you can approach failovers in Route 53: active-active failover and active-passive failover.

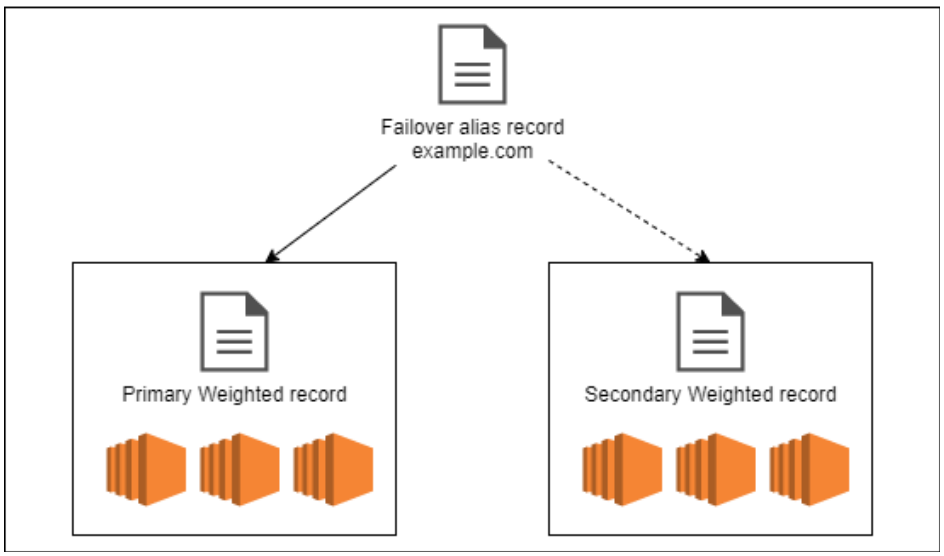
In an active-active failover setup, all DNS records that contain the same DNS name, the same record type (A, AAAA, CNAME, etc), and the same routing policy (simple, latency, weighted) are considered as active and queryable unless Route 53 marks them as unhealthy due to a health check. You can create multiple DNS records that have the same configuration but different targets in the same hosted zone. Route 53 will use any of these healthy records to respond to a DNS query.

Active-passive failover, on the other hand, uses the failover routing policy to handle DNS failovers. You'll be creating two failover alias records, one primary and one secondary, that are referencing your primary and secondary endpoints respectively. DNS queries are routed to your primary records for as long as their endpoints are healthy. In the event that your primary becomes unavailable, Route 53 will automatically respond to DNS queries using your secondary (failover). To create an active-passive failover configuration with one primary record and one secondary record, you just create the records and specify Failover for the routing policy. You can also associate multiple resources with the primary record, the secondary record, or both. Route 53 considers the primary failover record to be healthy as long as at least one of the associated resources is healthy.

If you are using Alias records for your primary and/or secondary records, there's no need for you to create manual health checks for those resources; just set Evaluate Target Health option in the record to Yes instead. For other record types, you will need to create manual health checks.







References:
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/dns-failover-types.html

https://aws.amazon.com/premiumsupport/knowledge-center/route-53-dns-health-checks/
https://tutorialsdojo.com/amazon-route-53/

Route 53 DNSSEC

Domain Name System Security Extensions, or DNSSEC, is a protocol for securing DNS traffic. It prevents attackers from hijacking traffic to internet endpoints by intercepting DNS queries and returning their own IP addresses to DNS resolvers, known as DNS spoofing. When you configure DNSSEC for your domain, a DNS resolver establishes a chain of trust for responses from intermediate resolvers. The chain of trust begins with the top-level domain registry for the domain and ends with the authoritative name servers at your DNS service provider. To configure DNSSEC for a domain, your domain and DNS service provider must meet the following prerequisites:

1. The registry for the TLD must support DNSSEC.
2. The DNS service provider for the domain must support DNSSEC. Route 53 supports DNSSEC signing as well as DNSSEC for domain registration.
3. You must configure DNSSEC with the DNS service provider for your domain before you add public keys for the domain to Route 53. Configuring DNSSEC in Route 53 involves two steps:
    a. Enable DNSSEC signing for Route 53, and have Route 53 create a key signing key (KSK) based on a customer managed CMK in AWS KMS.
    b. Create a chain of trust for the hosted zone by adding a Delegation Signer (DS) record to the parent zone, so DNS responses can be authenticated with trusted cryptographic signatures.
4. If you've configured DNSSEC with a different DNS service provider for the domain, you must add the public encryption keys to Route 53.
    a. In Route 53, under *Registered domains*, choose the name of the domain that you want to add keys for.
    b. At the *DNSSEC* status field, choose *Manage keys*.
    c. Specify the key type - key-signing key (KSK) or zone-signing key (ZSK).
    d. Specify the algorithm that you used to sign the records for the hosted zone.
    e. Specify the public key of the key pair that you used to configure DNSSEC.
    f. Click on Add to finish.

References:
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/domain-configure-dnssec.html
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/dns-configuring-dnssec.html

AWS Elastic Load Balancing

AWS ELB Request Routing Algorithms

You might have heard of a load balancer before, and you might already know what its purpose is, but are you familiar with how an AWS Elastic Load Balancer routes web requests to your targets?

We know that there are different variations of AWS ELBs, but for this section, we will just focus on these three types: Application Load Balancer, Network Load Balancer and Classic Load Balancer. Each of these types have their own routing procedures which we will elaborate below.

Application Load Balancer Routing	Network Load Balancer Routing	Classic Load Balancer Routing
1. When the load balancer receives a request, it first evaluates the listener rules in priority order to determine which rule to apply. Recall that listener rules specify how requests will be routed to appropriate targets. 2. Once a matching rule is found, the load balancer uses a routing algorithm to select a target from the target group for the rule action. The default routing algorithm is **round robin**. 3. Round robin algorithm attempts to distribute requests evenly to all targets by having each target take turns in receiving a request. 4. Another routing algorithm you can use for ALB is the **least outstanding requests algorithm**. Least outstanding requests algorithm is an algorithm that forwards incoming requests to targets with the lowest number of requests at that moment.	1. When the load balancer receives a request, it selects a target from the target group with a matching listener rule using **flow hash algorithm**. Flow hash algorithm checks on the following parameters: ● The protocol ● The source IP address and source port ● The destination IP address and destination port ● The TCP sequence number 2. The load balancer then routes each individual TCP connection to a single target for as long as the connection is alive, meaning once a TCP connection to a target has been established, NLB will keep using this connection for succeeding requests directed to this target.	1. This load balancer routes TCP requests to targets using round robin algorithm. 2. For HTTP and HTTPS requests, it uses the least outstanding requests algorithm.

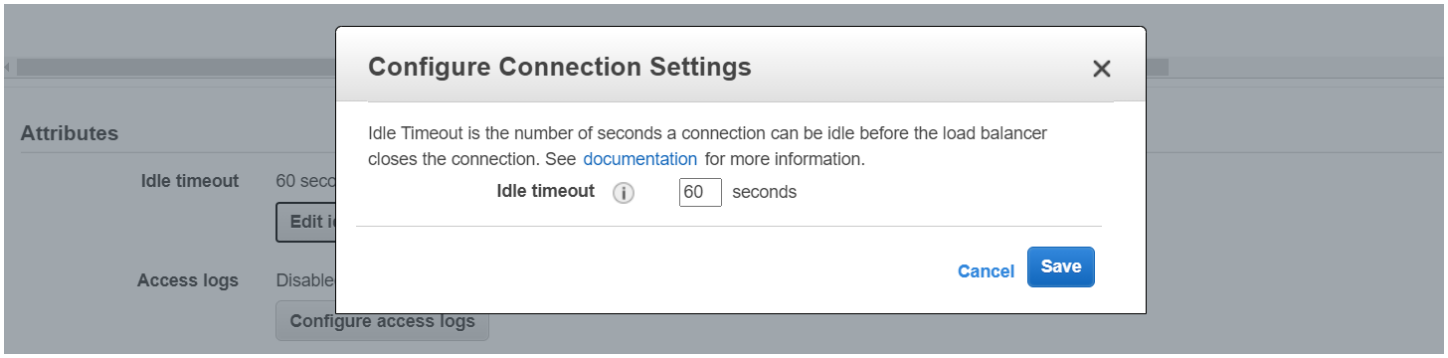
References:
https://docs.aws.amazon.com/elasticloadbalancing/latest/userguide/how-elastic-load-balancing-works.html#request-routing

ELB Idle Timeout

For every request that arrives at an ELB, the load balancer establishes two connections: one with the client application, and another one with the target destination. To make sure that these connections are only kept alive for as long as they are in use, your load balancer has an idle timeout period that monitors the state of these connections. An ELB idle timeout is the number of seconds that a connection has to send new data to keep the connection alive. Once the period elapses and there has been no transfer of new data, the load balancer closes the connection. This allows new connections to be established without using up all your connection resources. For network operations that take a long time to complete, you should send at least one byte of new data before your idle timeout elapses to maintain the connection.

The default idle timeout for load balancers is set at 60 seconds. You can modify the idle timeout period of classic and application load balancers if you need a much longer period, but do note that having a longer idle timeout might make it easier to reach the maximum number of connections for your load balancer. The maximum timeout period you can configure is 4000 seconds or 1 hour 6 minutes and 40 seconds. Network load balancers set the idle timeout value for TCP flows to 350 seconds. You cannot modify this value. Clients or targets can use TCP keepalive packets to reset the idle timeout.

Just to note. Setting the idle timeout to a higher number may be useful for some scenarios, but not all of them. When you are keeping a connection alive just to wait for a response from a long-running process, you should consider refactoring your applications to use asynchronous transmissions instead, or create a pipeline to decouple the response from the load balancer. Remember that, as a Solutions Architect, you should be designing the best solution for a given problem.

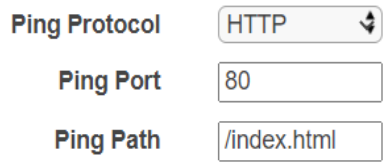
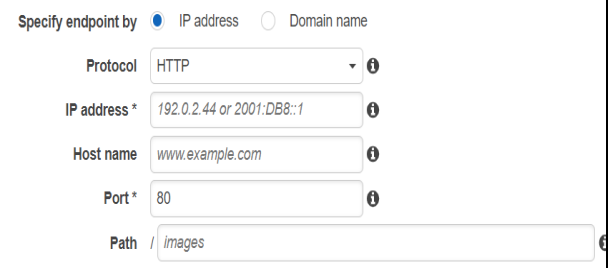
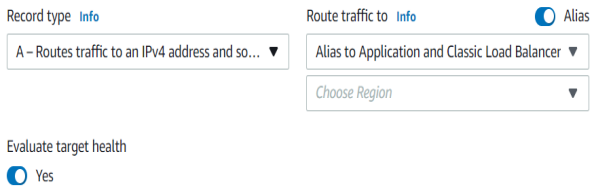


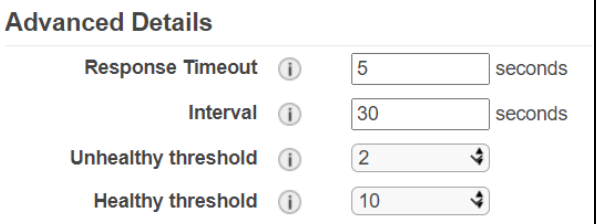
References:

https://docs.aws.amazon.com/elasticloadbalancing/latest/classic/config-idle-timeout.html
https://docs.aws.amazon.com/elasticloadbalancing/latest/application/application-load-balancers.html#connection-idle-timeout

ELB Health Checks vs Route 53 Health Checks For Target Health Monitoring

We all know that health checks are a very useful tool for making sure that AWS services such as AWS ELB and Amazon Route 53 know the state of their targets before forwarding traffic to them. In this section, we will take a look at ELB health checks and Route 53 health checks, and compare them with one another.

Health Check Service	AWS Elastic Load Balancing	Amazon Route 53
What is it for?	This health check periodically sends a request to a target instance, server or function to verify its status i.e. available to accept traffic requests.	This health check monitors the state of a record's target, which can be an EC2 instance, a server, or an AWS service that has an endpoint.
Target health check settings	You enter the port and common path of your targets that the load balancer will send the health check request to. 	You enter the domain name or the IP address, port, and path that Route 53 will use to send the health check request to if the record is a non-alias record,  or by setting *Evaluate target health* to Yes if the record is an alias record. 
Area span	Load balancers can monitor targets that	Route 53 monitors your targets regardless of

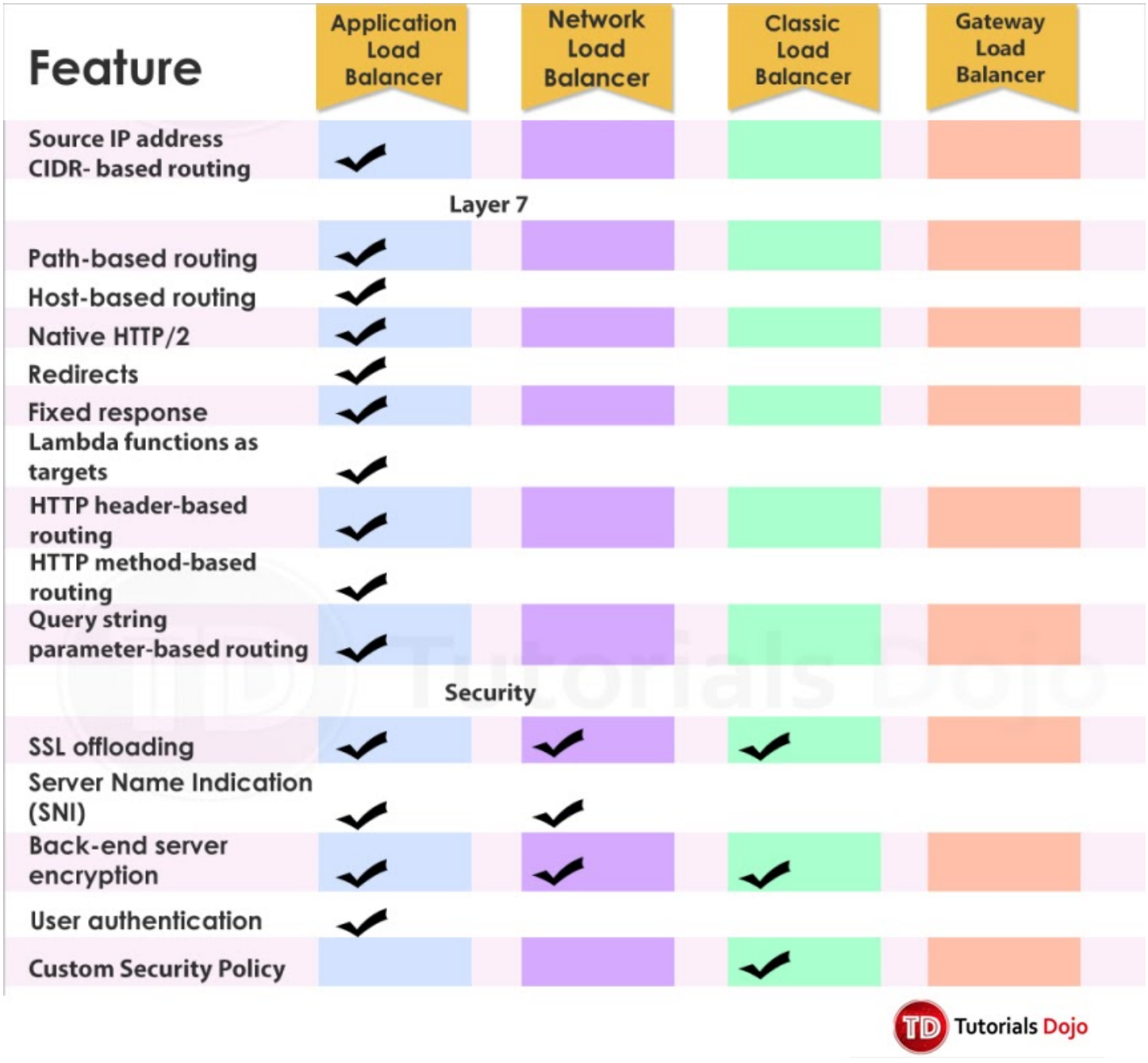
	span multiple availability zones but not multiple regions.	their location, as long as they are reachable by Route 53.
Health check frequency	You specify a value between 5 seconds and 300 seconds	Choose either every 10 seconds or every 30 seconds.
Response timeout	You can enter a value between 2 seconds and 60 seconds.	Cannot be configured.
Criteria to pass health check	You specify a threshold that a target should pass/fail a health check to determine its status. 	If more than 18% of health checkers report that an endpoint is healthy, Route 53 considers it healthy. If 18% of health checkers or fewer report that an endpoint is healthy, Route 53 considers it unhealthy. Route 53 health check servers are located in different locations worldwide.
Accessibility	Make sure targets are reachable by the load balancer. New targets can be easily added and removed from the load balancer.	Make sure endpoints are reachable and resolvable when users hit your URL. Due to DNS caching, it may take a while for new target endpoints to reflect to end users.
Primary purpose	High availability and fault tolerance for your services	DNS failover routing

There is no rule saying that you cannot use these two health checks together. In fact, it is a better practice to use them both! Amazon ELB will make sure that your traffic will only be handled by healthy targets, and Amazon Route 53 will make sure that your records have endpoints that are reachable and resolvable. Use different Route 53 record types and routing policies to perform an automatic DNS failover when an endpoint suddenly becomes unavailable, and control how the failover should occur.

References:
https://aws.amazon.com/blogs/aws/amazon-route-53-elb-integration-dns-failover/
https://docs.aws.amazon.com/Route53/latest/DeveloperGuide/dns-failover.html
https://docs.aws.amazon.com/elasticloadbalancing/latest/classic/elb-healthchecks.html

Application Load Balancer vs Network Load Balancer vs Classic Load Balancer vs Gateway Load Balancer

Feature	Application Load Balancer	Network Load Balancer	Classic Load Balancer	Gateway Load Balancer
Protocols	HTTP HTTPS	TCP, UDP, TLS	TCP, SSL/TLS, HTTP, HTTPS	IP
Platforms	VPC	VPC	EC2-Classic, VPC	VPC
Healthchecks	✓	✓	✓	✓
Cloudwatch Metrics	✓	✓	✓	✓
Logging	✓	✓	✓	✓
Zonal Failover	✓	✓	✓	✓
Connection Draining (deregistration delay)	✓		✓	
Load Balancing to multiple ports on the same instance	✓	✓		✓
IP addresses as targets	✓	✓ (TCP, TLS)		✓
Load balancer deletion protection	✓	✓		✓
Configurable idle connection timeout	✓		✓	
Cross-zone load balancing	✓	✓	✓	✓
Sticky sessions	✓	✓	✓	✓
Static IP		✓		
Elastic IP address		✓		
Preserve Source IP address		✓		✓
Resource-based IAM permissions	✓	✓	✓	✓
Tag-based IAM permissions	✓	✓		✓
Slow start	✓			
Web sockets	✓	✓		✓
PrivateLink Support		✓ (TCP, TLS)		✓ (GWLBE)



Application Load Balancer Listener Rule Conditions

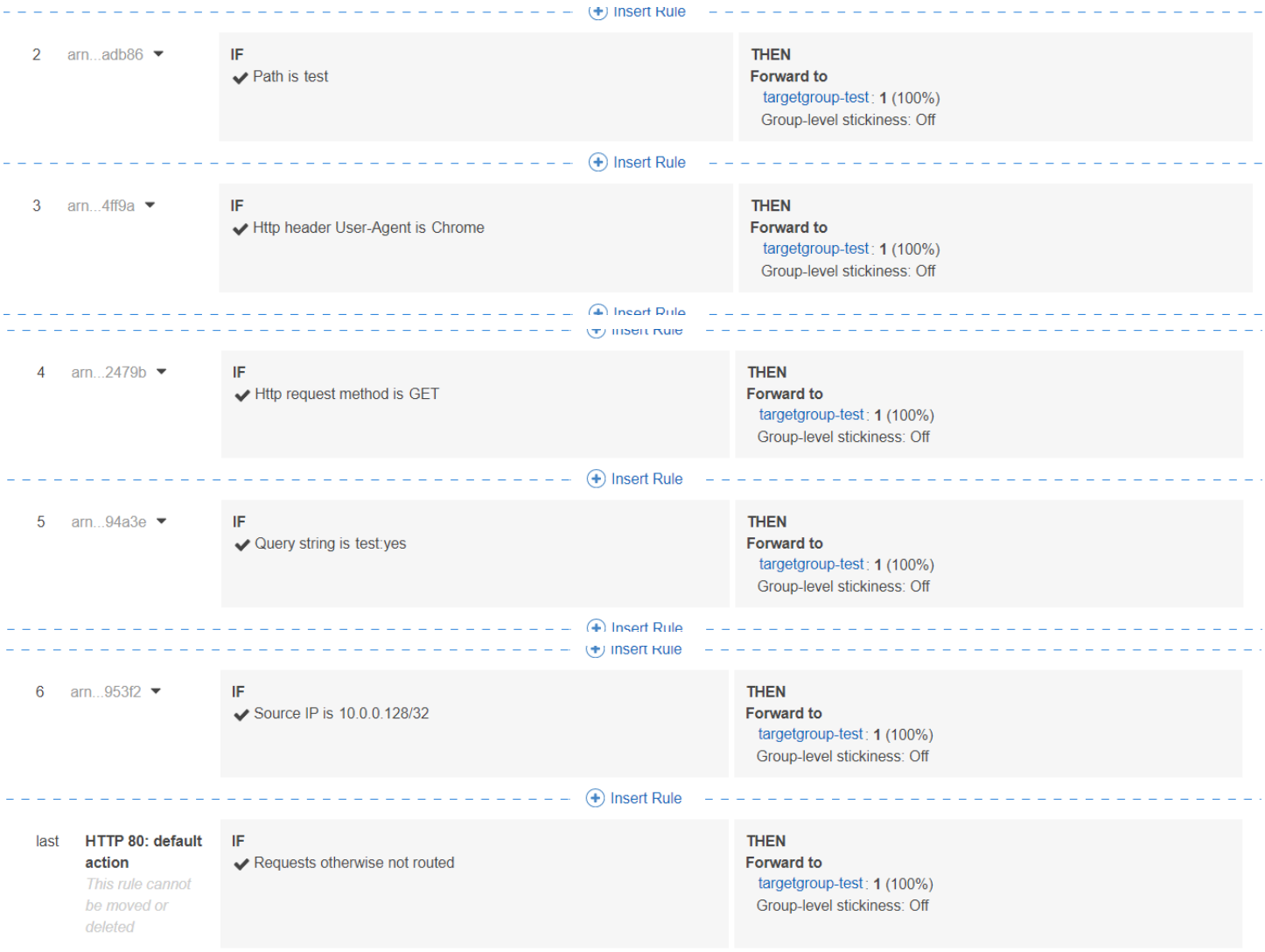
The AWS ELB Application Load Balancer is one of the most innovative services you can find in AWS. It offers many unique routing features that cannot be found in other types of elastic load balancers. But before we talk about listener rule conditions, let's first refresh ourselves with what listeners and listener rules are. A *listener* is

a process that checks for incoming connection requests, using the protocol and port that you configure. The *rules* that you define for a listener determine how the load balancer routes requests to its registered targets.

You can add the following conditions to a listener rule to create multiple routing paths under a single load balancer:

- **host-header** — Route based on the host name of each request. Also known as host-based routing. This condition enables you to support multiple subdomains and different top-level domains using a single load balancer. Hostnames and match evaluations are not case-sensitive.
- **http-header** — Route based on the HTTP headers for each request. Standard and custom headers are supported. Header name and match evaluation are not case-sensitive.
- **http-request-method** — Route based on the HTTP request method of each request. You can specify standard or custom HTTP methods for the value. The match evaluation is case-sensitive, so to properly route requests to this condition, the request method must exactly match the value you've entered.
- **path-pattern** — Route based on path patterns in the request URLs. Also known as path-based routing. This condition allows you to route to multiple targets depending on the URL path supplied in the request. URL path does not include the query parameters. Path evaluation is case-sensitive.
- **query-string** — Route based on key/value pairs or values in the query strings. Match evaluation is not case-sensitive. This condition does not include the URL path in the evaluation.
- **source-ip** — Route based on the source IP address of each request. The IP address must be specified in CIDR format. Both IPv4 and IPv6 addresses are supported as values for this condition. If a client is behind a proxy, the condition evaluates the IP address of the proxy, not the IP address of the client.

A listener rule can include up to one of each of the following conditions: host-header, http-request-method, path-pattern, and source-ip; and include one or more of each of the following conditions: http-header and query-string. You can also specify up to three match evaluations per condition, but only up to five match evaluations per rule. This gives you more values to work with for each condition you create.



References:

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https://tutorialsdojo.com/aws-elastic-load-balancing-elb

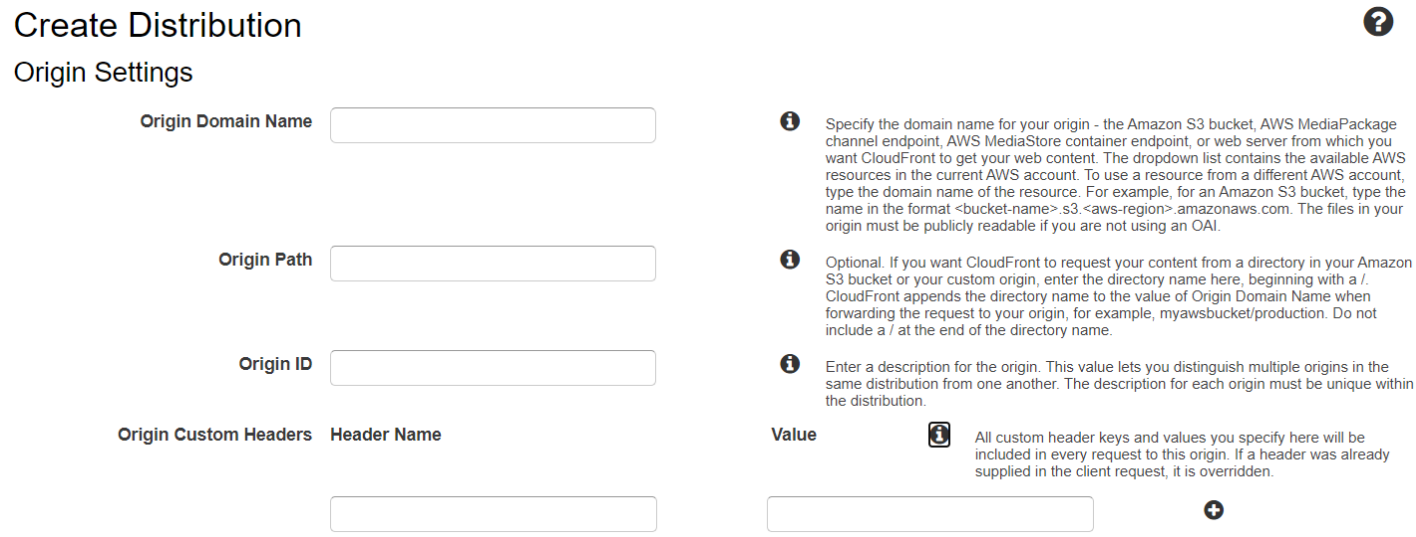
Amazon CloudFront

Custom DNS Names with Dedicated SSL Certificates for your CloudFront Distribution

Perhaps you have a set of EC2 web servers running behind an elastic load balancer serving your public website, and your website's DNS name is pointing directly to your load balancer in Route 53. This is the most common architecture you can build in the cloud. Although this architecture is absolutely fine as it is, there are still some areas you can improve upon. One of which is by placing a CDN (content delivery network) service such as Amazon CloudFront before your load balancer.

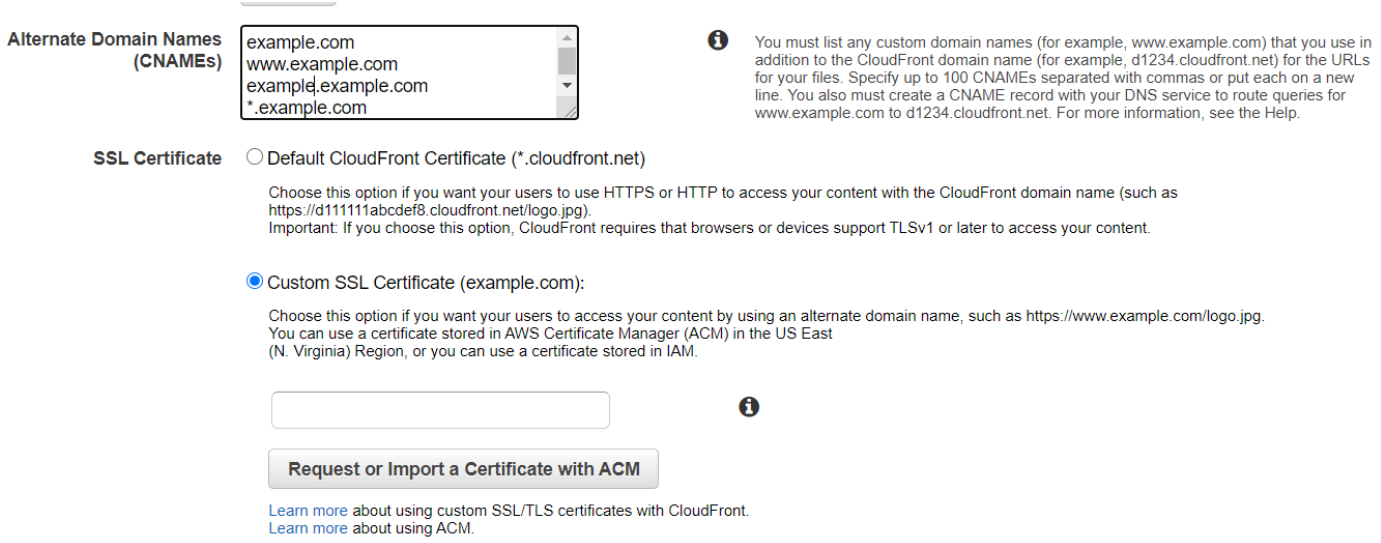
"Why?" you might ask. Amazon CloudFront is able to provide multiple benefits to your website. You can use CloudFront to have a better global reach since it's powered by AWS' global edge network. You can have CloudFront cache frequently requested objects from your website to speed up loading times for your users, while at the same time alleviating the burden from your web servers and databases from serving the same objects over and over again. It can also protect your website from security attacks such as DDoS since CloudFront introduces an extra layer before your actual architecture. You can also add in a WAF for additional security measures. These benefits sound great for any business that relies heavily on their website's performance. And here's how you can add a CloudFront to your architecture and repoint your domain name.

When you're creating a CloudFront distribution, you'll need to enter your origin domain name, which is the origin that CloudFront will use to serve requests. In this scenario, the origin domain name is the public DNS name of your elastic load balancer. You can also optionally provide an origin path if you want CloudFront to request your content from a specific directory in your custom origin. Next, you provide a custom origin ID so you can easily identify your custom origin. An origin ID is required since a single CloudFront distribution can support multiple origins and route requests to specific origins depending on the behavior that you define. For example, if the path pattern for a request includes */images/*.jpg*, you can tell CloudFront to route these requests to origin B and route everything else to origin A.



It is a good practice to always use HTTPS for your public websites, and you can enforce this in CloudFront, either by redirecting all HTTP requests to HTTPS or by allowing HTTPS requests only in the viewer protocol policy.

Each CloudFront distribution automatically generates a unique, publicly resolvable DNS endpoint for itself similar to an ELB. You can also list additional alternate domain names for your distribution. This enables your users to access your CloudFront using friendlier domain names. If you are enforcing HTTPS and you do not provide an alternate domain name for your CloudFront distribution, AWS lets you use the default CloudFront SSL certificate (*.cloudfront.net). But if you do provide alternate domain names for your CloudFront, you can utilize your own custom SSL certificates. The SSL certificate must be in AWS Certificate Manager (ACM) but doesn't necessarily have to be issued by ACM. You can import your own SSL certificate to ACM and it will work just fine.



For each origin, you can add multiple alternate domain names as long as they are supported by your custom SSL certificate. If you enter manilaph.com and manilaph1.com as alternate domain names, and manilaph1.com is not associated with your SSL certificate, the distribution will fail to launch. The domain names you enter can be parent domains, subdomains or wildcard domains.

Lastly, adding in your alternate domain names will not make them resolve automatically to your CloudFront distribution. You will also have to create the necessary DNS records for each of your alternate domain names in the appropriate hosted zones in Route 53 or any external DNS service you are using. If your hosted zone is in Route 53, you may create alias records to point the DNS records to your CloudFront. If you are using an external DNS service, you may create CNAME records and point them to the CloudFront-generated public DNS endpoint (*.cloudfront.net). In our scenario, the custom domain name was already pointing to your load balancer beforehand. Simply modify the record's target to point to your CloudFront and wait for the DNS cache to refresh.

Once you've created your CloudFront distribution and made the necessary changes in Route 53, requests to your website will now be handled by CloudFront. CloudFront searches for the correct destination origin to route these requests, and optionally caches the origin's response if you've configured caching. You can monitor the status of your CloudFront and your website's performance in Amazon Cloudwatch. Furthermore, you can enable logging for your CloudFront which logs all the requests that it receives and stores the logs in an Amazon S3 bucket.

References:
https://aws.amazon.com/premiumsupport/knowledge-center/multiple-domains-https-cloudfront/
https://docs.aws.amazon.com/AmazonCloudFront/latest/DeveloperGuide/using-https-alternate-domain-names.html
https://tutorialsdojo.com/amazon-cloudfront/

Restricting Content Access with Signed URLs and Signed Cookies

Sometimes, developers would like to add a CloudFront to their applications due to the benefits that the service provides, but these applications are not to be shared with the public. Take an S3 bucket for example. To prevent users from accessing your objects directly from the bucket, you'd place a CloudFront in front of the S3 bucket and have the users use CloudFront to access your objects. In this scenario, one potential security concern is that if your CloudFront URL got exposed to a third-party user, he or she will be able to access the same objects as well. To prevent this from happening, CloudFront has a neat feature that lets you securely serve private content to select users only. You can configure CloudFront to allow users to access your files using either *signed URLs* or *signed cookies* only.

When you create signed URLs or signed cookies to control access to your files, you can specify the following restrictions:

- An ending date and time, after which the URL is no longer valid.
- (Optional) The date and time that the URL becomes valid.
- (Optional) The IP address or range of addresses of the computers that can be used to access your content.

Part of a signed URL or a signed cookie is hashed using RSA-SHA1 algorithm and signed using the private key from an asymmetric key pair. When someone uses the signed URL or signed cookie, CloudFront compares the signed and unsigned portions of the URL or cookie. If they don't match, CloudFront doesn't serve the file.

Now what is the difference between signed URLs and signed cookies, and which one should you use? In a basic sense, they both provide the same functionality. Use signed URLs if you want to restrict access to individual files, or if your users are using a client that doesn't support cookies. Use signed cookies if you want to provide access to multiple restricted files, or if you don't want to change your current URLs. If your current URLs contain any of the following query string parameters, you cannot use either signed URLs or signed cookies:

- Expires
- Policy
- Signature
- Key-Pair-Id

CloudFront first checks your URLs for presence of any of the query parameters above. If any of them is present, CloudFront assumes that the URLs are signed URLs even if you haven't intended them as such, and therefore won't check for signed cookies.

Before you can create signed URLs or signed cookies, you need a signer. A signer is either a trusted key group that you create in CloudFront, or an AWS account that contains a CloudFront key pair. As soon as you add the signer to your CloudFront distribution, CloudFront starts requiring viewers to use signed URLs or signed

cookies to access your files. There might be cases wherein you don't want all your content to be accessed this way. Hence, you can create multiple cache behaviors in your distribution and only associate the signer with some of them. This allows you to require signed URLs or signed cookies for some files and not for others in the same distribution.

References:
https://docs.aws.amazon.com/AmazonCloudFront/latest/DeveloperGuide/PrivateContent.html
https://tutorialsdojo.com/amazon-cloudfront/
https://tutorialsdojo.com/s3-pre-signed-urls-vs-cloudfront-signed-urls-vs-origin-access-identity-oai/

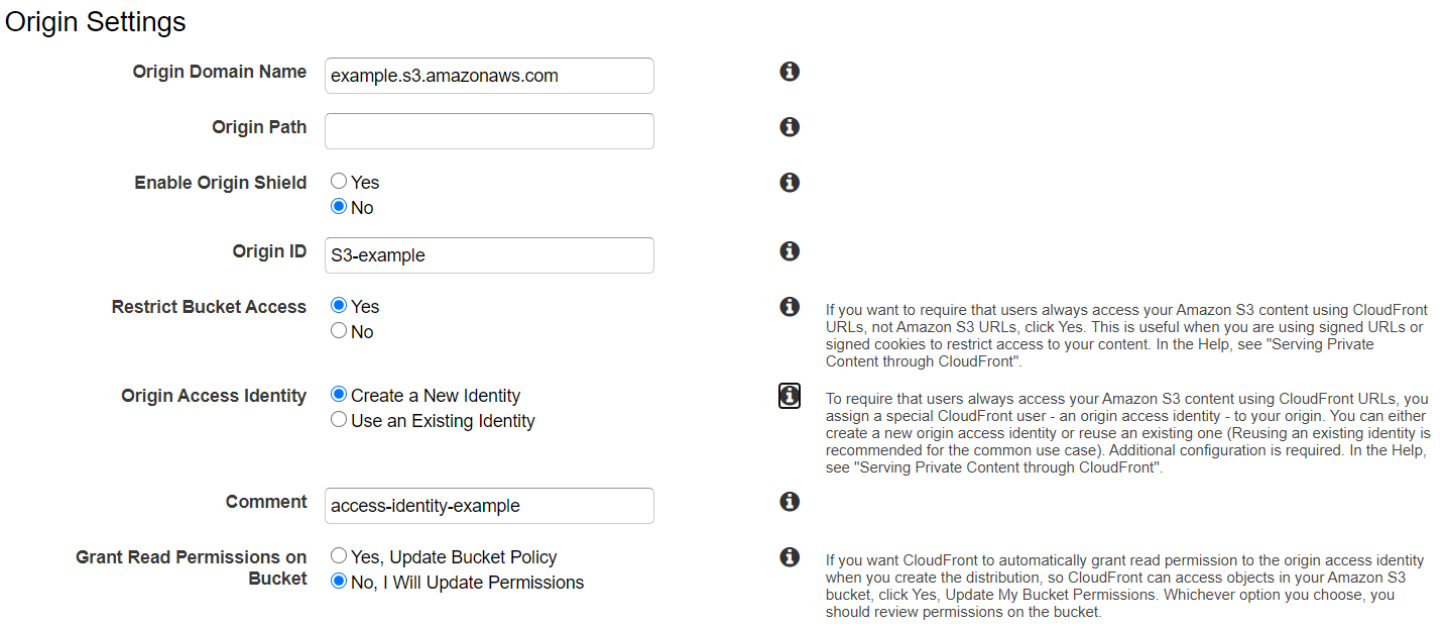
Origin Access Identity in CloudFront

When you first set up a publicly accessible S3 bucket as the origin of a CloudFront distribution, you grant everyone permission to read the files in your bucket. This allows anyone to access your files either through CloudFront or the Amazon S3 endpoint. This might be a security concern for you since you might want your objects to be accessible through CloudFront only. This is especially important if you have configured CloudFront signed URLs or signed cookies to restrict access to files in your S3 bucket, since they can bypass this by using the S3 file URL directly. Restricting access to content that you serve from S3 involves two steps:

1. Create a special CloudFront user called an origin access identity (OAI) and associate it with your distribution.
2. Configure your S3 bucket permissions so that CloudFront can use the OAI to access the files in your bucket and serve them to your users. Disable direct URL file access.

Origin access identity, or OAI, limits user access to your files only via CloudFront. So even if your S3 URL was exposed and a malicious attacker used it to try and access your files, the permissions you've set in your S3 bucket will prevent them from snooping around and retrieving anything. You can create an OAI while creating a CloudFront distribution or as an individual resource and associate it to a CloudFront distribution afterwards.

You can reuse existing OAIs since they are individual identities and are not directly tied to your origins. You can also have CloudFront immediately apply the necessary read permissions to your origin S3 bucket so that your OAI will be able to read your files. This saves you the time in writing your own S3 permissions (which might take you some time if you haven't done it before). An S3 bucket can have multiple OAIs as principals in its permission policy.



Here is an example of an S3 policy that allows an OAI to read all of its objects:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "AWS": "arn:aws:iam::cloudfront:user/CloudFront Origin Access Identity unique_identifier"
      },
      "Action": "s3:GetObject",
      "Resource": "arn:aws:s3:::tutorialsdojo/*"
    }
  ]
}
```

References:

https://docs.aws.amazon.com/AmazonCloudFront/latest/DeveloperGuide/private-content-restricting-access-to-s3.html
https://aws.amazon.com/premiumsupport/knowledge-center/cloudfront-access-to-amazon-s3/
https://tutorialsdojo.com/amazon-cloudfront/
https://tutorialsdojo.com/s3-pre-signed-urls-vs-cloudfront-signed-urls-vs-origin-access-identity-oai/

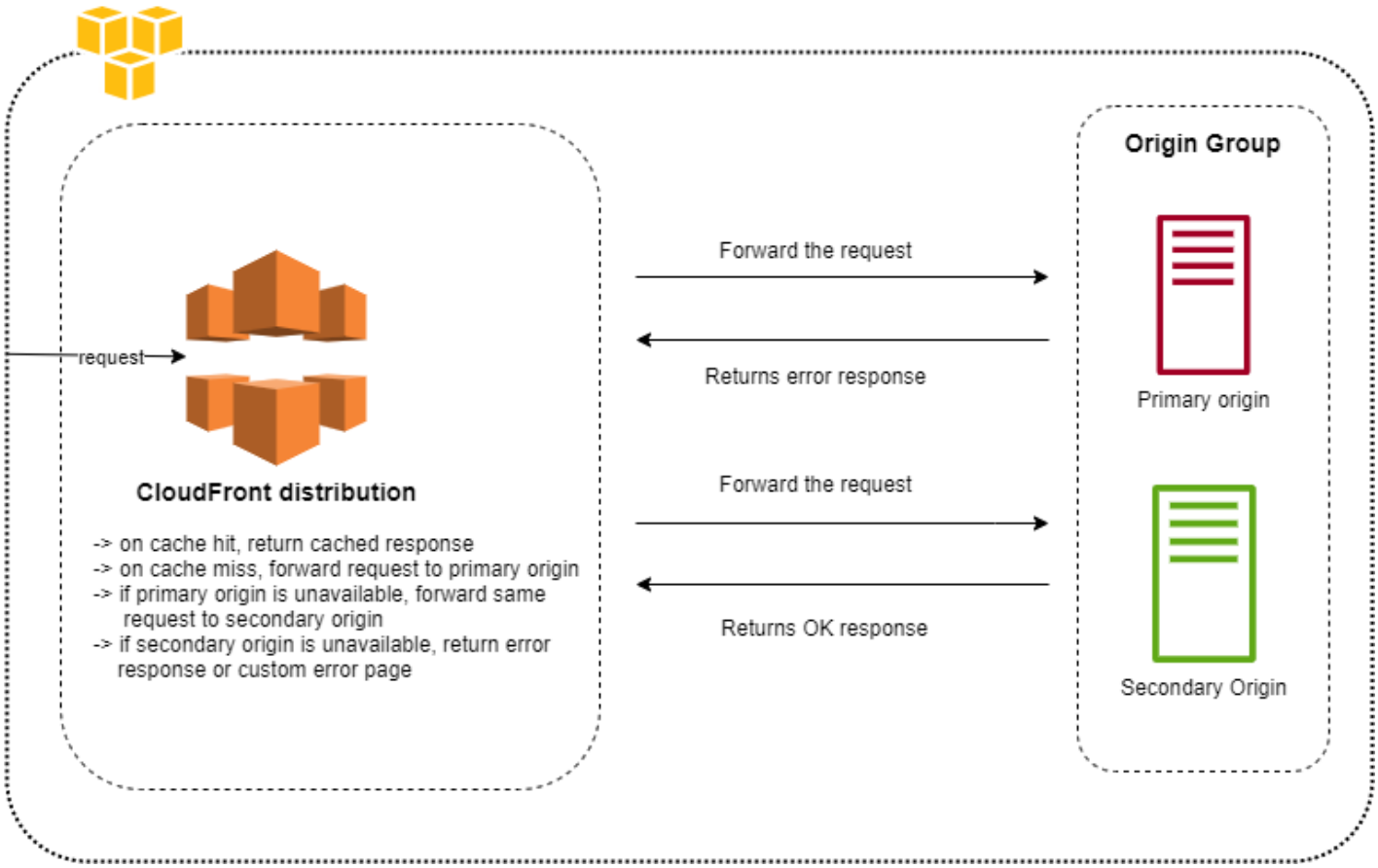
High Availability with CloudFront Origin Failover

Those that are using CloudFront must take into account the high availability of their origins. If it were to go down, your CloudFront should be able to automatically redirect traffic requests to a new origin. A CloudFront origin group lets you specify one primary origin and one secondary origin. If the primary origin becomes unavailable, or returns specific HTTP response status codes that indicate a failure, CloudFront automatically switches to the secondary origin. Origin failover requires your distribution to have at least two origins. Once you've created your origin group, you create or update a cache behavior to use the origin group.

After you configure origin failover for a cache behavior, CloudFront does the following for viewer requests:

1. When there's a cache hit, CloudFront returns the requested file.
2. When there's a cache miss, CloudFront routes the request to the primary origin in the origin group.
3. When the primary origin returns a status code that is not configured for failover, such as an HTTP 2xx or 3xx status code, CloudFront serves the requested content to the viewer.
4. CloudFront only routes the request to the secondary origin in the origin group when any of the following occur:
    a. The primary origin returns an HTTP status code that you've configured for failover
    b. CloudFront fails to connect to the primary origin
    c. The response from the primary origin times out

CloudFront fails over to the secondary origin only when the HTTP method of the viewer request is **GET**, **HEAD**, or **OPTIONS**. Other HTTP methods will not cause a failover. You can also create custom error pages for your primary and secondary origins in case they receive a request while they're unavailable.



References:

https://docs.aws.amazon.com/AmazonCloudFront/latest/DeveloperGuide/high_availability_origin_failover.html

https://tutorialsdojo.com/amazon-cloudfront/

AWS Direct Connect

Leveraging AWS Direct Connect

Some businesses have strict network and security requirements for their operations. For these cases, a dedicated and secure network to AWS is needed. If you need a dedicated network line for your traffic, provision an AWS Direct Connect from a provider and have it linked to your network. AWS Direct Connect provides many benefits compared to a VPN solution, such as a private connection to AWS, lower latency, and a higher network bandwidth. There are different ways to leverage Direct Connect:

1. If you need access to resources located inside a VPC, **create a private virtual interface (VIF) to a VGW attached to the VPC**. You can create 50 VIFs per Direct Connect connection, enabling you to connect to a maximum of 50 VPCs. Connectivity in this setup restricts you to the AWS Region that the Direct Connect location is homed to. This is not the best solution if you need to connect to a bunch of VPCs.
2. If your VPCs are located in different AWS Regions, **create a private VIF to a Direct Connect gateway associated with multiple VGWs**, where each VGW is attached to a VPC. You can attach multiple private virtual interfaces to your Direct Connect gateway from connections at any Direct Connect location. You have one BGP peering per Direct Connect Gateway per Direct Connect connection. This solution will not work if you need VPC-to-VPC connectivity.
3. You can associate a Transit Gateway to a Direct Connect gateway over a dedicated or hosted Direct Connect connection running at 1 Gbps or more. To do so, you need to create a **transit VIF to a Direct Connect gateway associated with Transit Gateway**. You can connect up to 3 transit gateways across different AWS Regions and AWS accounts over one VIF and BGP peering. This is the most scalable and manageable option if you have to connect to multiple VPCs in multiple locations.
4. If you need access to AWS public endpoints or services reachable from a public IP address (such as public EC2 instances, Amazon S3, and Amazon DynamoDB), **create a VPN connection to Transit Gateway over Direct Connect public VIF.** You can connect to any public AWS service and AWS Public IP in any AWS Region. When you create a VPN attachment on a Transit Gateway, you get two public IP addresses for VPN termination at the AWS end. These public IPs are reachable over the public VIF. You can create as many VPN connections to as many Transit Gateways as you want over public VIF. When you create a BGP peering over the public VIF, AWS advertises the entire AWS public IP range to your router.

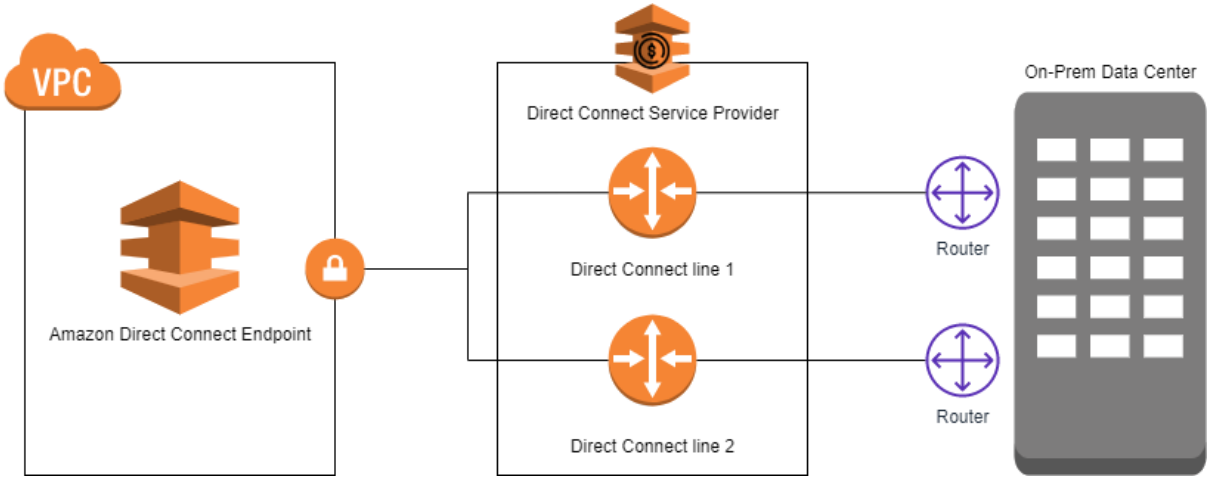
AWS Direct Connect supports both IPv4 and IPv6 on public and private VIFs. You will be able to add an IPv6 peering session to an existing VIF with IPv4 peering session (or vice versa). You can also create 2 separate VIFs – one for IPv4 and another one for IPv6.

References:
https://docs.aws.amazon.com/directconnect/latest/UserGuide/Welcome.html
https://tutorialsdojo.com/aws-direct-connect/

High Resiliency With AWS Direct Connect

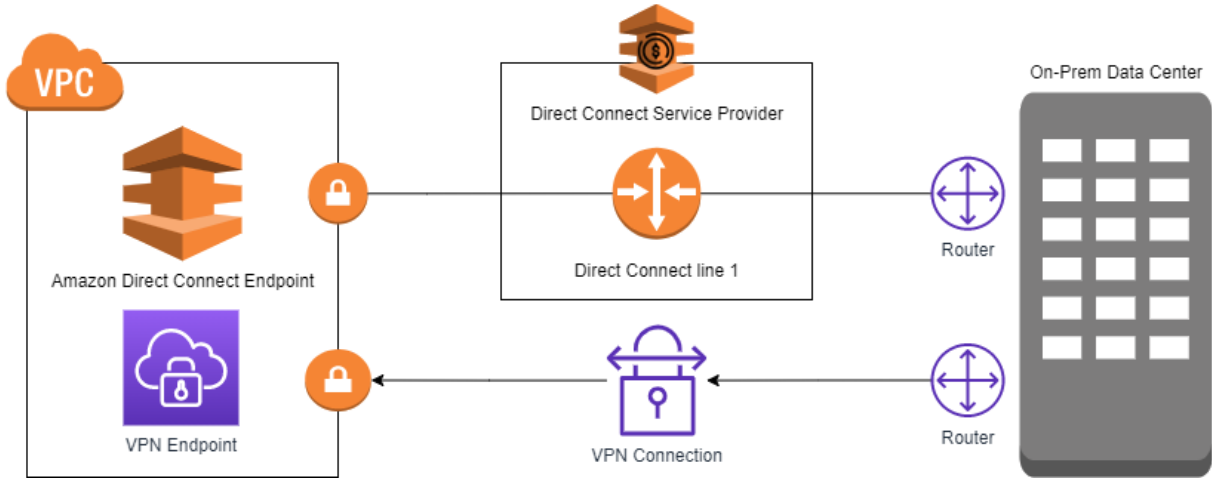
AWS Direct Connect, by default, is not a resilient network. The event of a line failure or network disruption can mean total downtime for you. There are approaches one can take to make an on-premises network connection to AWS more resilient, either by purchasing another Direct Connect line or by making use of the public internet and securing the connection with a VPN for example. Here we'll take a look at the different options in creating a resilient network with Direct Connect:

- Single on-premises data center having two Direct Connect lines (Development and Test)



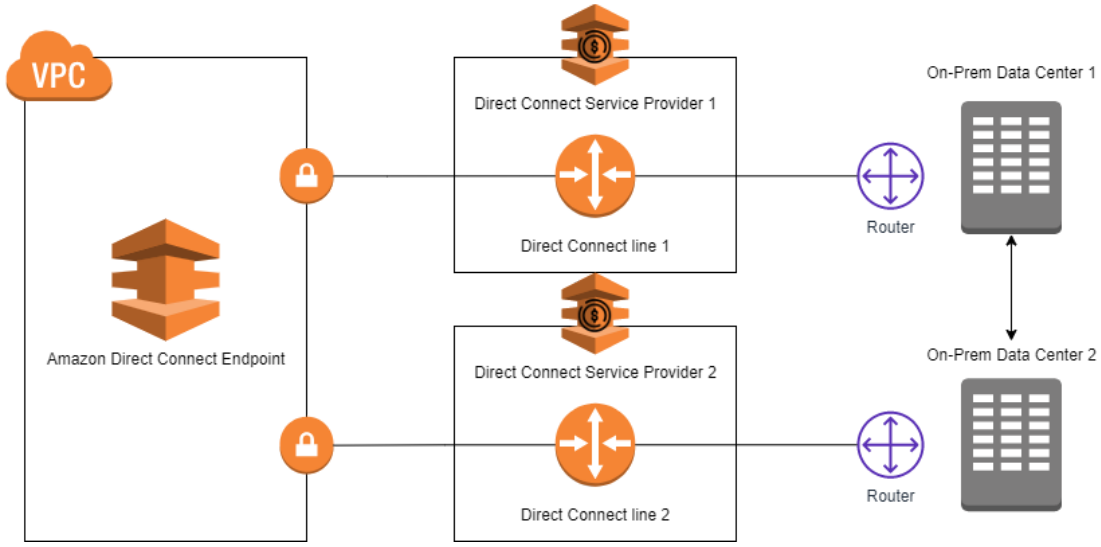
In this type of setup, if you only have a single on-premises data center connected to AWS, you may purchase two Direct Connect lines that are linked to two different devices or routers. If one of the connections were to fail, your network connection will automatically failover to the available Direct Connect line. You can also simulate a failover in AWS to verify if the setup meets your resiliency standards.

- Single on-premises data center having one Direct Connect line and a VPN solution as a secondary



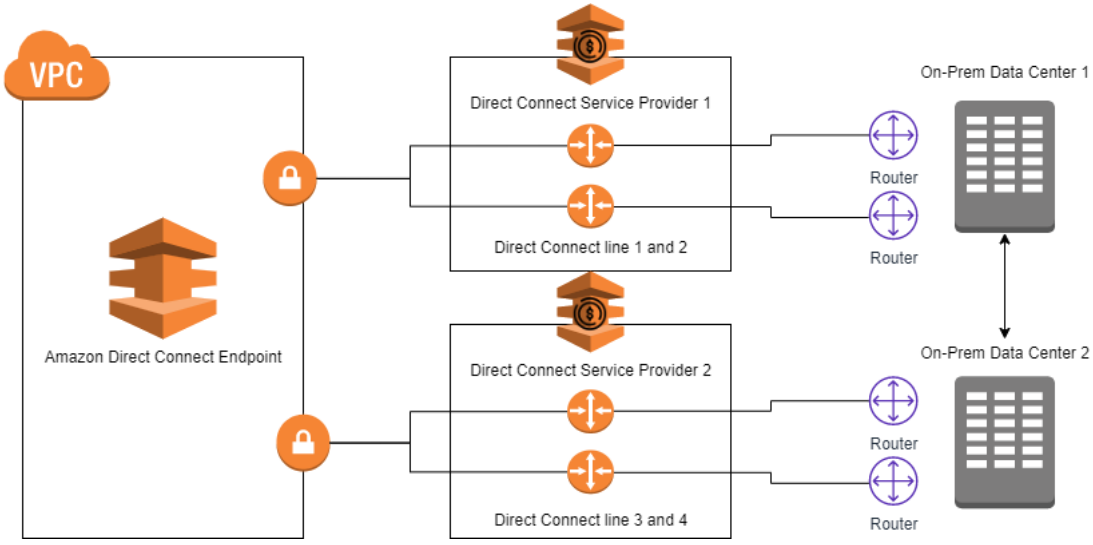
To save on cost, if a dedicated network is not a hard requirement, you may utilize an IPsec VPN connection as your failover solution instead. Do note that you will experience slower network speeds though with this approach.

- Two or more distinct on-premises data centers, each having its own Direct Connect line (High Resiliency)



The best way to make something resilient and highly available is to make it redundant. If you have multiple data centers in different locations connected to AWS, you can configure a Direct Connect line for each of them and link your data center networks together. If a data center's connection to AWS were to go offline, you can reroute the network to utilize the other active Direct Connect lines.

- Two or more distinct on-premises data centers with each having two Direct Connect lines (Max Resiliency)



If you truly, truly need that high uptime because you are running very critical workloads that cannot afford any kind of interruption, then you can set up redundant Direct Connect lines for each of your data centers. Think of this as the first resiliency solution, but applied for each of the critical data centers. This solution is very costly.

References:
https://aws.amazon.com/directconnect/resiliency-recommendation/
https://docs.aws.amazon.com/directconnect/latest/UserGuide/high_resiliency.html#high-resiliency-select-model
https://tutorialsdojo.com/aws-direct-connect/

AWS Global Accelerator

Connecting Multiple ALBs in Various Regions

AWS Global Accelerator provides you two global static customer facing IP addresses that you can use as a common endpoint for your public facing endpoints. These static IP addresses can be BYOIP or can be taken from the Amazon IP address pool. One huge benefit of Global Accelerator is the ability to consolidate your public endpoints in different AWS Availability Zones and Regions, and provide a common entry point which are the two aforementioned IP addresses. Furthermore, Global Accelerator is able to support up to 10 different regions. With this feature, you can add or remove origins, Availability Zones or Regions without affecting your application availability. If an endpoint suddenly fails or becomes unavailable, Global Accelerator will automatically redirect your new connections to a healthy endpoint within seconds.

Global Accelerator can associate its IP addresses to regional AWS resources or endpoints such as Network Load Balancers, Application Load Balancers, EC2 Instances, and Elastic IP addresses. You control the proportion of traffic sent to each endpoint by assigning them different weights. Global Accelerator complements Elastic Load Balancers well for load balancing and traffic routing at a global scale. ELB handles load balancing within one region, while Global Accelerator manages the traffic across multiple regions. Once you have mapped the static IP addresses to your load balancer endpoints, you'll need to update your DNS configuration to direct traffic to the static IP addresses or DNS name of the accelerator.

To start using Global Accelerator with ELBs, simply do the following:

1. Create a standard accelerator.
2. Add a listener with the allowed reachable ports or port range, and the protocol to accept: TCP, UDP, or both.
3. Add one or more endpoint groups, one for each region in which you have a load balancer.
4. Add one or more ELB endpoints to endpoint groups.

References:
https://docs.aws.amazon.com/global-accelerator/latest/dg/work-with-standard-accelerators.html
https://turon.tutorialsdojo.com/aws-global-accelerator/

AWS IAM

Identity-based Policies and Resource-based Policies

As you may already know, IAM policies are JSON documents that control what a principal can and cannot do in AWS. You explicitly state which permissions you'd like to grant and deny to a principal, and if they are only granted/denied permissions to specific resources. You can also add conditions to your policy statements, such as requiring the user to be MFA authenticated first before allowing any actions, for more granular controls. Below is an example of an IAM Policy:

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "ec2:AttachVolume",
            "ec2:DetachVolume"
         ],
         "Resource": [
            "arn:aws:ec2:*:*:volume/*",
            "arn:aws:ec2:*:*:instance/*"
         ],
         "Condition": {
            "ArnEquals": {"ec2:SourceInstanceARN": "arn:aws:ec2:*:*:instance/instance-id"}
         }
      }
   ]
}
```

There are two types of policies in IAM — **Identity-based** and **Resource-based**.

Identity-based policies are the ones you attach to IAM Users, Groups and Roles. Resource-based policies are ones that you attach to AWS services that support this type of policy, such as Amazon S3 buckets. Resource-based policies and resource-level permissions are two different things. Resource-based policies include a *Principal* element to specify which IAM identities can access that resource. Resource-level permissions refer to the ability to use ARNs to specify individual resources in a policy. Here is an example of a resource-based policy that allows principals with the *EC2RoleToAccessS3* role to retrieve objects from the sample S3 bucket, as long as the originating IP is not within 10.10.0.0/24 .

```
{
  "Version" : "2012-10-17",
  "Statement" : [
    {
      "Effect": "Allow",
      "Principal": {"AWS": "arn:aws:iam::123456789000:role/EC2RoleToAccessS3"},
      "Action": ["s3:GetObject","s3:GetObjectVersion"],
      "Resource": ["arn:aws:s3:::EXAMPLE-BUCKET/*"],
      "Condition": {
        "ForAnyValue:StringEquals": {
          "NotIpAddress": {"aws:SourceIp": "10.10.0.0/24"}
        }
      }
    }
  ]
}
```

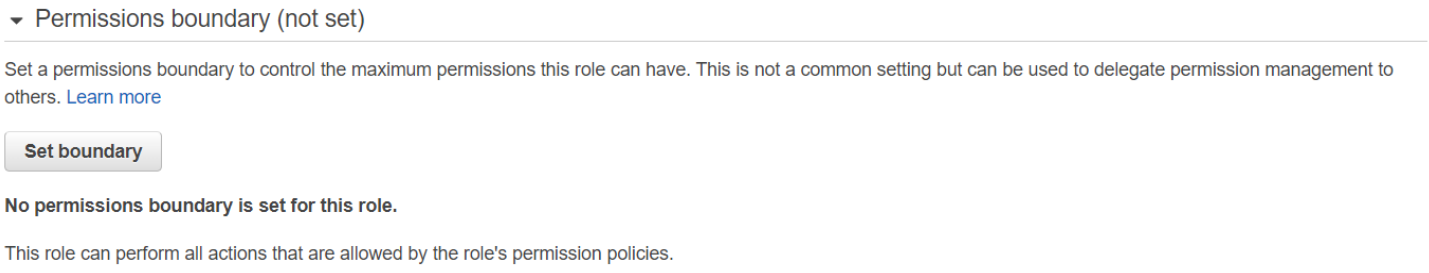
Both identity-based policies and resource-based policies are evaluated to determine if a principal will have access or not. If both do not provide an explicit allow, or either one has an explicit deny, then the principal is denied access.

References:
https://docs.aws.amazon.com/IAM/latest/UserGuide/access_policies_identity-vs-resource.html
https://tutorialsdojo.com/aws-identity-and-access-management-iam/

IAM Permissions Boundary

When you have users working on different projects and in different environments, it can be difficult to keep track of what permissions they need to do their work. Sometimes, it would be quicker to just let the users attach the IAM policies they need to their IAM roles. This can cause security issues in your AWS account since you are not following the principle of least privilege. You should not provide that much freedom of access to your users, but you also do not want to hinder their work, so what should you do? You can set a middle ground by simply creating IAM permissions boundaries.

"A permissions boundary is an advanced feature for using a managed policy to set the maximum permissions that an identity-based policy can grant to an IAM entity. An entity's permissions boundary allows it to perform only the actions that are allowed by both its identity-based policies and its permissions boundaries." Simply put, a permissions boundary keeps IAM user permissions and IAM role permissions in check by limiting what they can do. A boundary permission takes precedence over an identity policy, so even if your users attach *Administrator* privileges to their accounts, they will not be able to perform any actions that are beyond what is stated in their permissions boundary.



References:
https://docs.aws.amazon.com/IAM/latest/UserGuide/access_policies_boundaries.html
https://tutorialsdojo.com/aws-cheat-sheet-aws-identity-and-access-management-iam/

IAM Policy Structure and Conditions

We will be breaking down what constitutes an IAM Policy and what conditions you can add to your policies. The structure is as follows:

```
{
  "Statement":[{
    "Effect":"effect",
    "Action":"action",
    "Resource":"arn",
    "Condition":{
      "condition":{
        "key":"value"
        }
      }
    }
  ]
}
```

- **Effect** – The value can be either *Allow* or *Deny*. By default, IAM users don't have permission to do anything, so all requests are implicitly denied. **An explicit allow overrides the default. An explicit deny overrides any allows.**
- **Action** – The specific API action(s) that you are granting or denying permission.
- **Resource** – The resource that's affected by the action. You specify a resource using an Amazon Resource Name (ARN) or using the wildcard (*) to indicate that the statement applies to all resources.
- **Condition** – Conditions are optional. They can be used to control when your policy is in effect. Some conditions that you should be aware of are:

- StringEquals - Exact string matching and case sensitive
- StringNotEquals
- StringLike - Exact matching but ignoring case
- StringNotLike
- Bool - Lets you construct Condition elements that restrict access based on true or false values.
- IpAddress - Matching specified IP address or range.
- NotIpAddress - All IP addresses except the specified IP address or range
- ArnEquals, ArnLike
- ArnNotEquals, ArnNotLike
- Use a Null condition operator to check if a condition key is present at the time of authorization.
- You can add IfExists to the end of any condition operator name (except the Null condition)—for example, *StringLikeIfExists*.

References:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/iam-policy-structure.html
https://tutorialsdojo.com/aws-cheat-sheet-aws-identity-and-access-management-iam/

IAM Policy Evaluation Logic

When a principal sends a request to AWS, the following events occur to determine if AWS will accept or deny your request:

1) AWS first authenticates the principal that makes the request.
2) AWS processes the information gathered in the request to determine which policies apply to the request.
3) AWS evaluates all of the policy types, which affect the order in which the policies are evaluated.
4) AWS then processes the policies to determine whether the request is allowed or denied.

There can be multiple policy types applied onto a single account. They are all evaluated by AWS following the evaluation logic:

1) If only identity-based policies apply to a request, then AWS checks all of those policies for at least one explicit Allow and does not have an explicit Deny.
2) If resource-based policies and identity-based policies both apply to a request, then AWS checks all the policies for at least one Allow and does not have an explicit Deny.
3) When you set a permissions boundary for an entity, the entity can perform only the actions that are allowed by both its identity-based policies and its permissions boundaries. An implicit deny in a permissions boundary does not limit the permissions granted by a resource-based policy.
4) If an AWS Organization SCP is present, identity-based and resource-based policies grant permissions to principals in member accounts only if those policies and the SCP allow the action. If both a permissions boundary and an SCP are present, then the boundary, the SCP, and the identity-based policy must all allow the action with no explicit deny.

In summary, to know if a principal has permissions for an action or not, remember the behavior of each policy involved:

- By default, all requests are implicitly denied. Also, by default, the AWS account root user has full access.
- An explicit allow in an identity-based or resource-based policy overrides this default.
- If a permissions boundary, Organizations SCP, or session policy is present, it might override the allow with an implicit deny.
- An explicit deny in any policy overrides any allows.

References:
https://docs.aws.amazon.com/IAM/latest/UserGuide/reference_policies_evaluation-logic.html
https://tutorialsdojo.com/aws-cheat-sheet-aws-identity-and-access-management-iam/

AWS Key Management Service

AWS KMS Customer Master Key

The Customer Master Key or CMK is the most basic resource in AWS KMS. A CMK includes metadata, such as the key ID, creation date, description, and key state. The CMK also contains the key material used to encrypt and decrypt data. AWS KMS has two types of CMK encryption keys:

1) **Symmetric** - a 256-bit key that is used for encryption and decryption.
2) **Asymmetric** - an RSA key pair that is used for encryption and decryption or signing and verification (but not both), or an elliptic curve (ECC) key pair that is used for signing and verification.

Symmetric CMKs and the private keys of asymmetric CMKs never leave AWS KMS unencrypted.

Furthermore, there are three variations of CMKs in KMS:

1) **Customer managed** - These CMKs are what you have full control over. You handle establishing and maintaining their key policies, IAM policies, and grants, enabling and disabling them, rotating key material, adding tags, creating aliases that refer to the CMK, and scheduling the CMKs for deletion.
2) **AWS-managed** - These are CMKs in your account that are created, managed, and used on your behalf by an AWS service that is integrated with KMS. You cannot manage these CMKs, rotate them, or change their key policies. You also cannot use these CMKs in cryptographic operations directly; the service that creates them uses them on your behalf.
3) **AWS-owned** - These are CMKs that an AWS service creates, owns, and manages for use in multiple AWS accounts. You cannot view, use, track, or audit these CMKs.

By default, KMS creates the key material for all CMKs. You cannot extract, export, view, or manage this key material. Also, you cannot delete the key material alone; you must delete the whole CMK. However, you can import your own key material into a (customer-managed) CMK or create the key material for a (customer-managed) CMK in the AWS CloudHSM custom key store. Any type of CMK can be used for encryption and decryption. Data keys (symmetric data keys) and data key pairs (asymmetric data keys) can also be used for encryption and decryption. Only asymmetric CMKs and data key pairs can be used for signing and verification.

References:
https://docs.aws.amazon.com/kms/latest/developerguide/concepts.html#master_keys
https://tutorialsdojo.com/aws-key-management-service-aws-kms/

Custom Key Store

A custom key store for AWS KMS is a hardware security module (HSM) in a AWS CloudHSM cluster that you own and manage. You can create your CMKs in a custom key store, and KMS generates a 256-bit AES **symmetric key** material in the associated CloudHSM cluster that you can view and manage. This key material never leaves your HSM cluster unencrypted. You also have full control over the CloudHSM cluster, such as creating and deleting HSMs and managing backups. When you use a CMK stored in a custom key store, encryption and decryption happens in the hardware module in the cluster using this key material.

You should consider using a custom key store if you have any of the following requirements:

1. Key material cannot be stored in a shared environment.
2. Key material must be subject to a secondary, independent audit path. By independent, meaning AWS CloudHSM logs all API activity, local activity, user, and key management activity.
3. You need the ability to immediately remove key material from AWS KMS.
4. The HSMs that generate and store key material must be certified at FIPS 140-2 Level 3.

Custom key stores do not support creation of asymmetric CMKs, asymmetric data key pairs, or CMKs with imported key material, and you cannot enable automatic key rotation on a CMK in a custom key store. Key rotation must be performed manually by creating new keys and re-mapping AWS KMS key aliases. Each CloudHSM cluster can be associated with only one custom key store, and a cluster must contain at least two active HSMs in different Availability Zones. You can connect and disconnect your custom key store from a CloudHSM cluster at any time. When connected, you can create and use its CMKs. When it is disconnected, you can view and manage the custom key store and its CMKs, but not create new CMKs or use the CMKs in the custom key store for cryptographic operations.

References:
https://docs.aws.amazon.com/kms/latest/developerguide/custom-key-store-overview.html
https://tutorialsdojo.com/aws-key-management-service-aws-kms/

AWS KMS CMK Key Rotation

It is a security best practice to rotate encryption keys and passwords regularly, especially if these keys are used to protect very sensitive data. Key rotation lowers the risk of getting your key exposed and misused. AWS KMS is a service that lets you create and manage customer master keys. A customer master key is the primary resource in KMS. It is a logical representation of a master key.

The CMK includes metadata, such as the key ID, creation date, description, and key state, and it also contains the key material used for encrypting and decrypting data. When rotating your (customer-managed) CMKs in AWS KMS, you can create new CMKs and then modify your applications to use the new CMK. You can also enable automatic key rotation and let AWS KMS generate new cryptographic material for your CMKs every year.

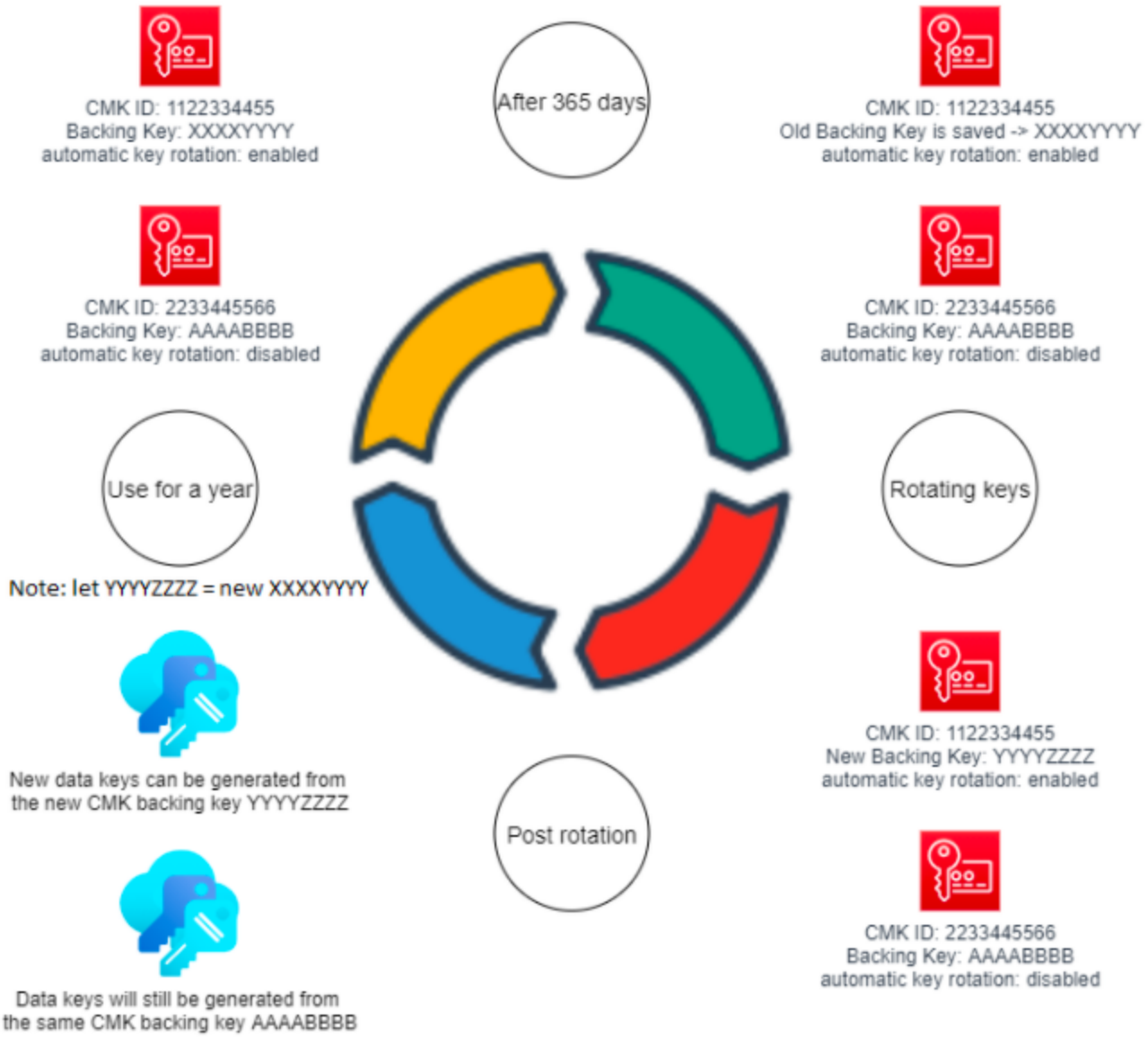
KMS also saves the older cryptographic material so it can be used to decrypt data that it has encrypted. KMS does not delete any rotated key material until you delete the CMK. There are limitations to automatic key rotation – asymmetric CMKs, CMKs in custom key stores, and CMKs with imported key material cannot be automatically rotated.

Automatic key rotation provides the following advantages:

1. The properties of the CMK, including its key ID, key ARN, region, policies, and permissions, do not change when the key is rotated.
2. You do not need to change applications or aliases that refer to the CMK ID or ARN.
3. AWS KMS rotates the CMK automatically every year. You don't need to remember or schedule the update.

However, automatic key rotation has no effect on the data that the CMK protects. It does not rotate the data keys that the CMK generated or re-encrypt any data protected by the CMK, and it will not mitigate the effect of a compromised data key. If you prefer having control over your rotation schedule and frequency, you should opt for manual key rotations instead.

How automatic key rotation works:



References:
https://docs.aws.amazon.com/kms/latest/developerguide/rotate-keys.html
https://tutorialsdojo.com/aws-key-management-service-aws-kms/

AWS Web Application Firewall

AWS WAF Rule Statements To Filter Web Traffic

AWS WAF is capable of protecting your public endpoints in CloudFront, Elastic Load Balancers, and API Gateway APIs from a multitude of web security threats. Rule statements tell AWS WAF how to filter out a web request. AWS WAF applies the corresponding action — allow, block or count — to a web request that matches a rule. Rule statements can be very simple (just one criteria to match) or complex (multiple statements combined using AND, OR, and NOT operators). You can use the following match statements to create a simple or complex rule statement:

Match Statement	Use Case
Geographic match	Allows you to allow or block web requests based on country of origin by creating one or more geographical, or geo, match statements. If you use the CloudFront geo restriction feature to block a country, requests from that country are blocked and are not forwarded to WAF.
IP set match	Inspects the IP address of a request against a set of IP addresses and address ranges that you want to allow through or block with your WAF.
Label match rule statement	Inspects the request for labels that have been added by other rules in the same web ACL.
Regex pattern set	Lets you compare regex patterns against a specified component of a web request.
Size constraint	Compares the size of a request component against a size constraint in bytes.
SQLi attack	Inspects for malicious SQL code in a web request.
String match	Searches for a matching string in a web request component. If a matching string is found, WAF allows/blocks the request.
XSS scripting attack	Inspects for cross-site scripting attacks in a web request.
Rate-based	Tracks the rate of requests of each originating IP addresses, and triggers a rule action on IPs with rates that go over a limit. You can use this type of rule to put a temporary block on requests from an IP address that's sending excessive requests.

References:
https://docs.aws.amazon.com/waf/latest/developerguide/waf-rules.html
https://tutorialsdojo.com/aws-waf/

Amazon Cloudwatch

Monitoring Additional Metrics with the Cloudwatch Agent

We know that Amazon Cloudwatch is your default service for monitoring different performance, network, and statistics related metrics of your AWS services. Although Cloudwatch Metrics is able to collect different types of data from your resources, it does not capture everything. There are some system-level metrics and logs that we should also be monitoring but cannot be directly monitored by Cloudwatch. For such cases, you need to install a Cloudwatch agent into your servers (on-prem, EC2 instances, containers, etc) to be able to retrieve these system-level metrics and logs, and have them monitored by Cloudwatch metrics. Furthermore, you can configure Cloudwatch agent to use the StatsD and collectd protocols to collect custom application and service metrics. StatsD is supported on both Linux servers and servers running Windows Server. Collectd is supported only on Linux servers.

Once you've installed the agent in your server, you specify the configuration settings of the agent that will define what metrics and logs to collect and send to Cloudwatch. The default namespace for metrics collected by the CloudWatch agent is CWAgent, which means that the custom metrics will be stored under this folder. You can specify a different namespace in your configuration file.

When configuring the Cloudwatch agent in your server for the first time, you can simplify the configuration process by running the configuration wizard, which provides you with some predefined metric sets that you can start off with. In the exam, if you have a scenario wherein you need to monitor any of the following metrics in your servers, be sure to choose the option that uses Cloudwatch agent:

Windows Server Metrics	Linux Metrics
Paging: Paging File % Usage	Swap: swap_used_percent
LogicalDisk: LogicalDisk % Free Space	Disk: disk_used_percent, disk_inodes_free
PhysicalDisk: PhysicalDisk % Disk Time, PhysicalDisk Disk Write Bytes/sec, PhysicalDisk Disk Read Bytes/sec, PhysicalDisk Disk Writes/sec, PhysicalDisk Disk Reads/sec	Diskio: diskio_io_time, diskio_write_bytes, diskio_read_bytes, diskio_writes, diskio_reads
Memory: Memory % Committed Bytes In Use	Memory: mem_used_percent
Network Interface: Network Interface Bytes Sent/sec, Network Interface Bytes Received/sec, Network Interface Packets Sent/sec, Network Interface Packets Received/sec	Network: net_bytes_sent, net_bytes_recv, net_packets_sent, net_packets_recv
TCP: TCPv4 Connections Established, TCPv6	Netstat: netstat_tcp_established,

Connections Established	netstat_tcp_time_wait
Processor: Processor % Processor Time, Processor % Idle Time, Processor % Interrupt Time, Processor % User Time	CPU: cpu_usage_guest, cpu_usage_idle, cpu_usage_iowait, cpu_usage_steal, cpu_usage_user, cpu_usage_system

References:
https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/Install-CloudWatch-Agent.html
https://tutorialsdojo.com/amazon-cloudwatch/

Cloudwatch Alarms for Triggering Actions

Cloudwatch Alarms is a useful, reactive automation tool for monitoring your AWS resources and making sure appropriate actions are made in response to certain situations. A metric alarm has three states:

- **OK** – The metric or expression is within the defined threshold.
- **ALARM** – The metric or expression is outside of the defined threshold.
- **INSUFFICIENT_DATA** – The alarm has just started, the metric is not available, or not enough data is available for the metric to determine the alarm state.

Each metric alarm consists of data points that inform Cloudwatch of the state of the metric that is being monitored. A data point reported to CloudWatch can fall under one of three categories:

- Not breaching (within the threshold)
- Breaching (violating the threshold)
- Missing

If the number of data points that are in a certain category meets your alarm threshold and changes the state of the alarm, you can define actions that Cloudwatch will perform for you in response to it. Examples of actions include:

1. Notifying a user or a group of users about the alarm by sending a message through Amazon SNS.
2. Stop, terminate, reboot, or recover an EC2 instance.
3. Scale an auto scaling group.
4. Create OpsItems in Systems Manager Ops Center to remediate the issue that triggered the alarm.

References:
https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/AlarmThatSendsEmail.html
https://tutorialsdojo.com/amazon-cloudwatch/

Cloudwatch Events (Amazon EventBridge) for Specific Events and Recurring Tasks

Another useful automation tool in AWS is Amazon Cloudwatch Events (Amazon EventBridge). Cloudwatch Events (Amazon EventBridge) lets you perform specific actions in response to an event or to a predefined schedule (cron). There are three ways to trigger a Cloudwatch Event (EventBridge Event):

1. Triggers on a matching event pattern emitted by an AWS service.
2. AWS API Call via CloudTrail.
3. Triggers on a regular schedule or regular rate (cron or rate expressions).

You can set up your AWS account to send events to other AWS accounts, or to receive events from other accounts. The sender account and receiver account must be using the same AWS Region in this case, since Cloudwatch is a regional service. You must also provide the required permissions to allow sending of events.

What's important to know is the supported targets of Amazon Cloudwatch Events (Amazon EventBridge) for processing events:

1. Amazon EC2 instances
2. AWS Lambda functions
3. Streams in Amazon Kinesis Data Streams
4. Delivery streams in Amazon Kinesis Data Firehose
5. Log groups in Amazon CloudWatch Logs
6. Amazon ECS tasks
7. Systems Manager Run Command, Automation, OpsItem and RunCommand
8. AWS Batch jobs
9. Step Functions state machines
10. Pipelines in CodePipeline
11. CodeBuild projects
12. Amazon Inspector assessment templates
13. Amazon SNS topics
14. Amazon SQS queues
15. EC2 CreateSnapshot, RebootInstances, StopInstances and TerminateInstances API calls.
16. The default event bus of another AWS account

And again, an event rule's target must be in the same region as the rule.

References:
https://docs.aws.amazon.com/AmazonCloudWatch/latest/events/WhatIsCloudWatchEvents.html
https://tutorialsdojo.com/amazon-cloudwatch/

AWS CloudTrail

What's Not Monitored By Default in CloudTrail and How To Start Monitoring Them

There are three types of events that you can log in AWS CloudTrail:

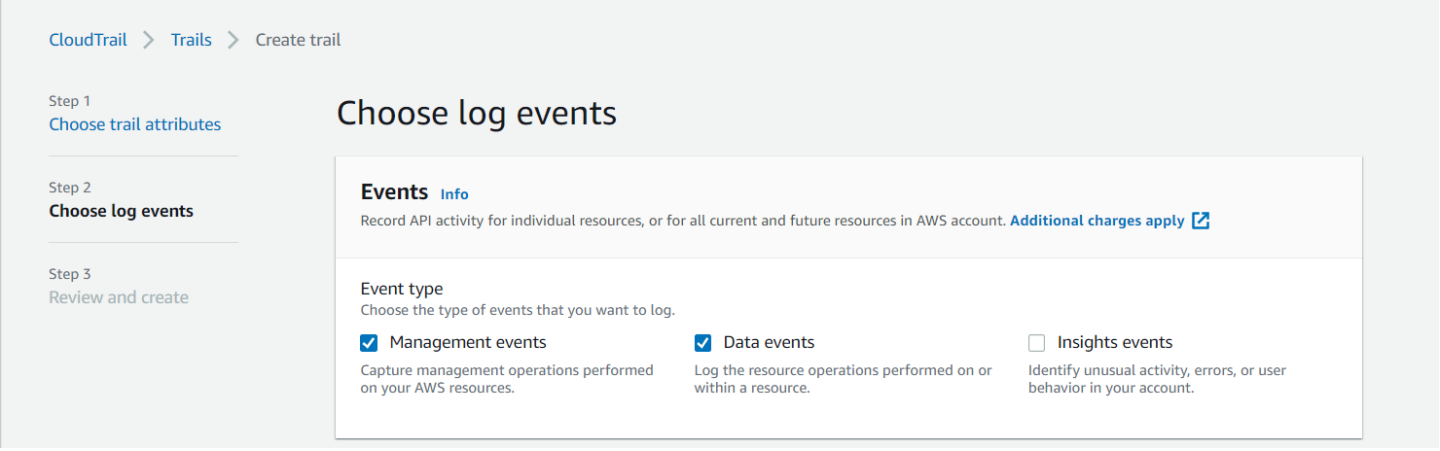
1. Management events which provide visibility into management operations that are performed on resources in your AWS account.
2. Data events which provide visibility into the resource operations performed on or within a resource.
3. Insights events which are logged when CloudTrail detects unusual write management API activity in your account.

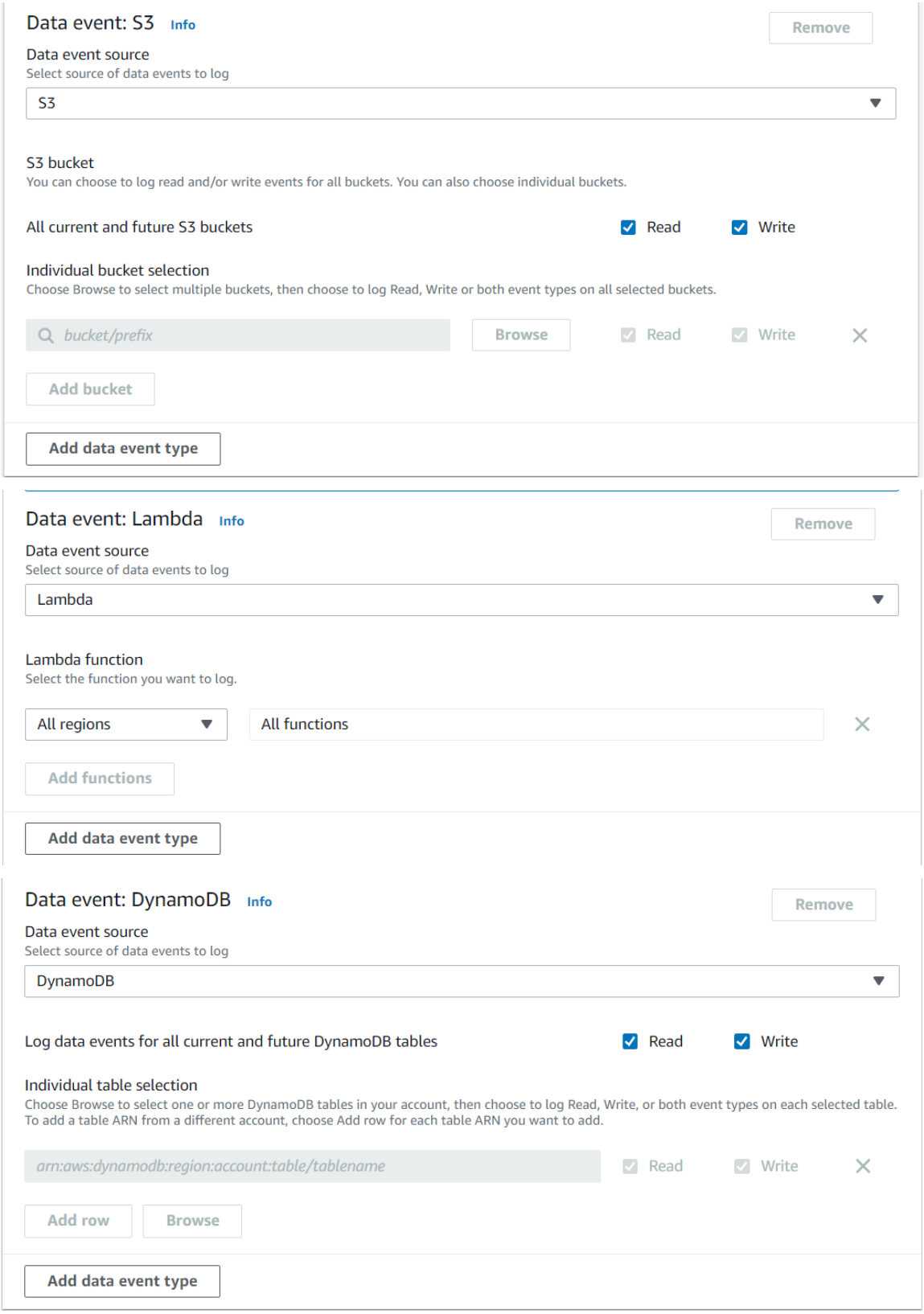
By default, AWS CloudTrail trails log all management events but don't include data or insights events.

Data events are often high-volume activities, which is why they are not automatically logged. Events that belong under the data events include:

- Amazon S3 GetObject, DeleteObject, and PutObject API operations
- AWS Lambda function Invoke API
- Amazon DynamoDB PutItem, DeleteItem, and UpdateItem API operations.

To start recording CloudTrail data events, you must explicitly add the resources or resource types you want to collect activity to a trail. For single-region trails, you can log data events only for resources that you can access in that region. Though S3 buckets are global, Lambda functions and DynamoDB tables are regional. Note that you will incur additional charges for enabling data event logging.




Data event: S3 Info
Remove
Data event source
Select source of data events to log
S3
S3 bucket
You can choose to log read and/or write events for all buckets. You can also choose individual buckets.
All current and future S3 buckets
Read
Write
Individual bucket selection
Choose Browse to select multiple buckets, then choose to log Read, Write or both event types on all selected buckets.
bucket/prefix
Browse
Read
Write
Add bucket
Add data event type
Data event: Lambda Info
Remove
Data event source
Select source of data events to log
Lambda
Lambda function
Select the function you want to log.
All regions
All functions
Add functions
Add data event type
Data event: DynamoDB Info
Remove
Data event source
Select source of data events to log
DynamoDB
Log data events for all current and future DynamoDB tables
Read
Write
Individual table selection
Choose Browse to select one or more DynamoDB tables in your account, then choose to log Read, Write, or both event types on each selected table.
To add a table ARN from a different account, choose Add row for each table ARN you want to add.
arn:aws:dynamodb:region:account:table/tablename
Read
Write
Add row
Browse
Add data event type

CloudTrail Insights is a feature that will log any unusual write API activity in your account which is then delivered to the destination S3 bucket for your trail. It uses machine learning to capture write management API usage that differs significantly from your account's typical usage patterns. And similar to data event logging, additional charges apply for logging Insights events.

References:
https://docs.aws.amazon.com/awscloudtrail/latest/userguide/cloudtrail-working-with-log-files.html
https://aws.amazon.com/premiumsupport/knowledge-center/cloudtrail-data-management-events/
https://tutorialsdojo.com/aws-cloudtrail/

Receiving CloudTrail Logs from Multiple Accounts and Sharing Logs To Other Accounts

There are occasions where one needs to monitor the CloudTrail of multiple AWS accounts, whether individually or as members of an AWS Organization. Consolidating the trails of each account into one will give you a centralized security viewpoint over the different accounts, and lets you store the trail logs in a single, secure location. To start receiving CloudTrail log files from multiple accounts, simply create an S3 bucket with cross-account write permissions for the target accounts in your master account, and configure the CloudTrail of the target accounts to publish their logs to the S3 bucket you created. After this, to make sure that audit logging does not get interrupted, you can create a policy in AWS Config that notifies you if any tampering was made to the CloudTrail configuration in the target accounts.

There are also situations when you need to share your CloudTrail logs to another AWS account, perhaps for auditing and investigation purposes. To share log files between multiple AWS accounts, you must perform the following steps:

1. Create an IAM role for each account that you want to share log files with.
2. For each of the IAM roles, create an access policy that grants read-only access to the account you want to share the log files with. For multiple account sharing, you can further restrict the policy to each account by granting read-only access to the logs that were generated by it.
3. Have an IAM user in each account assume the appropriate IAM role and retrieve the log files. Make sure that the IAM users in each account have the permission to assume their respective roles.

Once an account does not need to continue having access to the CloudTrail logs anymore, you can disable its access simply by deleting the IAM role you've created for it in the master account.

References:
https://docs.aws.amazon.com/awscloudtrail/latest/userguide/cloudtrail-receive-logs-from-multiple-accounts.html
https://docs.aws.amazon.com/awscloudtrail/latest/userguide/cloudtrail-sharing-logs.html
https://tutorialsdojo.com/aws-cloudtrail/

Amazon Simple Notification Service

Amazon SNS Message Filtering

By default, an Amazon SNS topic subscriber receives every message published to the topic. There are cases when a subscriber should not be receiving every message published to a topic, or should only be receiving a subset of the messages relevant to the subscriber. To achieve this, a subscriber must assign a filter policy to the topic subscription.

A *filter policy* is a JSON object that defines the attributes to look for in a message before it is sent to a subscriber. When you publish a message to a topic, SNS first compares the message attributes to the attributes in the filter policy for each of the topic's subscriptions. If a match is found, the message is sent to the matching subscription's subscriber. If there are no filter policies in a topic, then all messages are sent to subscribers.

Since filter policies are written in JSON, the attributes are in a name: value format. A subscription accepts a message under the following conditions:

- Each attribute name in a filter policy matches an attribute name in the message.
- For each matching attribute name, at least one match exists between the values of the attribute name in the filter policy and the message attributes.

The way SNS evaluates a message against a filter policy for a match is that all policy attributes must match the message's attributes, but the message's attributes do not need to contain just the policy's attributes. Message attributes that aren't specified in the policy are just ignored by SNS.

Here is an example of an SNS subscription filter policy:

```
{
  "company": ["tutorialsdojo"],
  "platform": [{"anything-but": "Internet Explorer"}],
  "exams ": [
    "SAA",
    "SOA",
    "CDA"
  ],
  "fordiscount": [{"numeric": [">=", 5.99]}],
  "sale" : [{"exists": true}]
}
```

If we were to receive an SNS message that does not have all the attributes in the filter policy above, or if there is at least one matching attribute with a non-matching value, then the message is rejected. A filter policy can have a maximum of 5 attribute names.

In a filter policy, you can use the following conditionals to create more specific rules:

1. **Exact matching** — matches if a policy attribute value includes one or more message attribute values.
2. **Anything-but matching** — matches if a message attribute doesn't include any of the policy attribute values.
3. **Prefix matching** — matches any message attribute value that begins with the specified characters.
4. **Value range matching** — lets you use <, <=, >, and >= and = operators. Matches any message attribute that satisfies the policy attribute's operation.
5. **Attribute key matching** — uses the exists operator to check whether a message has an attribute whose key is listed in the filter policy.
6. **AND/OR logic** — You can apply AND logic using multiple attribute names. You can apply OR logic by assigning multiple values to an attribute name.

References:
https://docs.aws.amazon.com/sns/latest/dg/sns-message-filtering.html
https://tutorialsdojo.com/amazon-sns/

Amazon SNS Topic Types, Message Ordering and Deduplication

Amazon SNS has two types of topics that fulfill different requirements. We compare the two types below:

Amazon SNS Topic Type	Standard Topic	FIFO Topic
Throughput	Can support nearly unlimited number of messages per second	Can support up to 300 messages per second or 10 MB per second per FIFO topic
Ordering	Best effort; Does not guarantee that the messages are fanned out the order they come in	Guarantees the ordering of the messages. First in first out.
Message Deduplication (does not send duplicate)	Best effort; A message is delivered at least once, but occasionally more than one copy of a message is delivered.	Duplicate messages aren't delivered. Deduplication happens within a 5-minute interval, from the message publish time.
Delivery endpoints	Messages can be sent to Amazon SQS, to AWS Lambda, to Amazon	Messages can only be sent to SQS FIFO queue subscriptions.

	Kinesis Data Firehose, through HTTP/S webhooks, through SMS, through mobile push notifications, and through email.	
Support for encryption	Messages sent to encrypted topics are immediately encrypted using a 256-bit AES-GCM algorithm and an AWS KMS CMK. Decryption occurs at the delivery endpoint.	
Fanout Limitations	Each account can have up to 100,000 Standard topics and each topic supports up to 12.5M subscriptions.	Each account can have up to 1000 FIFO topics and each topic supports up to 100 subscriptions.
Receive multiple messages in parallel	Yes	Yes, though to avoid any conflicts in the ordering, you need to consider adding another method to avoid messages arriving at the same time.

When you publish messages to an SNS FIFO topic, you set the message group ID. The group ID is a mandatory token that specifies that a message belongs to a specific message group. The SNS FIFO topic passes the group ID to the subscribed SQS FIFO queues. In the event that SNS FIFO loses access to the SQS FIFO queue (by some policy error for example), all messages are kept in SNS until the access is repaired and messages can be forwarded again.

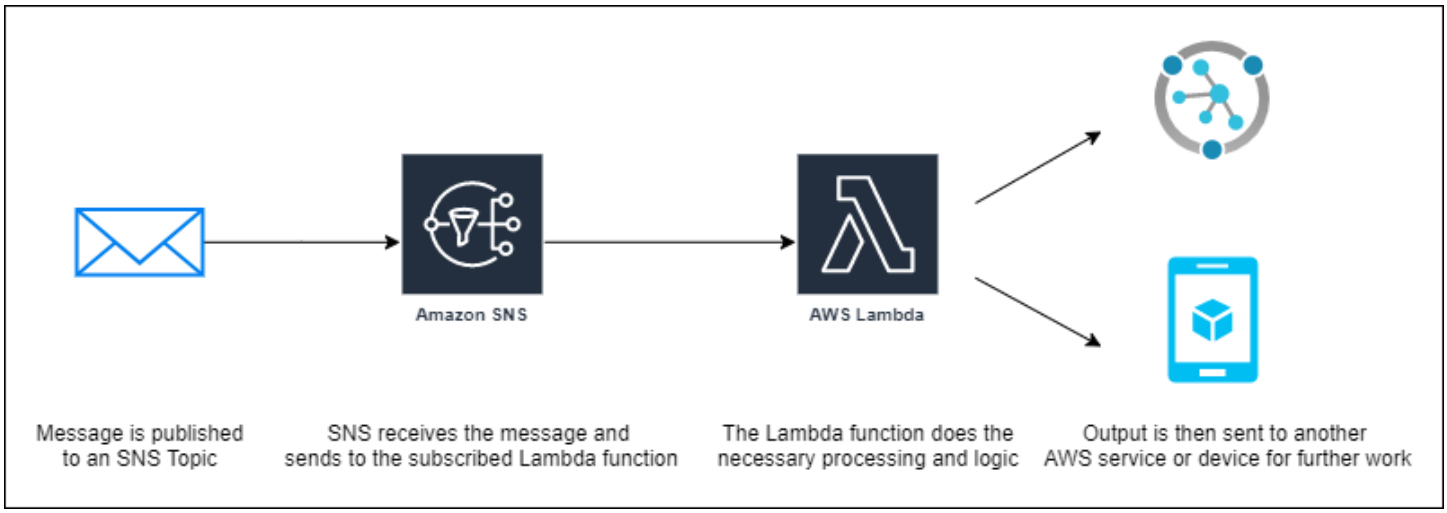
You can avoid delivering duplicated messages by enabling content-based deduplication or by adding a deduplication ID to the messages being published. Each message published to a FIFO topic has its own sequence number. The sequence number is passed to the subscribed SQS FIFO queues as part of the message body.

References:
https://aws.amazon.com/sns/features/
https://tutorialsdojo.com/amazon-sns/

Invoke Lambda Functions Using SNS Subscription

There are many ways to invoke a Lambda function in and out of AWS; it can be invoked directly with the Lambda console, the Lambda API, the AWS SDK, the AWS CLI, and AWS toolkits. You can also configure other AWS services to invoke your function, or you can configure Lambda to read from a stream or queue and invoke

your function. In this section, we'll take a look at how you can use Amazon SNS to invoke Lambda functions through subscriptions or in response to certain messages.



Amazon SNS supports Lambda functions as a target for messages sent to a topic. You can subscribe your function to topics in your account or in another AWS account. You can also choose target functions in your account or in another AWS account. For cross account subscriptions, you need to ensure that the AWS account with the target Lambda function authorizes your SNS topic to invoke their Lambda function. Additionally, you must create permissions to the target Lambda function to subscribe to your SNS topic.

To subscribe a function to a topic via the SNS console:

1) Go to your SNS console.
2) On the **Topics** page, choose a topic.
3) In the **Subscriptions** section, choose **Create subscription**.
4) On the **Create subscription** page, in the **Details** section, do the following:
    a) Verify the chosen **Topic ARN**
    b) **Protocol**: **AWS Lambda**
    c) **Endpoint**: Enter the ARN of a Lambda function.
5) Choose **Create subscription**.

You can also configure an SNS trigger in your Lambda function:

1) Go to the Lambda console and look for your function.
2) Under **Function Overview**, do the following
    a) Click **Add trigger**.
    b) Choose **SNS**.
    c) Choose the **SNS Topic** that will trigger your Lambda function.
    d) Click **Add**.
3) Save and verify your changes.

When a message is published to the SNS topic, SNS invokes the target function *asynchronously* with an event that contains the message and some metadata. The Lambda function receives the message payload as an input (event) parameter in JSON format, which you can manipulate and use however you like.

References:
https://docs.aws.amazon.com/lambda/latest/dg/with-sns.html
https://docs.aws.amazon.com/sns/latest/dg/sns-lambda-as-subscriber.html
https://tutorialsdojo.com/amazon-sns/

Amazon Simple Queue Service (Amazon SQS)

The Different SQS Queues

Amazon SQS is a message queueing service that uses a “polling” method, unlike Amazon SNS where messages are “pushed” to devices and targets. Amazon SQS is highly scalable and durable, and you don’t need to set up any message brokers. In this section, we’ll quickly take a look at the different queues that are available in Amazon SQS and the use cases of each one.

Standard queue is your default, general purpose SQS queue. This type of queue can support a nearly unlimited number of API calls per second, per API action which are the following: SendMessage, ReceiveMessage, or DeleteMessage. Standard queues make sure to deliver your messages at least once, but because of its high throughput, there is a chance that more than one copy of a message might be delivered. Your applications should be idempotent to avoid any problems in consuming a copy of a previously consumed message. Also, standard queues do not ensure that your messages are queued in the same sequence they arrive in, so maintaining the ordering is a best effort. You can think of standard queues as the counterpart of standard topics in Amazon SNS.

Some use cases of a standard queue include:

- Decouple live user requests from intensive background work
- Allocate tasks to multiple worker nodes
- Batch messages for future processing

FIFO (first-in first-out) queue is a type of SQS queue that is designed for preserving the order of messages as they arrive, and that every message is delivered exactly once, but at the expense of some throughput speed. FIFO queues are best used for messaging when the order of messages is critical, or where duplicates can't be tolerated. Unlike standard queues where it can support a nearly unlimited number of API calls per second, FIFO queues can only support up to 300 API calls per second, per API method. If you use batching, which is grouping 10 messages into one API call, then FIFO queues can support up to 3,000 transactions per second, per batch API method (SendMessageBatch, ReceiveMessage, or DeleteMessageBatch). Similar to SNS FIFO, SQS FIFO queues use a message deduplication ID to identify sent messages. There is also the required message group ID which is a tag that indicates if a message belongs to a specific message group.

You can't convert an existing standard queue into a FIFO queue. You must either create a new FIFO queue for your application or delete your existing standard queue and recreate it as a FIFO queue.

Some use cases of a FIFO queue include:

- To make sure that user-entered commands are run in the right order.
- To display the correct product price by sending price modifications in the right order.
- To prevent a student from enrolling in a course before registering for an account.

Messages that can't be processed successfully in standard and FIFO queues are sent to a dead letter queue. Dead letter queues let you debug your application or messaging system to determine why some messages weren't processed successfully. The maxReceiveCount is a parameter that you specify in your queue to manage the number of times a message can fail processing. When the ReceiveCount for a message exceeds this max value, SQS moves the message to a dead-letter queue with its original message ID. Dead letter queues must be the same type as their source queues. You cannot use a standard dead letter queue for a FIFO source queue for example.

A dead letter queue lets you achieve the following:

- Configure an alarm for any messages delivered to a dead-letter queue.
- Examine logs for exceptions that might have caused messages to be delivered to a dead-letter queue.
- Analyze the contents of messages delivered to a dead-letter queue to diagnose software or the producer's or consumer's hardware issues.
- Determine whether you have given your consumer sufficient time to process messages.

Delay queues let you postpone the delivery of new messages to a queue for a short duration. If you create a delay queue, any messages that you send to the queue remain invisible to consumers for the duration of the delay period. The default and minimum delay for a queue is 0 seconds. The maximum is 15 minutes. Delay queues work similarly to visibility timeouts in that they make messages invisible from consumers for a specific period of time. The main difference between the two is that, for delay queue, a message is hidden when it is first added into the queue, whereas for visibility timeout, a message is hidden only after it is consumed from the queue.

Different queue types have different delay behaviors. For standard queues, changing the per-queue delay setting doesn't affect the delay of messages already in the queue. For FIFO queues, changing the per-queue delay setting affects the delay of messages already in the queue. You can set the delay on individual messages, rather than on an entire queue, using message timers.

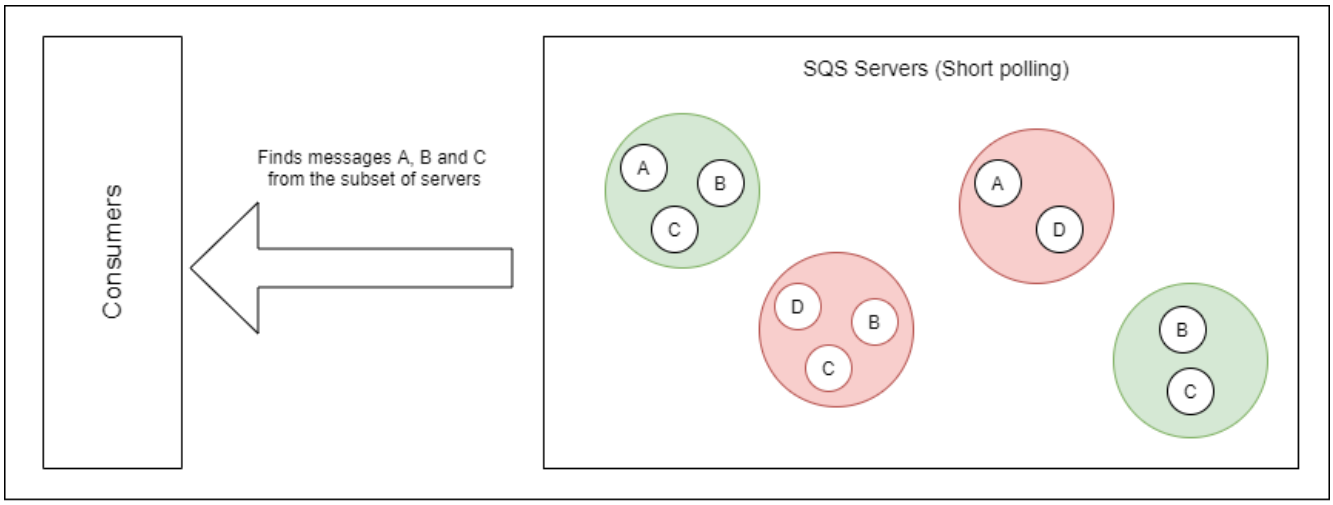
References:
https://docs.aws.amazon.com/AWSSimpleQueueService/latest/SQSDeveloperGuide/sqs-how-it-works.html
https://tutorialsdojo.com/amazon-sqs/

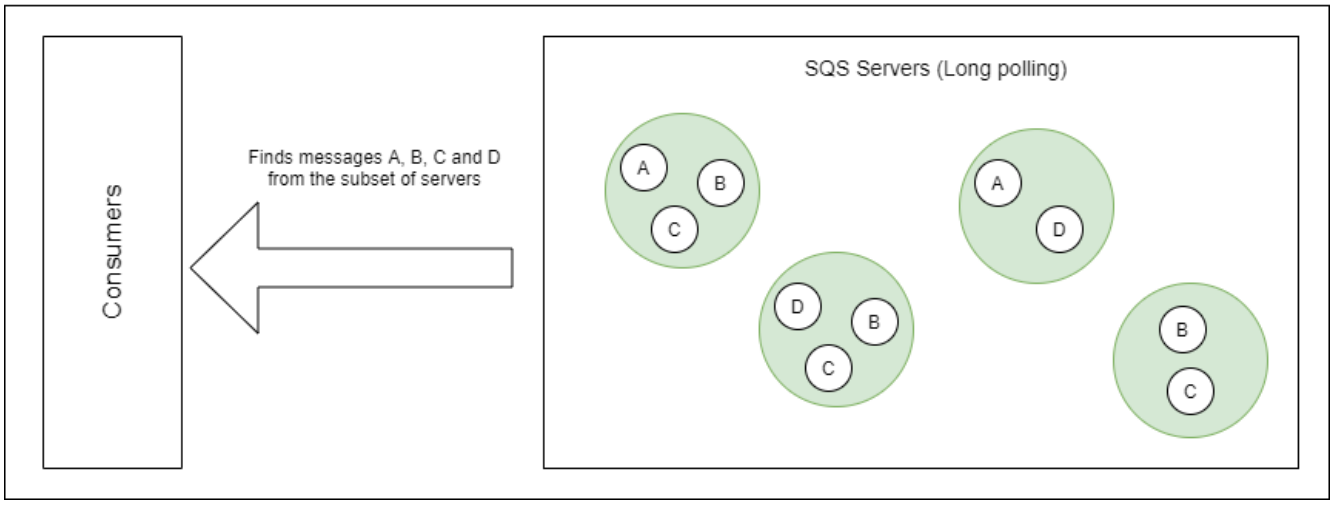
SQS Long Polling and Short Polling

Your SQS polling method determines the way SQS searches and returns your messages to you. There are two polling methods to choose from: **long polling** and **short polling**. Each polling method has its own advantages and disadvantages which we'll take a look at below.

Short polling is in effect when your wait time is 0. With short polling, the ReceiveMessage request searches only a subset of the SQS servers to find messages to include in the response. SQS sends the response right away, even if the query finds no messages. And since only a subset of servers are searched, a request might not return all of your applicable messages. Short polling is best for time-sensitive applications or batch applications that can send another query if it received an empty response previously.

Long polling is in effect when your wait time is greater than 0. With long polling, the ReceiveMessage request searches all of the SQS servers for messages. SQS returns a response after it collects at least one available message, up to the maximum number of messages specified in the request, and will only return an empty response if the polling wait time expires. The maximum long polling wait time is 20 seconds. Long polling helps reduce the cost of using SQS by eliminating the number of empty responses and false empty responses.





References:

https://docs.aws.amazon.com/AWSSimpleQueueService/latest/SQSDeveloperGuide/sqs-short-and-long-polling.html
https://tutorialsdojo.com/amazon-sqs/

Scaling Out EC2 Instances Based On SQS

Amazon SQS is able to support a high number of API calls for sending and receiving messages in a queue. You can have your applications run in an auto scaling group of EC2 instances to send and consume messages from an SQS queue in parallel to maximize work efficiency. Although, estimating the number of EC2 instances you'll need can be quite difficult if you do not use a proper metric for your auto scaling group. You'd be able to avoid this predicament if you had visibility on the number of messages in your SQS queue that needs to be processed.

There is an SQS metric in CloudWatch called ApproximateNumberOfMessagesVisible that tracks the number of messages in a queue. However, this metric might not be the most suitable for your target tracking policy since there are other factors besides the number of messages in a queue that should determine the number of auto scaling instances that you should have. You also have to consider the rate of messages processed by an auto scaling instance per unit of time and the latency between different components of your system.

Instead of tracking the number of backlog messages in a queue metric, it would be better to use *a backlog per instance* metric with the target value being the acceptable backlog per instance to maintain. To calculate your backlog per instance, get the *ApproximateNumberOfMessagesVisible* queue attribute to determine the length of the SQS queue, and divide that number by the number of auto scaling instances in the InService state. To calculate the acceptable backlog per instance, first determine how much your application can accept in terms of latency. Then, take the acceptable latency value and divide it by the average time that an EC2 instance takes to process a message.

References:
https://docs.aws.amazon.com/autoscaling/ec2/userguide/as-using-sqs-queue.html
https://tutorialsdojo.com/amazon-sqs/

Amazon Kinesis

Kinesis Scaling, Resharding and Parallel Processing

- **Kinesis Resharding** enables you to increase or decrease the number of shards in a stream in order to adapt to changes in the rate of data flowing through the stream.
- Resharding is always pairwise. You cannot split into more than two shards in a single operation, and you cannot merge more than two shards in a single operation.
- The Kinesis Client Library (KCL) tracks the shards in the stream using an Amazon DynamoDB table, and adapts to changes in the number of shards that result from resharding. When new shards are created as a result of resharding, the KCL discovers the new shards and populates new rows in the table.
- The workers automatically discover the new shards and create processors to handle the data from them. The KCL also distributes the shards in the stream across all the available workers and record processors.
- When you use the KCL, you should ensure that **the number of instances does not exceed the number of shards** (except for failure standby purposes).
    - **Each shard is processed by exactly one KCL worker and has exactly one corresponding record processor**.
    - **One worker can process any number of shards**.
- You can scale your application to use more than one EC2 instance when processing a stream. By doing so, you allow the record processors in each instance to work in parallel. When the KCL worker starts up on the scaled instance, it load-balances with the existing instances, so now each instance handles the same amount of shards.
- To scale up processing in your application:
    - Increase the instance size (because all record processors run in parallel within a process)
    - Increase the number of instances up to the maximum number of open shards (because shards can be processed independently)
    - Increase the number of shards (which increases the level of parallelism)

Reference:
https://docs.aws.amazon.com/streams/latest/dev/kinesis-record-processor-scaling.html

Kinesis Data Streams vs Kinesis Data Firehose vs Kinesis Data Analytics vs Kinesis Video Streams

Given that there are four different variations of Amazon Kinesis, it's understandable that use cases between each of them can get confusing. Although there are definitely some scenarios where two or more Kinesis services can overlap, we have some pointers below that you can look out for to distinguish the correct service to use in the exam:

	Data Streams	Data Firehose	Data Analytics	Video Streams
Short definition	Scalable and durable real-time data streaming service.	Capture, transform, and deliver streaming data into data lakes, data stores, and analytics services.	Transform and analyze streaming data in real time with Apache Flink.	Stream video from connected devices to AWS for analytics, machine learning, playback, and other processing.
Data sources	Any data source (servers, mobile devices, IoT devices, etc) that can call the Kinesis API to send data.	Any data source (servers, mobile devices, IoT devices, etc) that can call the Kinesis API to send data.	Amazon MSK, Amazon Kinesis Data Streams, servers, mobile devices, IoT devices, etc.	Any streaming device that supports Kinesis Video Streams SDK.
Data consumers	Kinesis Data Analytics, Amazon EMR, Amazon EC2, AWS Lambda	Amazon S3, Amazon Redshift, Amazon Elasticsearch Service, generic HTTP endpoints, Datadog, New Relic, MongoDB, and Splunk	Analysis results can be sent to another Kinesis stream, a Kinesis Data Firehose delivery stream, or a Lambda function	Amazon Rekognition, Amazon SageMaker, MxNet, TensorFlow, HLS-based media playback, custom media processing application
Use cases	- Log and event data collection - Real-time analytics - Mobile data capture - Gaming data feed	- IoT Analytics - Clickstream Analytics - Log Analytics - Security monitoring	- Streaming ETL - Real-time analytics - Stateful event processing	- Smart technologies - Video-related AI/ML - Video processing

References:
https://aws.amazon.com/kinesis/
https://tutorialsdojo.com/amazon-kinesis/

AWS Glue

AWS Glue ETL Process

AWS Glue simplifies a lot of the extract, transform, and load workloads you have because it reduces the manual processes and management tasks that you have to do. AWS Glue runs your ETL jobs in an Apache Spark serverless environment. The user has access to multiple tools under AWS Glue that provide visualizations and frameworks so you won't have to write your own code.

- AWS Glue Data Catalog lets users easily search and access data located in different data stores.
- AWS Glue Studio lets users visually create, run, and monitor ETL workflows.
- AWS Glue DataBrew lets users visually enrich, clean, and normalize data without writing code.
- AWS Glue Elastic Views lets users use SQL to combine and replicate data across different data stores.

Process:

- When initiating an ETL operation, AWS Glue Data Catalog will discover and search across your AWS data sets without moving the data. AWS Glue is able to collect both structured and semi-structured data from Amazon Redshift, Amazon S3, Amazon RDS, Amazon DynamoDB, and self-managed databases running on EC2 instances data stores. AWS Glue also supports data streams from Amazon MSK, Amazon Kinesis Data Streams, and Apache Kafka.
- If you have multiple data stores and you need to combine their data, you may use AWS Glue Elastic Views to do so and create materialized views. Views can be stored in Amazon Redshift, Amazon S3, Amazon Elasticsearch Service, Amazon DynamoDB, and Amazon RDS.
- Once the data is cataloged, it can be searched and queried using Amazon Athena, Amazon EMR, and Amazon Redshift Spectrum. AWS Glue Data Catalog stores metadata for all your data assets.
- You can compose visual workflows of ETL jobs in AWS Glue Studio and monitor their statuses there. You can also use AWS Glue Data Brew to clean and normalize your data.
- Output of the ETL jobs can be stored in AWS Lake Formation, Amazon Redshift, or Amazon S3. If further analytics is required, you may use Amazon Athena, Amazon Redshift Spectrum, Amazon EMR, Amazon Sagemaker and Amazon Quicksight to derive meaningful insights from the ETL outputs.
- Automate your succeeding ETL jobs by integrating AWS Lambda with AWS Glue.

References:
https://docs.aws.amazon.com/glue/latest/dg/how-it-works.html
https://tutorialsdojo.com/aws-glue/

Comparison of AWS Services and Features

AWS CloudTrail vs Amazon CloudWatch

- **CloudWatch** is a monitoring service for AWS resources and applications. **CloudTrail** is a web service that records API activity in your AWS account. They are both useful monitoring tools in AWS.
- By default, **CloudWatch** offers free basic monitoring for your resources, such as EC2 instances, EBS volumes, and RDS DB instances. **CloudTrail** is also enabled by default when you create your AWS account.
- With **CloudWatch**, you can collect and track metrics, collect and monitor log files, and set alarms. **CloudTrail**, on the other hand, logs information on who made a request, the services used, the actions performed, parameters for the actions, and the response elements returned by the AWS service. CloudTrail Logs are then stored in an S3 bucket or a CloudWatch Logs log group that you specify.
- You can enable detailed monitoring from your AWS resources to send metric data to CloudWatch more frequently, with an additional cost.
- **CloudTrail** delivers one free copy of management event logs for each AWS region. Management events include management operations performed on resources in your AWS account, such as when a user logs in to your account. Logging data events are charged. Data events include resource operations performed on or within the resource itself, such as S3 object-level API activity or Lambda function execution activity.
- **CloudTrail** helps you ensure compliance and regulatory standards.
- **CloudWatch Logs** reports on application logs, while **CloudTrail Logs** provide you specific information on what occurred in your AWS account.
- **CloudWatch Events** is a near real time stream of system events describing changes to your AWS resources. **CloudTrail** focuses more on AWS API calls made in your AWS account.
- Typically, **CloudTrail** delivers an event within 15 minutes of the API call. **CloudWatch** delivers metric data in 5 minutes periods for basic monitoring and 1 minute periods for detailed monitoring. The CloudWatch Logs Agent will send log data every five seconds by default.

AWS DataSync vs Storage Gateway

	DataSync	Storage Gateway
Description	AWS DataSync is an online data transfer service that simplifies, automates, and accelerates the process of copying large amounts of data to and from AWS storage services over the Internet or over AWS Direct Connect.	AWS Storage Gateway is a hybrid cloud storage service that gives you on-premises access to virtually unlimited cloud storage by linking it to S3. Storage Gateway provides 3 types of storage interfaces for your on-premises applications: file, volume, and tape.
How it Works	Uses an **agent** which is a virtual machine (VM) that is owned by the user and is used to read or write data from your storage systems. You can activate the agent from the Management Console. The agent will then read from a source location, and sync your data to Amazon S3, Amazon EFS, or Amazon Fsx for Windows File Server.	Uses a **Storage Gateway Appliance** - a VM from Amazon - which is installed and hosted on your data center. After the setup, you can use the AWS console to provision your storage options: File Gateway, Cached Volumes, or Stored Volumes, in which data will be saved to Amazon S3. You can also purchase the hardware appliance to facilitate the transfer instead of installing the VM.
Protocol	DataSync connects to existing storage systems and data sources with standard storage protocols (NFS, SMB), or using the Amazon S3 API.	Storage Gateway provides a standard set of storage protocols such as iSCSI, SMB, and NFS.
Storage	AWS DataSync can copy data between Network File Systems (NFS), SMB file servers or self-managed object storages. It can also move data between your on-premises storage and AWS Snowcone, Amazon S3, Amazon EFS, or Amazon FSx.	File Gateway enables you to store and retrieve objects in Amazon S3 using file protocols such as NFS and SMB. Volume Gateway stores your data locally in the gateway and syncs them to Amazon S3. It also allows you to take point-in-time copies of your volumes with EBS snapshots which you can restore and mount to your appliances as iSCSI devices. Tape Gateway data is immediately stored in Amazon S3 and can be archived to Amazon S3 Glacier or Amazon S3 Glacier Deep Archive.
Pricing	You are charged standard request, storage, and data transfer rates to read from and write to AWS services, such as Amazon S3, Amazon EFS, Amazon FSx for Windows File Server, and AWS KMS.	You are charged based on the type and amount of storage you use, the requests you make, and the amount of data transferred out of AWS.
Combination	You can use a combination of DataSync and File Gateway to minimize your on-premises' operational costs while seamlessly connecting on-premises applications to your cloud storage. AWS DataSync enables you to automate and accelerate online data transfers to AWS storage services. File Gateway then provides your on-premises applications with low latency access to the migrated data.	

S3 Transfer Acceleration vs Direct Connect vs VPN vs Snowball Edge vs Snowmobile

S3 Transfer Acceleration (TA)

- Amazon S3 Transfer Acceleration makes public Internet transfers to S3 faster, as it leverages Amazon CloudFront's globally distributed AWS Edge Locations.
- There is no guarantee that you will experience increased transfer speeds. If S3 Transfer Acceleration is not likely to be faster than a regular S3 transfer of the same object to the same destination AWS Region, AWS will not charge for the use of S3 TA for that transfer.
- This is not the best transfer service to use if transfer disruption is not tolerable.
- S3 TA provides the same security benefits as regular transfers to Amazon S3. This service also supports multi-part upload.
- ***S3 TA vs AWS Snow****
    - The AWS Snow* Migration Services are ideal for moving large batches of data at once. In general, if it will take more than a week to transfer over the Internet, or there are recurring transfer jobs and there is more than 25Mbps of available bandwidth, S3 Transfer Acceleration is a good option.
    - Another option is to use AWS Snowball Edge or Snowmobile to perform initial heavy lift moves and then transfer incremental ongoing changes with S3 Transfer Acceleration.
- ***S3 TA vs Direct Connect***
    - AWS Direct Connect is a good choice for customers who have a private networking requirement or who have access to AWS Direct Connect exchanges. S3 Transfer Acceleration is best for submitting data from distributed client locations over the public Internet, or where variable network conditions make throughput poor.
- ***S3 TA vs VPN***
    - You typically use (IPsec) VPN if you want your resources contained in a private network. VPN tools such as OpenVPN allow you to set up stricter access controls if you have a private S3 bucket. You can complement this further with the increased speeds from S3 TA.
- ***S3 TA vs Multipart Upload***
    - Use multipart upload if you are uploading large files and you want to handle failed uploads gracefully. With multipart upload, each part of your upload is a contiguous portion of the object's data. You can upload these object parts independently and in any order. If transmission of any part fails, you can retransmit that part without affecting other parts.
    - For S3 TA, as the name implies, accelerates your transfer speeds, not just for upload but also for download speed. There is no reason why you can't use S3 TA and multipart upload together, but if you are only handling small files, using multipart upload is not necessary.

AWS Direct Connect

- Using AWS Direct Connect, data that would have previously been transported over the Internet can now be delivered through a **private physical network connection** between AWS and your datacenter or

corporate network. Customers' traffic will remain in AWS global network backbone, after it enters AWS global network backbone.

- Benefits of Direct Connect vs internet-based connections
    - reduced costs
    - increased bandwidth
    - a more consistent network experience
- Each AWS Direct Connect connection can be configured with one or more **virtual interfaces**. Virtual interfaces may be configured to access AWS services such as Amazon EC2 and Amazon S3 using public IP space, or resources in a VPC using private IP space.
- You can run IPv4 and IPv6 on the same virtual interface.
- Direct Connect does not support multicast.
- A Direct Connect connection is **not redundant**. Therefore, a second line needs to be established if redundancy is required. Enable *Bidirectional Forwarding Detection* (BFD) when configuring your connections to ensure fast detection and failover.
- AWS Direct Connect offers SLA.
- Direct Connect vs IPsec VPN
    - A VPC VPN Connection utilizes IPSec to establish **encrypted network connectivity** between your intranet and Amazon VPC **over the Internet.** VPN Connections can be configured in minutes and are a good solution if you have an immediate need, have low to modest bandwidth requirements, and can tolerate the inherent variability in Internet-based connectivity. AWS Direct Connect **does not involve the public Internet**; instead, it uses **dedicated, private network connections** between your intranet and Amazon VPC.
- You can combine one or more Direct Connect dedicated network connections with the Amazon VPC VPN. This combination provides an IPsec-encrypted private connection that also includes the benefits of Direct Connect.

AWS VPN

- AWS VPN is comprised of two services:
    - AWS Site-to-Site VPN enables you to securely connect your on-premises network or branch office site to your Amazon VPC.
    - AWS Client VPN enables you to securely connect users to AWS or on-premises networks.
- Data transferred between your VPC and datacenter routes over an encrypted VPN connection to help maintain the confidentiality and integrity of data in transit.
- If data that passes through Direct Connect moves in a dedicated private network line, AWS VPN instead encrypts the data before passing it through the public Internet.
- VPN connection throughput can depend on multiple factors, such as the capability of your customer gateway, the capacity of your connection, average packet size, the protocol being used, TCP vs. UDP, and the network latency between your customer gateway and the virtual private gateway.
- All the VPN sessions are **full-tunnel VPN**. (cannot split tunnel)
- AWS Site-to-Site VPN enables you to create **failover** and CloudHub solutions **with AWS Direct Connect**.

- AWS Client VPN is designed to connect devices to your applications. It allows you to use an **OpenVPN-based client**.

Snowball Edge

- Snowball Edge is a **petabyte-scale data transport** solution that uses secure appliances to transfer large amounts of data into and out of AWS.
- Benefits of Snowball Edge include:
    - lower network costs,
    - Shorter transfer times,
    - and security using 256-bit encryption keys you manage through AWS Key Management Service (KMS)..
- Options for device configurations
    - **Storage optimized** – this option has the most storage capacity at up to 80 TB of usable storage space, 24 vCPUs, and 32 GiB of memory for compute functionality. You can transfer up to **100 TB** with a single Snowball Edge Storage Optimized device.
    - **Compute optimized** – this option has the most compute functionality with 52 vCPUs, 208 GiB of memory, and 7.68 TB of dedicated NVMe SSD storage for instance. This option also comes with 42 TB of additional storage space.
    - **Compute Optimized with GPU** – identical to the compute-optimized option, save for an installed GPU, equivalent to the one available in the P3 Amazon EC2 instance type.
- Similar to Direct Connect, AWS Snowball Edge is **physical hardware**. It includes a 10GBaseT network connection. You can order a device with either **50TB** or an **80TB** storage capacity.
- Data transported via Snowball Edge are stored in Amazon S3 once the device arrives at AWS centers.
- AWS Snowball Edge is not only for shipping data into AWS, but also out of AWS.
- AWS Snowball Edge can be used as a quick order for additional temporary petabyte storage.
- You can cluster Snowball Edge devices for local storage and compute jobs to achieve 99.999 percent data durability across 5–10 devices, and to locally grow and shrink storage on demand.
- For security purposes, data transfers must be completed **within 360 days of a Snowball Edge's preparation**.
- When the transfer is complete and the device is ready to be returned, the E Ink shipping label will automatically update to indicate the correct AWS facility to ship to, and you can track the job status by using Amazon Simple Notification Service (SNS), text messages, or directly in the console.
- Snowball Edge is the best choice if you need to more securely and quickly transfer terabytes to many petabytes of data to AWS. Snowball Edge can also be the right choice if you don't want to make expensive upgrades to your network infrastructure, if you frequently experience large backlogs of data, if you're located in a physically isolated environment, or if you're in an area where high-bandwidth Internet connections are not available or cost-prohibitive.
- For latency-sensitive applications such as machine learning, you can deploy a **performance-optimized SSD volume (sbp1)**. Performance optimized volumes on the Snowball Edge Compute Optimized device

use NVMe SSD, and on the Snowball Edge Storage Optimized device they use SATA SSD. Alternatively, you can use capacity-optimized **HDD volumes (sbg1)** on any Snowball Edge.
- If you will be transferring data to AWS on an ongoing basis, it is better to use AWS Direct Connect.
- If multiple users located in different locations are interacting with S3 continuously, it is better to use S3 TA.
- You **cannot** export data directly from S3 Glacier. It should be first restored to S3.

Snowmobile

- Snowmobile is Snowball Edge with larger storage capacity. Snowmobile is literally a mobile truck.
- Snowmobile is an **Exabyte-scale data transfer** service.
- You can transfer up to **100PB** per Snowmobile.
- Snowmobile uses multiple layers of security to help protect your data including dedicated security personnel, GPS tracking, alarm monitoring, 24/7 video surveillance, and an optional escort security vehicle while in transit. All data is encrypted with 256-bit encryption keys you manage through the AWS Key Management Service (KMS).
- After the data transfer is complete, the Snowmobile will be returned to your designated AWS region where your data will be uploaded into the AWS storage services such as S3 or Glacier.
- Snowball Edge vs Snowmobile
    - To migrate large datasets of 10PB or more in a single location, you should use Snowmobile. For datasets less than 10PB or distributed in multiple locations, you should use Snowball Edge.
    - If you have a high speed backbone with hundreds of Gb/s of spare throughput, then you can use Snowmobile to migrate the large datasets all at once. If you have limited bandwidth on your backbone, you should consider using multiple Snowball Edge to migrate the data incrementally.
    - Snowmobile **does not** support data export. Use Snowball Edge for this cause.
- When the data import has been processed and verified, AWS performs a software erasure based on NIST guidelines.

Amazon EBS vs EC2 Instance Store

	Amazon EBS volumes	EC2 instance store
Definition	Disk drives that you can virtually mount onto EC2 instances for persistent, block-level storage.	Physical disks mounted directly on the host computer of your EC2 instances that provide temporary block-level storage.
Lifespan	An EBS volume exists independently from EC2 instances. Even if your EC2 instances are terminated, you can retain your EBS volumes.	The instance store is deleted once you stop, reboot or terminate the EC2 instance.
Volume Types	1. General purpose SSD (gp2, gp3) 2. Provisioned IOPS SSD (io1, io2) 3. Throughput Optimized HDD (st1) 4. Cold HDD (sc1)	1. HDD 2. SSD 3. NVMe SSD
Availability	Only available in the AZ where it was launched, but snapshots can be copied to another AWS Region.	Only available on the instance where it was launched with.
Sizing constraints	Min of 1GiB and max of 16 TiB per volume. Size of volumes can be upgraded without downtime.	Storage size depends on the instance type you use. If it is used as a root volume, the maximum size is 10GB.
Remounting capabilities	Can be detached and reattached to another EC2 instance	No remounting capabilities since physical disks are directly attached to the host computer.
Multi-attach features	Lets you attach a single Provisioned IOPS SSD (io1 or io2) volume to multiple instances that are in the same Availability Zone.	Not supported
Backup and restore	Via EBS snapshots which are incremental backups of your EBS volumes. Backups are stored in S3 which you cannot directly access except through the EBS interface.	AMI backups

Native encryption support	AWS KMS encryption	AWS hardware encryption
Pricing	You are billed for the amount of storage provisioned, amount of IOPS provisioned, and/or amount of throughput provisioned. Pricing varies between AWS Regions and volume types.	Included as part of the EC2 instance's usage cost.
Use cases	• Boot volume • Persistent data store even after EC2 instance is stopped. • Backup and restore capabilities • Multi attach capabilities • High IO/Throughput volumes • Can be swapped between instances • Encryption via KMS	• Boot volume for some instance types • Very high IO/Throughput because directly attached to the physical machine • Temporary storage

Amazon S3 vs EBS vs EFS

Tutorials Dojo	S3	EBS	EFS
Type of storage	Object storage. You can store virtually any kind of data in any format.	Persistent block level storage for EC2 instances.	POSIX-compliant file storage for EC2 instances
Features	Accessible to anyone or any service with the right permissions	Deliver performance for workloads that require the lowest-latency access to data from a single EC2 instance	Has a file system interface, file system access semantics (such as strong consistency and file locking), and concurrently-accessible storage for multiple EC2 instances
Max Storage Size	Virtually unlimited	16 TiB for one volume	Unlimited system size
Max File Size	Individual Amazon S3 objects can range in size to a maximum of 5 terabytes.	Equivalent to the maximum size of your volumes	47.9 TiB for a single file
Performance (Latency)	Low, for mixed request types, and integration with CloudFront	Lowest, consistent; SSD-backed storages include the highest performance Provisioned OPS SSD and General Purpose SSD that balance price and performance.	Low, consistent; use Max I/O mode for higher performance
Performance (Throughput)	Multiple GBs per second; supports multi-part upload	Up to 2 GB per second. HDD-backed volumes include Throughput Optimized HDD for frequently accessed, throughput intensive workloads and Cold HDD for less frequently accessed data.	10+ GB per second. Bursting Throughput mode scales with the size of the file system. Provisioned Throughput mode offers higher dedicated throughput than burstring throughput.
Durability	Stored redundantly across multiple AZs; has 99.999999999% durability	Stored redundantly in a single AZ	Stored redundantly across multiple AZs
Availability	S3 Standard - 99.99% availability S3 Standard-IA - 99.9% availability S3 One Zone-IA - 99.5% availability. S3 Intelligent Tiering - 99.9%	Has 99.999% availability	99.9% SLA. Runs in multi-AZ

Tutorials Dojo	S3	EBS	EFS
Scalability	Highly scalable	Manually increase/decrease your memory size. Attach and detach additional volumes to and from your EC2 instance to scale.	EFS file systems are elastic, and automatically grow and shrink as you add and remove files.
Data Accessing	One to millions of connections over the web; S3 provides a REST web services interface	Single EC2 instance in a single AZ Amazon EBS Multi-Attach enables you to attach a single Provisioned IOPS SSD (io1 or io2) volume to up to 16 Nitro-based instances that are in the same Availability Zone.	One to thousands of EC2 instances or on-premises servers, from multiple AZs, regions, VPCs, and accounts concurrently
Access Control	Uses bucket policies and IAM user policies. Has *Block Public Access* settings to help manage public access to resources.	IAM Policies, Roles, and Security Groups	Only resources that can access endpoints in your VPC, called a *mount target*, can access your file system; POSIX-compliant user and group-level permissions
Encryption Methods	Supports SSL endpoints using the HTTPS protocol, Client-Side and Server-Side Encryption (SSE-S3, SSE-C, SSE-KMS)	Encrypts both data-at-rest and data-in-transit through EBS encryption that uses AWS KMS CMKs.	Encrypt data at rest and in transit. Data at rest encryption uses AWS KMS. Data in-transit uses TLS.
Backup and Restoration	Use versioning or cross-region replication	All EBS volume types offer durable snapshot capabilities.	EFS to EFS replication through third party tools or AWS DataSync
Pricing	Billing prices are based on the location of your bucket. Lower costs equals lower prices. You get cheaper prices the more you use S3 storage.	You pay GB-month of provisioned storage, provisioned IOPS-month, GB-month of snapshot data stored in S3	You pay for the amount of file system storage used per month. When using the Provisioned Throughput mode you pay for the throughput you provision per month.
Use Cases	Web serving and content management, media and entertainment, backups, big data analytics, data lake	Boot volumes, transactional and NoSQL databases, data warehousing & ETL	Web serving and content management, enterprise applications, media and entertainment, home directories, database backups, developer tools, container storage, big data analytics
Service endpoint	Can be accessed within and outside a VPC (via S3 bucket URL)	Accessed within one's VPC	Accessed within one's VPC

AWS Global Accelerator vs Amazon CloudFront

- CloudFront uses multiple sets of dynamically changing IP addresses while Global Accelerator will provide you a set of static IP addresses as a fixed entry point to your applications.
- CloudFront pricing is mainly based on data transfer out and HTTP requests while Global Accelerator charges a fixed hourly fee and an incremental charge over your standard Data Transfer rates, also called a Data Transfer-Premium fee (DT-Premium).
- CloudFront uses Edge Locations to cache content while Global Accelerator uses Edge Locations to find an optimal pathway to the nearest regional endpoint.
- CloudFront is designed to handle HTTP protocol meanwhile Global Accelerator is best used for both HTTP and non-HTTP protocols such as TCP and UDP.

Interface Endpoint vs Gateway Endpoint vs Gateway Load Balancer Endpoint

Interface Endpoint	Gateway Endpoint	Gateway Load Balancer Endpoint
• An elastic network interface with a private IP address that serves as an entry point for traffic destined to a supported AWS service, endpoint service, or AWS Marketplace service. • For each interface endpoint, you can choose only one subnet per Availability Zone. Endpoints are regional, which means they are only usable within the same region they are created in. • Since interface endpoints use ENIs, they also use security groups to control traffic. • Can be accessed through AWS VPN connections or AWS Direct Connect connections, through intra-region VPC peering connections from Nitro instances, and through inter-region VPC peering connections from any type of instance. • An endpoint only returns responses to traffic that is initiated from resources in your VPC. • An interface endpoint supports IPv4 TCP traffic only.	• A gateway that is a target for a specific route in your route table, used for traffic destined to a supported AWS service which is either DynamoDB or S3. • You can create multiple gateway endpoints in a single VPC, for example, to multiple services. You can also create multiple endpoints for a single service, and use different route tables to enforce different access policies from different subnets to the same service. But you cannot have multiple endpoint routes to the same service in a single route table. • You can modify the endpoint policy that's attached to your gateway endpoint, and add or remove the route tables that are used by the endpoint. • Gateway endpoints are supported within the same region only. You cannot create an endpoint between a VPC and a service in a different region. • Gateway endpoints support IPv4 traffic only. • You must enable DNS resolution in your VPC, or if	• Enables you to intercept traffic and route it to a service that you've configured using Gateway Load Balancers. • You choose the VPC and subnet that your endpoint should be created in. An endpoint network interface is assigned a private IP address from the IP address range of your subnet. You cannot change the subnet later. • After you create the Gateway Load Balancer endpoint, it's available to use when it's accepted by the service provider. The service provider can configure the service to accept requests automatically or manually. • Security groups and endpoint policies are not supported. • Endpoints support IPv4 traffic only. • You cannot transfer an endpoint from one VPC to another, or from one service to another.

• You can add endpoint policies to interface endpoints. The Amazon VPC endpoint policy defines which principal can perform which actions on which resources. An endpoint policy does not override or replace IAM user policies or service-specific policies. It is a separate policy for controlling access from the endpoint to the specified service. • After you create an interface endpoint, it's available to use when it's accepted by the service provider. The service provider must configure the service to accept requests automatically or manually. AWS services and AWS Marketplace services generally accept all endpoint requests automatically. • An interface endpoint (except S3 interface endpoint) has corresponding private DNS hostnames.	you're using your own DNS server, ensure that DNS requests to the required service are resolved correctly to the IP addresses maintained by AWS. • When you associate a route to your gateway endpoint, all instances in subnets associated with this route table automatically use the endpoint to access the service. • A gateway endpoint cannot be used beyond the scope of the VPC it is linked to.	

Amazon Kinesis vs Amazon SQS

Amazon Kinesis is a real-time data streaming service that can handle any amount of streaming data and process data from hundreds of thousands of sources with very low latencies. Amazon SQS is a message queueing service that decouples your applications, and although it provides high message throughput, it is not as fast as Kinesis. Consumer applications both poll data from these two services. Multiple consumers can process Kinesis stream data at the same time, while only a single consumer can process a single message from SQS.

There are four types of Kinesis streams:

1. Kinesis Data Streams
2. Kinesis Video Streams
3. Kinesis Data Firehose
4. Kinesis Data Analytics

There are two types of SQS queues:

1. Standard queue
2. FIFO queue

In Kinesis streams, data records are stored in the order they arrive in. SQS standard queue does a best effort in maintaining message ordering, while SQS FIFO queue stores messages in the order they arrive in. You need to use Kinesis libraries to interact with your Kinesis streams. For SQS, you only need to use AWS API or AWS SDK to handle your messages.

In Kinesis, data is kept in the stream for as long as the retention period is not up, and consumers can choose which chunks of data they will consume. This also means that consumers can replay messages in Kinesis Data Streams in the same exact order they arrived in. In SQS, the message after polling becomes invisible from other consumers for a set amount of time, and you need to manually delete the message from the queue for it to be completely removed.

In Kinesis Data Streams, to handle a large amount of streaming data, you must make sure that you have enough shards in your stream. In SQS, you must make sure that your producers do not go over the API throughput limit for sending messages.

Kinesis has many built in big data, analytics, & ETL features and integrations. For example, Kinesis Data Streams enables real-time processing of streaming big data. Kinesis Data Analytics lets you run SQL queries immediately on the streamed data. Kinesis Firehose immediately captures, transforms, and loads streaming data into your target consumers. SQS Standard queue provides at-least-once delivery. SQS FIFO queue provides exactly-once processing, which means that each message is delivered once and remains available until a consumer processes it and deletes it. Duplicates are not introduced into the queue.

Latency Based Routing vs Amazon CloudFront

The goal of using Route 53 latency based routing and/or Amazon CloudFront is to speed up delivery of content to your users. The difference between the two technologies depends on a few factors:

1. Your infrastructure setup
2. The content you wish to deliver
3. Your goal in using the technology

For infrastructure setup, if you are currently using multiple AWS regions to deliver content to your users around the globe, then Route 53 latency based routing makes sure that your users are redirected to the application endpoint that provides them the best latency. With CloudFront, you don't necessarily need to deploy your applications in multiple regions. Instead, you just deploy your application in a single region and configure the locations where you want CloudFront to cache and serve your content. This setup can save you huge amounts of money if you don't require using multiple AWS regions.

For the content you wish to deliver, latency based routing always delivers the latest content that your application has. This might be important for you if for example you are serving real time data. CloudFront, on the other hand, lets you cache static and dynamic content that match the caching rules you specify (e.g. matching headers). If you do not enable caching, then CloudFront does not help reduce the latency of content delivery to your global customers. There are also instances wherein you'd only want to cache specific objects, which in this case, CloudFront will be useful.

Aside from reducing the latency for content delivery to your customers, you might have other reasons why you would use latency based routing or CloudFront. For example, you can combine latency based routing with weighted routing to create a highly available global infrastructure. Or you might want to customize your content depending on the region that the content originates from. You might also want to run some analytics on your global customers and which region is accessed the most.

Perhaps you want to integrate Route 53 routing records with some endpoints health checks. For CloudFront, you might want to put some geo restriction rules. You might want to control how your cached content is served to customers. Or you might like to run Lambda@Edge to perform some edge location computing. Perhaps you are not only using CloudFront to reduce network latency, but also as an anti-DDoS solution for your web applications, since CloudFront integrates with AWS WAF. CloudFront can also let you serve custom error pages if you need to. There are many other features that you can use along with Route 53 latency based routing or CloudFront depending on your needs. There is also no rule saying that you can't use both technologies together.

Amazon EFS vs. Amazon FSx for Windows File Server vs. Amazon FSx for Lustre

Amazon EFS	Amazon FSx for Windows File Server	Amazon FSx for Lustre
• Amazon EFS is a serverless, scalable, high-performance file system in the cloud. • EFS file systems can be accessed by Amazon EC2 Linux instances, Amazon ECS, Amazon EKS, AWS Fargate, and AWS Lambda functions via a file system interface such as NFS protocol. • Amazon EFS supports file system access semantics such as strong consistency and file locking. • EFS file systems can automatically scale in storage to handle petabytes of data. With Bursting mode, the throughput available to a file system scales as a file system grows. Provisioned Throughput mode allows you to provision a constant file system throughput independent of the amount of data stored. • EFS file systems can be concurrently accessed by thousands of compute services without sacrificing performance.	• Amazon FSx for Windows File Server is a fully managed, scalable file storage that is accessible over SMB protocol. • Since it is built on Windows Server, it natively supports administrative features such as user quotas, end-user file restore, and Microsoft Active Directory integration. • FSx for WFS is accessible from Windows, Linux, and MacOS compute instances and devices. Thousands of compute instances and devices can access a file system concurrently. • FSx for WFS can connect your file system to Amazon EC2, Amazon ECS, VMware Cloud on AWS, Amazon WorkSpaces, and Amazon AppStream 2.0 instances. • Every file system comes with a default Windows file share, named “share”. • Common use cases for FSx for WFS include CRM, ERP, custom or .NET applications, home directories, data analytics, media and entertainment workflows, software build environments, and Microsoft	• Amazon FSx for Lustre is a serverless file system that runs on Lustre — an open-source, high-performance file system. • The Lustre file system is designed for applications that require fast storage. FSx for Lustre file systems can scale to hundreds of GB/s of throughput and millions of IOPS. FSx for Lustre also supports concurrent access to the same file or directory from thousands of compute instances. • Unlike EFS, storage capacity needs to be manually increased, and only every six hours can you do so. • Amazon FSx for Lustre also integrates with Amazon S3, which lets you process cloud data sets with the Lustre high-performance file system. • Common use cases for Lustre include machine learning, high-performance computing (HPC), video processing, financial modeling, genome sequencing, and electronic design automation (EDA). • FSx for Lustre can only be used by Linux-based instances. To access your file system, you first

- Common use cases for EFS file systems include big data and analytics workloads, media processing workflows, content management, web serving, and home directories.
- Amazon EFS has four storage classes: Standard, Standard Infrequent Access, One Zone, and One Zone Infrequent Access
- You can create lifecycle management rules to move your data from standard storage classes to infrequent access storage classes.
- Every EFS file system object of Standard storage is redundantly stored across multiple AZs.
- EFS offers the ability to encrypt data at rest and in transit. Data encrypted at rest using AWS KMS for encryption keys. Data encryption in transit uses TLS 1.2
- To access EFS file systems from on-premises, you must have an AWS Direct Connect or AWS VPN connection between your on-premises datacenter and your Amazon VPC.

SQL Server.

- You can access FSx file systems from your on-premises environment using an AWS Direct Connect or AWS VPN connection between your on-premises datacenter and your Amazon VPC.
- You can choose the storage type for your file system: SSD storage for latency-sensitive workloads or workloads requiring the highest levels of IOPS/throughput. HDD storage for throughput-focused workloads that aren't latency-sensitive.
- Every FSx for WFS file system has a throughput capacity that you configure when the file system is created and that you can change at any time.
- Each Windows File Server file system can store up to 64 TB of data. You can only manually increase the storage capacity.
- Your file system can be deployed in multiple AZs or a single AZ only. Multi-AZ file systems provide automatic failover.
- FSx for Windows File Server always encrypts your file system data and your backups at-rest using keys you manage through AWS KMS. Data-in-transit encryption uses SMB Kerberos session keys.

install the open-source Lustre client on that instance. Then you mount your file system using standard Linux commands. Lustre file systems can also be used with Amazon EKS and AWS Batch.

- FSx for Lustre provides two deployment options:
  1) Scratch file systems are for temporary storage and shorter-term processing of data. Data is not replicated and does not persist if a file server fails.
  2) Persistent file systems are for longer-term storage and workloads. The file servers are highly available, and data is automatically replicated within the AZ that is associated with the file system.
- You can choose the storage type for your file system: SSD storage for latency-sensitive workloads or workloads requiring the highest levels of IOPS/throughput. HDD storage for throughput-focused workloads that aren't latency-sensitive.
- FSx for Lustre always encrypts your file system data and your backups at-rest using keys you manage through AWS KMS. FSx encrypts data-in-transit when accessed from supported EC2 instances.

Amazon RDS vs DynamoDB

Tutorials Dojo	RDS	DynamoDB
Type of database	Managed relational (SQL) database	Fully managed key-value and document (NoSQL) database
Features	Has several database instance types for different kinds of workloads and supports six database engines - Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle Database, and SQL Server.	Delivers single-digit millisecond performance at any scale.
Storage Size	- 128 TB for Aurora engine. - 64 TB for MySQL, MariaDB, Oracle, and PostgreSQL engines. - 16 TB for SQL Server engine.	Supports tables of virtually any size.
Number of tables per unit	Depends on the database engine	256
Performance	General Purpose Storage is an SSD-backed storage option that delivers a consistent baseline of 3 IOPS per provisioned GB with the ability to burst up to 3,000 IOPS. Provisioned IOPS Storage is an SSD-backed storage option designed to deliver a consistent IOPS rate that you specify when creating a database instance, up to 40,000 IOPS per database instance. Amazon RDS provisions that IOPS rate for the lifetime of the database instance. Optimized for OLTP database workloads. Magnetic – Amazon RDS also supports magnetic storage for backward compatibility.	Single-digit millisecond read and write performance. Can handle more than 10 trillion requests per day with peaks greater than 20 million requests per second, over petabytes of storage. DynamoDB Accelerator (DAX) is an in-memory cache that can improve the read performance of your DynamoDB tables by up to 10 times—taking the time required for reads from milliseconds to microseconds, even at millions of requests per second. You specify the read and write throughput for each of your tables.
Availability and durability	Amazon RDS Multi-AZ deployments synchronously replicates your data to a standby instance in a different Availability Zone Amazon RDS will automatically replace the compute instance powering your deployment in the event of a hardware failure..	DynamoDB global tables replicate your data automatically across 3 Availability Zones of your choice of AWS Regions and automatically scale capacity to accommodate your workloads.
Backups	The automated backup feature enables point-in-time recovery for your database instance. Database snapshots are user-initiated backups of your instance stored in Amazon S3 that are kept until you explicitly delete them.	Point-in-time recovery (PITR) provides continuous backups of your DynamoDB table data, and you can restore that table to any point in time up to the second during the preceding 35 days. On-demand backup and restore allows you to create full backups of your DynamoDB tables' data for data archiving.

	RDS	DynamoDB
Scalability	The Amazon Aurora engine will automatically grow the size of your database volume. The MySQL, MariaDB, SQL Server, Oracle, and PostgreSQL engines allow you to scale on-the-fly with zero downtime. RDS also supports storage auto scaling Read replicas are available in Amazon RDS for MySQL, MariaDB, and PostgreSQL as well as Amazon Aurora.	Support tables of virtually any size with horizontal scaling. For tables using on-demand capacity mode, DynamoDB instantly accommodates your workloads as they ramp up or down to any previously reached traffic level. For tables using provisioned capacity, DynamoDB delivers automatic scaling of throughput and storage based on your previously set capacity.
Security	Isolate your database in your own virtual network. Connect to your on-premises IT infrastructure using industry-standard encrypted IPsec VPNs. You can configure firewall settings and control network access to your database instances. Integrates with IAM.	Integrates with IAM.
Encryption	Encrypt your databases using keys you manage through AWS KMS. With encryption enabled, data stored at rest is encrypted, as are its automated backups, read replicas, and snapshots. Supports Transparent Data Encryption in SQL Server and Oracle. Supports the use of SSL to secure data in transit.	DynamoDB encrypts data at rest by default using encryption keys stored in AWS KMS.
Maintenance	Amazon RDS will update databases with the latest patches. You can exert optional control over when and if your database instance is patched.	No maintenance since DynamoDB is serverless.
Pricing	A monthly charge for each database instance that you launch. Option to reserve a DB instance for a one or three year term and receive discounts in pricing, compared to On-Demand instance pricing.	Charges for reading, writing, and storing data in your DynamoDB tables, along with any optional features you choose to enable. There are specific billing options for each of DynamoDB's capacity modes.
Use Cases	Traditional applications, ERP, CRM, and e-commerce.	Internet-scale applications, real-time bidding, shopping carts, and customer preferences, content management, personalization, and mobile applications. Tutorials Dojo

Redis (cluster mode enabled vs disabled) vs Memcached

	Redis (cluster mode enabled)	Redis (cluster mode disabled)	Memcached
Data Types	string, sets, sorted sets, lists, hashes, bitmaps, hyperloglog, geospatial indexes	string, sets, sorted sets, lists, hashes, bitmaps, hyperloglog, geospatial indexes	string, objects (like databases)
Data Partitioning (distribute your data among multiple nodes)	Supported	Unsupported	Supported
Modifiable cluster	Only versions 3.2.10 and later	Yes	Yes
Online resharding	Only versions 3.2.10 and later	No	No
Encryption	3.2.6, 4.0.10 and later	3.2.6, 4.0.10 and later	Unsupported
Sub-millisecond latency	Yes	Yes	Yes
FedRAMP, PCI DSS and HIPAA compliant	3.2.6, 4.0.10 and later	3.2.6, 4.0.10 and later	No
Multi-threaded (make use of multiple processing cores	No	No	Yes
Node type upgrading	No	Yes	No
Engine upgrading	Yes		
Cluster replication (create multiple copies of a primary cluster)	Supported	Supported	Unsupported
Multi-AZ for automatic failover	Required	Optional	Unsupported
Transactions (execute a group of commands as an isolated and atomic operation)	Supported	Supported	Unsupported
Pub/Sub capability	Yes	Yes	No
Backup and restore (keep your data on disk with a point in time snapshot)	Supported	Supported	Unsupported
Lua Scripting (execute transactional Lua scripts)	Supported	Supported	Unsupported
Use Case	• You need to partition your data across two to 250 or 500 nodes if the Redis engine version is 5.0.6 or higher. (clustered mode only). • You need geospatial indexing (clustered mode or non-clustered mode). • You don't need to support multiple databases. • Plus features of non-clustered mode	• You need complex data types, such as strings, hashes, lists, sets, sorted sets, and bitmaps. • You need to sort or rank in-memory datasets. • You need persistence of your key store. • You need to replicate your data from the primary to one or more read replicas for read intensive applications. • You need automatic failover if your primary node fails. • You need pub/sub capabilities. • You need backup and restore capabilities. • You need to support multiple databases.	• You need the simplest model possible. • You need to run large nodes with multiple cores or threads. • You need the ability to scale out and in, adding and removing nodes as demand on your system increases and decreases. • You need to cache objects, such as a database. • Needs Auto Discovery to simplify the way an application connects to a cluster.

AWS WAF vs AWS Shield Basic vs AWS Shield Advanced

	AWS WAF	AWS Shield Basic	AWS Shield Advanced
Security Features	AWS WAF can monitor web requests transmitted over HTTP or HTTPS. AWS WAF helps protect web applications from attacks by allowing you to configure rules that allow, block, rate-limit, or monitor web requests based on conditions that you define. These conditions include IP addresses, HTTP headers, HTTP body, URI strings, SQL injection, and cross-site scripting. Rate-based rules also help you from web-layer DDoS attacks, brute force login attempts, and bad bots.	AWS Shield provides protection against common and most frequently occurring OSI layer 3 and 4 attacks like SYN/UDP floods, reflection attacks, and DDoS attacks for applications running on AWS. AWS Shield's detection and mitigations work with IPv4 and IPv6 traffic.	AWS Shield Advanced provides additional protections against more sophisticated and larger attacks for your applications running in AWS. Provides near real-time notifications of suspected DDoS incidents. Also employs advanced attack mitigation and routing techniques for automatically mitigating attacks. Having a Business or Enterprise support plan lets you engage with the AWS DDoS Response Team.
Integration	AWS WAF is tightly integrated with Amazon CloudFront, Application Load Balancer, Amazon API Gateway, and AWS AppSync	Most of the AWS resources are automatically integrated and protected from common and frequently occurring network and transport layer DDoS attacks.	Can be integrated with Amazon EC2, Elastic Load Balancing, Amazon CloudFront, AWS Global Accelerator, and Route 53 for a higher level of DDoS attack mitigation.
Pricing	You are charged based on the number of web access control lists (web ACLs) that you create, the number of rules that you add per web ACL, and the number of web requests that you receive.	AWS Shield Standard is automatically enabled to all AWS customers at no cost.	You pay a monthly fee of $3,000 per month per organization. In addition, you also pay for AWS Shield Advanced Data Transfer usage fees for AWS resources enabled for advanced protection.

AWS KMS vs AWS CloudHSM

Many AWS services provide native encryption support for data in-transit and data at rest. Knowing what you need to protect and how to protect it will let you determine which AWS encryption service you should use.

When to use KMS:
When you encrypt data, you need to protect your encryption key. To further secure your data, you should also encrypt your encryption key. The final encryption key, or master key, is the most crucial segment in your encryption process, since it can decipher all the data keys that you used to encrypt your data. AWS Key Management Service, or AWS KMS, lets you create, store, and manage customer master keys (CMKs) securely. Your CMKs never leave AWS KMS unencrypted, and CMKs can only be used through AWS KMS to decrypt objects. AWS KMS has key policies that let you specify who has access to your CMKs and what they can do with it.

A CMK can be used to encrypt small amounts of data (up to 4096 bytes). If you need to encrypt larger content, use the CMK to generate, encrypt, and decrypt the data keys that are then used to encrypt your data, in place of the CMK. Data keys can encrypt data of any size and format, including streamed data. However, do keep in mind that AWS KMS does not store or manage data keys, and you cannot use KMS to encrypt or decrypt with data keys. AWS KMS only manages the CMKs.

With AWS KMS, you can create symmetric and asymmetric keys and data key pairs, as well as import your own symmetric key material. Keys generated by AWS KMS can be scheduled to automatically rotate on an annual basis. When creating a CMK, you must specify whether the key will be used for encryption/decryption or sign/verify operations.

When to use CloudHSM:
AWS KMS CMKs are stored in FIPS-validated hardware service modules (HSMs) that KMS manages (shared tenancy among AWS customers). A hardware security module (HSM) is a specialized security device that generates and stores cryptographic keys. If you prefer to manage your own HSMs to store your keys in KMS, or you require FIPS 140-2 type 3, you may use AWS CloudHSM. Once you've created your own HSM, you can have the HSM generate and store your encryption keys, and create users and set their permissions for your HSM. For security and isolation from other AWS customers, CloudHSM must be provisioned inside an Amazon VPC.

Additionally, you can offload SSL/TLS cryptographic processing for HTTPS sessions to your CloudHSM module, which cannot be done on AWS KMS. Offloading the process lessens the computational burden on your servers. Some other uses for CloudHSM include securing the private keys for an issuing Certificate Authority (CA), and enabling Transparent Data Encryption for Oracle databases.

RDS Read Replica vs RDS Multi-AZ vs Vertical Scaling vs Elasticache

There are many ways to increase the performance, availability and scalability of an Amazon RDS instance. However, some implementations overlap each other in use cases and may seem redundant. Choosing the correct implementation for a certain situation may not necessarily be as obvious as it seems, but there are definitely some nuances that you can make note of.

Amazon RDS Read Replicas provide enhanced performance and durability for your DB instances. They provide horizontal scaling for read-heavy databases. Read replicas can also be manually promoted to master DB instances if the master instance starts failing. Data between the master instance and read replicas are replicated asynchronously. Remember that read replicas can only read-only connections; write connections will not go through. Read replicas provide scaling on read capacity while reducing the burden on your master instance.

Amazon RDS Multi-AZ is a solution that increases the availability of your RDS master instance. In the event of an outage, RDS will do an automatic failover to your backup DB instance in the other AZ. RDS Aurora uses asynchronous data replication to keep the master and standby instances updated. Non-Aurora engines use synchronous replication. With Multi-AZ enabled, your database will always span at least two Availability Zones within a single region. Your standby replica cannot handle read and write queries.

When you need more resources for your master DB instance, you can always **scale up the instance size** to gain more CPU, memory, network throughput, and dedicated EBS bandwidth. You usually scale up your DB instance if you need more read and write capacity, and that read replicas are unnecessary for your needs. Oftentimes, the initial size you choose for your RDS instance is incorrect or inadequate. An Amazon RDS performance best practice is to allocate enough RAM so that your working set resides almost completely in memory. The working set is the data and indexes that are frequently in use on your instance. There is minimal downtime when you are scaling up on a Multi-AZ environment because the standby database gets upgraded first, then a failover will occur to the newly sized database. A Single-AZ instance will be unavailable during the scale operation.

Adding an Elasticache in front of your RDS instance increases the read performance for your application since the data resides in memory. If you have items that are frequently accessed, you can cache them in Elasticache and reduce the burden on your DB instance. Elasticache is not a good option if your database is more write-heavy than read-heavy, unless you really need that extra bump in read performance. Comparing a cache to a read replica, a cache is better suited if the application queries the same items over and over again or the results are static. If you have been previously using Redis or Memcached already, Elasticache also allows you to lift and shift your solution over. If the items that are being read vary way too much, a read replica might be a better choice instead.

Scaling DynamoDB RCU vs DynamoDB Accelerator (DAX) vs Secondary Indexes vs ElastiCache

Similar to Amazon RDS, there are also multiple options available to DynamoDB when you want to increase the performance of your tables. Each option has its own use case, pros, and cons that you should consider all together when choosing for the best solution.

Scaling DynamoDB Read Capacity can be achieved in two ways, depending on your capacity mode. For On-Demand Mode, you do not need to perform capacity planning. DynamoDB automatically scales your read and write capacity to meet demands. However, if your workloads spike very often, On-Demand mode might become very costly for you if you do not manage your capacity limits properly. For Provisioned Mode, you specify the number of reads and writes per second that you require for your application to meet all the time. You can use auto scaling to adjust your table's provisioned capacity automatically in response to traffic changes. This helps you manage your usage to stay at or below a defined request rate in order to make cost more predictable. DynamoDB auto scaling will actively manage the throughput capacity for your tables and global secondary indexes. You just define an upper and lower limit for the read and write capacity units. You also define a target utilization percentage within that range. You should scale your read capacity units when your DynamoDB tables and indexes experience high read operations and the items being read are not suited for cache.

DynamoDB DAX is a fully managed, in-memory cache for DynamoDB. You use DynamoDB DAX if you wish to achieve microsecond response time. With DynamoDB DAX, there is no need to change your code. You can continue using DynamoDB SDKs and APIs as is. If you have very strict performance requirements, or if you have common table items that are being queried repeatedly, DynamoDB DAX is the solution for you. You also avoid having to overprovision read capacity for your DynamoDB. You only pay for the capacity you provision in DynamoDB DAX. Since DAX is a cache, it is possible that your applications might query stale data. If your applications require strongly consistent reads or have write-intensive workloads, then you should not use DAX.

Secondary Indexes can speed up read operations by helping you avoid scanning your whole table when querying non-primary key attributes. You can retrieve data from the index using a *Query* operation, in much the same way as you use *Query* with a table. You can also *Scan* an index, in much the same way as you would *Scan* a table. A table can have multiple secondary indexes, allowing you to have multiple query patterns. Every secondary index is also automatically maintained by DynamoDB. When you add, modify, or delete items in the base table, any indexes on that table are also updated to reflect these changes. Do note that the read performance of your secondary indexes are still bound by the read capacity units of your DynamoDB table. Also, rather than boosting the performance of your table, indexes are more like optimizing your data structure to help you query the results you need faster.

For caching requirements, you would usually go with DynamoDB Accelerator, since it does not require any code modification if you've been using DynamoDB already. You'll only prefer Amazon Elasticache as your caching

service if you're specifically required to use Redis or Memcached, or if you have a feature in Elasticache that is not currently supported in DAX. Some of the unsupported features for example are:

- DAX does not support Transport Layer Security (TLS).
- DAX only supports applications written in Go, Java, Node.js, Python, and .NET.
- DAX may not be available in your desired region.
- You want to manage the cache invalidation logic.

FINAL REMARKS AND TIPS

That's a wrap! Thank you once again for choosing our Study Guide and Cheat Sheets for the AWS Certified Solutions Architect Associate (SAA-C02) exam. The Tutorials Dojo team spent considerable time and effort to produce this content to help you pass the AWS exam.

We also recommend that before you take the actual SAA-C02 exam, allocate some time to check your readiness first by taking our AWS practice test course in the Tutorials Dojo Portal. You can also try the free sampler version of our full practice test course here. This will help you identify the topics that you need to improve on and help reinforce the concepts that you need to fully understand in order to pass the SAA-C02 exam. It also has different training modes that you can choose from such as Timed mode, Review mode, Section-Based tests, Topic-based tests, and Final test plus bonus flashcards. In addition, you can read the technical discussions in our forums or post your queries if you have one. If you have any issues, concerns or constructive feedback on our eBook, feel free to contact us at support@tutorialsdojo.com.

On behalf of the Tutorials Dojo team, I wish you all the best in your upcoming AWS Certified Solutions Architect - Associate exam. May it help advance your career, as well as increase your earning potential.

With the right strategy, hard work, and unrelenting persistence, you can definitely make your dreams a reality! You can make it!

Sincerely,
Jon Bonso, Adrian Formaran and the Tutorials Dojo Team

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