Monitoring & Reporting

EC2

Default Cloudwatch metrics EC2:

- CPU
- Disk
- Network
- Status Check

Standard monitoring is 5 minutes

Detailed monitoring is minimum granularity of 1 minute

Create EC2 role => Access to Cloudwatch

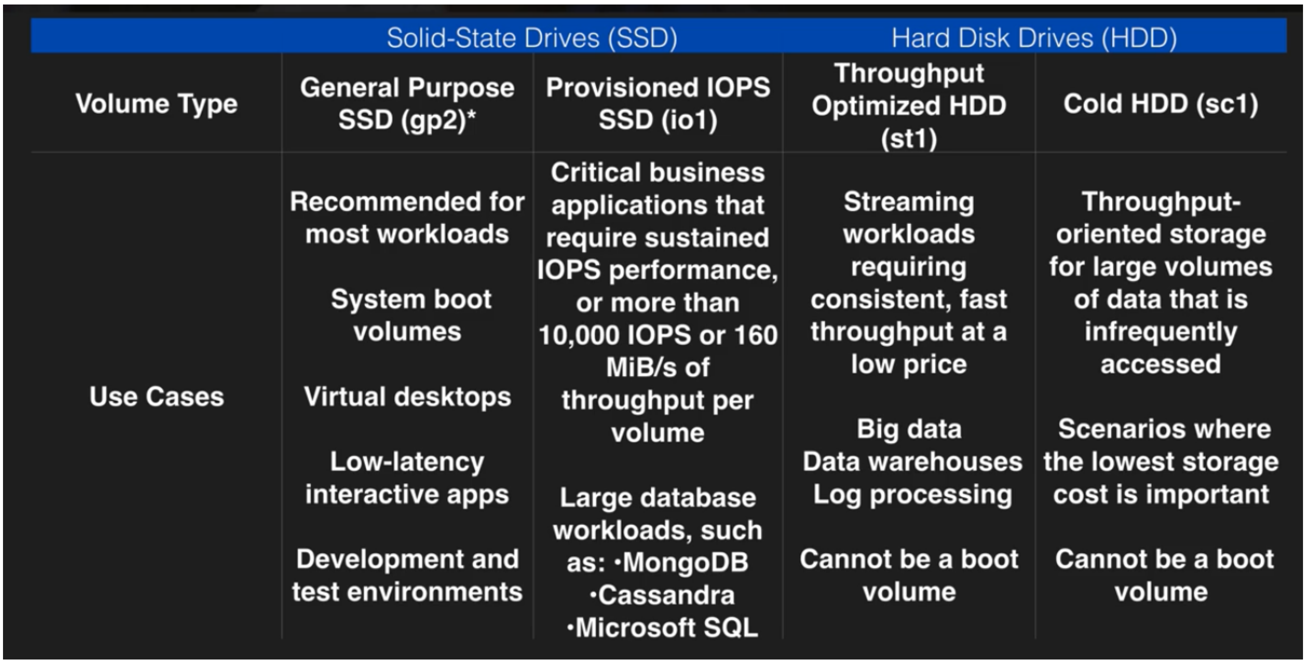
Custom metrics (Memory)

```
sudo apt-get update
sudo apt-get install unzip
sudo apt-get install libwww-perl libdatetime-perl

curl https://aws-cloudwatch.s3.amazonaws.com/downloads/CloudWatchMonitoringScripts-1.2.2.zip -O

unzip CloudWatchMonitoringScripts-1.2.2.zip && \
rm CloudWatchMonitoringScripts-1.2.2.zip && \
cd aws-scripts-mon

/home/admin/aws-scripts-mon# ls
awscreds.template    LICENSE.txt                NOTICE.txt
AwsSignatureV4.pm    mon-get-instance-stats.pl
CloudWatchClient.pm  mon-put-instance-data.pl

echo "*/1 *   * * *   root    /home/admin/aws-scripts-mon/mon-put-instance-data.pl --mem-util --mem-used --mem-avail" >> /etc/crontab
```

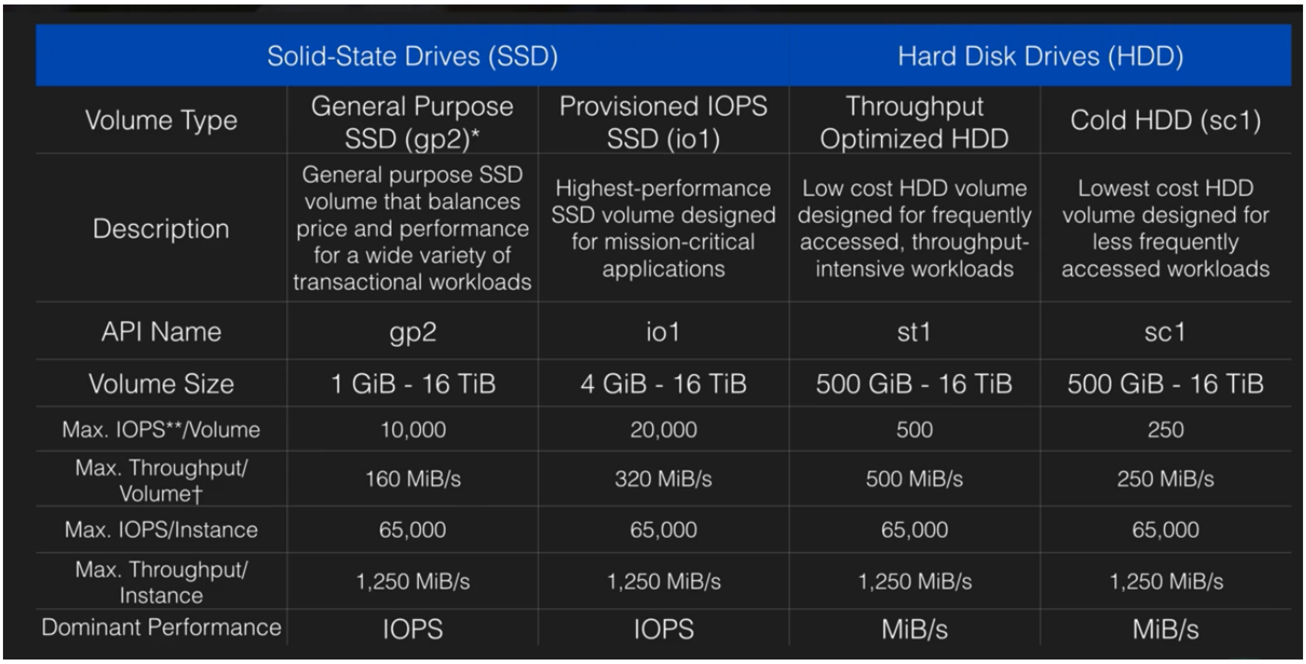
Go to Cloudwatch => Metrics => Linux System => InstanceId

EBS

Compare Volume types



	Solid-State Drives (SSD)		Hard Disk Drives (HDD)	
Volume Type	General Purpose SSD (gp2)*	Provisioned IOPS SSD (io1)	Throughput Optimized HDD (st1)	Cold HDD (sc1)
Use Cases	Recommended for most workloads System boot volumes Virtual desktops Low-latency interactive apps Development and test environments	Critical business applications that require sustained IOPS performance, or more than 10,000 IOPS or 160 MiB/s of throughput per volume Large database workloads, such as: ·MongoDB ·Cassandra ·Microsoft SQL	Streaming workloads requiring consistent, fast throughput at a low price Big data Data warehouses Log processing Cannot be a boot volume	Throughput-oriented storage for large volumes of data that is infrequently accessed Scenarios where the lowest storage cost is important Cannot be a boot volume



	Solid-State Drives (SSD)		Hard Disk Drives (HDD)	
Volume Type	General Purpose SSD (gp2)*	Provisioned IOPS SSD (io1)	Throughput Optimized HDD	Cold HDD (sc1)
Description	General purpose SSD volume that balances price and performance for a wide variety of transactional workloads	Highest-performance SSD volume designed for mission-critical applications	Low cost HDD volume designed for frequently accessed, throughput-intensive workloads	Lowest cost HDD volume designed for less frequently accessed workloads
API Name	gp2	io1	st1	sc1
Volume Size	1 GiB - 16 TiB	4 GiB - 16 TiB	500 GiB - 16 TiB	500 GiB - 16 TiB
Max. IOPS**/Volume	10,000	20,000	500	250
Max. Throughput/ Volume†	160 MiB/s	320 MiB/s	500 MiB/s	250 MiB/s
Max. IOPS/Instance	65,000	65,000	65,000	65,000
Max. Throughput/ Instance	1,250 MiB/s	1,250 MiB/s	1,250 MiB/s	1,250 MiB/s
Dominant Performance	IOPS	IOPS	MiB/s	MiB/s

IOPS

gp2:

- 3 IOPS/Gb
- Burst up to 3000 IOPS
- I/O credits
- Burst up to 2997 IOPS when using 1 Gb Volume
- max of 10 000 IOPS (more => use Provisioned IOPS)

- Burn all I/O credits if burst for 30 minutes

If you creat a volume from snapshot from s3 => use pre-warming ebs volume for maximum performance => What this basically means is just read every data block which has data on your ebs volume before using it.

Metrics

Metric	Description
VolumeReadBytes	Provides information on the read operations in a specified period of time. The Sum statistic reports the total number of bytes transferred during the period. The Average statistic reports the average size of each read operation during the period, except on volumes attached to a Nitro-based instance, where the average represents the average over the specified period. The SampleCount statistic reports the total number of read operations during the period, except on volumes attached to a Nitro-based instance, where the sample count represents the number of data points used in the statistical calculation. For Xen instances, data is reported only when there is read activity on the volume. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Bytes

Metric	Description
VolumeWriteBytes	Provides information on the write operations in a specified period of time. The Sum statistic reports the total number of bytes transferred during the period. The Average statistic reports the average size of each write operation during the period, except on volumes attached to a Nitro-based instance, where the average represents the average over the specified period. The SampleCount statistic reports the total number of write operations during the period, except on volumes attached to a Nitro-based instance, where the sample count represents the number of data points used in the statistical calculation. For Xen instances, data is reported only when there is write activity on the volume. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Bytes
VolumeReadOps !	The total number of read operations in a specified period of time. To calculate the average read operations per second (read IOPS) for the period, divide the total read operations in the period by the number of seconds in that period. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Count

Metric	Description
VolumeWriteOps !	The total number of write operations in a specified period of time. To calculate the average write operations per second (write IOPS) for the period, divide the total write operations in the period by the number of seconds in that period. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Count
VolumeTotalReadTime	Note This metric is not supported with Multi-Attach enabled volumes. The total number of seconds spent by all read operations that completed in a specified period of time. If multiple requests are submitted at the same time, this total could be greater than the length of the period. For example, for a period of 5 minutes (300 seconds): if 700 operations completed during that period, and each operation took 1 second, the value would be 700 seconds. For Xen instances, data is reported only when there is read activity on the volume. The Average statistic on this metric is not relevant for volumes attached to Nitro-based instances. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Seconds

Metric	Description
VolumeTotalWriteTime	Note This metric is not supported with Multi-Attach enabled volumes. The total number of seconds spent by all write operations that completed in a specified period of time. If multiple requests are submitted at the same time, this total could be greater than the length of the period. For example, for a period of 5 minutes (300 seconds): if 700 operations completed during that period, and each operation took 1 second, the value would be 700 seconds. For Xen instances, data is reported only when there is write activity on the volume. The Average statistic on this metric is not relevant for volumes attached to Nitro-based instances. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Seconds
VolumeIdleTime	Note This metric is not supported with Multi-Attach enabled volumes. The total number of seconds in a specified period of time when no read or write operations were submitted. The Average statistic on this metric is not relevant for volumes attached to Nitro-based instances. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Seconds

Metric	Description
VolumeQueueLength !	The number of read and write operation requests waiting to be completed in a specified period of time. The Sum statistic on this metric is not relevant for volumes attached to Nitro-based instances. The Minimum and Maximum statistics on this metric are supported only by volumes attached to Nitro-based instances. Units: Count
VolumeThroughputPercentage	Note This metric is not supported with Multi-Attach enabled volumes. Used with Provisioned IOPS SSD volumes only. The percentage of I/O operations per second (IOPS) delivered of the total IOPS provisioned for an Amazon EBS volume. Provisioned IOPS SSD volumes deliver their provisioned performance 99.9 percent of the time. During a write, if there are no other pending I/O requests in a minute, the metric value will be 100 percent. Also, a volume's I/O performance may become degraded temporarily due to an action you have taken (for example, creating a snapshot of a volume during peak usage, running the volume on a non-EBS-optimized instance, or accessing data on the volume for the first time). Units: Percent
VolumeConsumedReadWriteOps	Used with Provisioned IOPS SSD volumes only. The total amount of read and write operations (normalized to 256K capacity units) consumed in a specified period of time. I/O operations that are smaller than 256K each count as 1 consumed IOPS. I/O operations that are larger than 256K are counted in 256K capacity units. For example, a 1024K I/O would count as 4 consumed IOPS. Units: Count

Metric	Description
BurstBalance	Used with General Purpose SSD (gp2), Throughput Optimized HDD (st1), and Cold HDD (sc1) volumes only. Provides information about the percentage of I/O credits (for gp2) or throughput credits (for st1 and sc1) remaining in the burst bucket. Data is reported to CloudWatch only when the volume is active. If the volume is not attached, no data is reported. The Sum statistic on this metric is not relevant for volumes attached to Nitro-based instances. If the baseline performance of the volume exceeds the maximum burst performance, credits are never spent. The reported burst balance is either 0% (Nitro-based instances) or 100% (non-Nitro-based instances). For more information, see I/O Credits and burst performance. Units: Percent

Status

Volume status	I/O enabled status	I/O performance status (only available for Provisioned IOPS volumes)
ok	Enabled (I/O Enabled or I/O Auto-Enabled)	Normal (Volume performance is as expected)
warning	Enabled (I/O Enabled or I/O Auto-Enabled)	Degraded (Volume performance is below expectations) Severely Degraded (Volume performance is well below expectations)

Volume status	I/O enabled status	I/O performance status (only available for Provisioned IOPS volumes)
impaired	Enabled (I/O Enabled or I/O Auto-Enabled) Disabled (Volume is offline and pending recovery, or is waiting for the user to enable I/O)	Stalled (Volume performance is severely impacted) Not Available (Unable to determine I/O performance because I/O is disabled)
insufficient-data	Enabled (I/O Enabled or I/O Auto-Enabled) Insufficient Data	Insufficient Data

EBS modifications

You can adjust the volume type, size and IOPS on the fly. If you adjust the volume size, you must manually expand the filesystem.

ELB

Cloudwatch monitors performance (Metrics)

Cloudtrail monitors API calls to AWS (Audit)

Cloudwatch monitoring is enabled by default when creating a loadbalancer.

Access logs are not enabled by default (Stored in S3). You can use Sumologic or AWS Athena to query these logs. Once EC2 instances have been deleted, there is no way to recover nginx access logs if you want to debug.

You can use Request tracing on an ALB. It adds or updates the X-Amzn-Trace-id header before sending it through.

ElasticCache

Standard monitoring:

- CPU utilization
- Swap usage
- Evictions

- Concurrent Connections

CPU

Memcached is multi-threaded and can handle loads of up to 90%. Add more nodes to the cluster when it exceeds 90%.

Redis is not multi-threaded. To determine the threshold in which to scale, take 90 and devide by the number of cores.

Swap

If you use 4 Gb of RAM, use 4 Gb of Swapfile

Memcached should have arount 0 swap and should not exceed 50Mb, If it does increase hte memcached_connections_overhead parameter (defines the amount of memory of reserved memcached connections and other miscellanous overhead). Increase the memory of your memcached.

With Redis no SwapUsage metric is shown, instead it uses reserved-memory

Evictions

Evictions => remove data when no new data can be stored.

Memcached => no recommended setting, either scale up or scale out.

Redis => only option the scale out by adding read replicas

Concurrent Connections

No recommended settings. If there is a spike, this is due a spike in traffic or your application is not releasing connections as it should (Set an alarm on the number of connections).

Multiple Regions & Custom Dashboard

Dashboards are internationally! You have to change region if you want a widget with metrics from that region.

Create a billing alarm

Cloudwatch => Create billing alarm => Select time check => Define threshold in USD => Select SNS create topic => Enter your e-mailadres => Confirm email-address.

AWS Organizations

Allows you to manage multiple AWS accounts:

- Centrally manage policies across multiple accounts (IAM groups)
- Control access to AWS services (Service control policy => Allow or Deny AWS services)
- Automate AWS account creation and management
- Consolidate Billing across multiple AWS accounts (good for discounts)

Create an organization inside helpful tips, 2 choices:

- Enable all features
- Enable only consolidated billing

Policies:

- Deny (a list of denied services)
- Allow (a list of allowed services)

AWS Rescource Groups & Tagging

Resource groups make it easy to group your resources using tags that are assigned to them. You can group resources that share one or more tags.

Resource groups contain information such as:

- Region
- Name
- Health checks

Specific information:

- EC2: Public and private IP
- ELB: Port configurations
- RDS: Database engine etc

Create resource group based on tags or cloudformation stack based. Add tags and give your group a name.

Via AWS System Manager your can execute automation on resource groups (f.e. Stop Ec2 instances).

Cost explorer & Cost Allocation Tags

You can create csv reports. In Cost allocation tags you can set the tags where you want to know the cost of in cost explorer. It is across multiple accounts.

AWS Config

Aws config is a fully managed service that provides you with an AWS resource inventory, configuration history, and configuration change notifications to enable security and governance.

- Configurations snapshots and logs config changes of AWS resources
- Automated compliance checking

Enable it per region. AWS config stores everything in S3 and could trigger a lambda or pulled by Lambda. As soon as a rule is being broken an SNS notification will be send to someone (email).

Terminology:

- Configuration Items: point in time attributes of resource
- Configuration Snapshots: Collection of Config Items
- Configuration Streams: Stream of changed Config Items
- Configuration History: Collection of Config Items for a resource over time
- Configuration Recorder: The configuration of Config that records and stores Config Items => Logs config for account in Region and Stores in S3, Notification through SNS

What we can see:

- Resource Type
- Resource ID
- Compliance
- Timeline:
    - Configuration Details

  - Relationships
  - Changes
  - Cloudtrail Events

Compliance checks:

- Trigger:
  - periodic
  - Configuration snapshot delivery
- Managed Rules:
  - About 40
  - Basic, but fundamental

AWS Config needs Read only permissions to the recorded resources, write access to S3 logging bucket and publish access to SNS.

Health Dashboards

(https://status.aws.amazon.com/)

Service Health Dashboard => Show the health of each AWS Service as a whole per region

Personal Health Dashboard => AWS Personal Health Dashbaord provides alerts and remediation guidance when AWS is experiencing events that may impact you.

Deployment & Provisioning

Deploy an EC2

Running on spot options:

- Add max price
- Persistent request
- Interruption behaviour:
  - Terminate
  - Stop (lose data on RAM)
  - Hibernate (Keep RAM)
- Request valid from/to
- Launch group (only launches when all can launch)

- Placement group: Add instances to one AZ
- Enable Termination protection
- Shutdown Behavior (stop/terminate)
- Enable detailed monitoring
- Tenancy (Shared - Run a shared hardware)
- T2 unlimited (Burst CPU)
- User data (bootscripts)

EC2 Launch Issues

Common issues:

- InstanceLimitExceeded error: Default limit 20 per region limit (AWS support to raise limit)
- InsufficientInstanceCapacity error: AWS does not have enough available on-demand capacity (wait few minutes / request fewer instance types / select other instance types / purchase reserved instances / Submit request without AZ)

EBS Volumes and IOPS

- gp2 : minimum 100 IOPS to max 16 000 IOPS
- io1 (provisioned iops => databases) : minimum 50 IOPS/Gb to max 64 000 IOPS

Hitting limit gp2 iops => I/O request queuing => Application becomes slow

- raise gp2 volume size
- already 16 000 iops => change to io1

Elatic Loadbalancers

- Application loadbalancer (layer 7)
- Network loadbalancer (layer 4 => Handles millions of request per second)
- Classic loadbalancer (X-forwarded and sticky sessions)

Pre-warming loadbalancer => contact AWs support to pre-warm to handle spikes

- start and enddate
- expected req/sec
- total size of typical request

ALB changes ip addresses when scaling

Network loadbalancers create static ip per subnet (good for firewalling)

Solution: Put an ALB behind a network loadbalancer for static ip

ELB Error Messages

Classic and ALB:

- 200 => success
- 4xx client side error
- 5xx server side error

Client side error:

- 400 => Bad/malformed request (header malformed)
- 401 => unauthorized
- 403 => Forbidden (blocked by WAF access control list)
- 460 => Client closed connection before loadbalancer could respond
- 463 => Loadbalancer received X-forwarded-For header with > 30 ips

Server side error:

- 500 => Internal server error (loadbalancer)
- 502 => Bad Gateway (application server closed connection)
- 503 => Service unavailable (no registered targets)
- 504 => Gateway timeout
- 561 => unauthorized (identity provider)

ELB Cloudwatch Metrics

Loadbalancer have default Cloudwatch metrics and also for the backends

- BackendConnectionErrors => number of unsuccessful connections to the backend instances
- HealthyHostCount
- UnHealthyHostCount
- HTTPCode_Backend_2xx,3xx,4xx,5xx
- Latency => number of second taken for instance to respond

- RequestCount => number of request completed
- SurgeQueueLength => number of pending requests - max of 1024 (Classic only)
- SpolloverCount => number of requests rejected when surge queue is full (Classic only)

AWS Systems Manager

- Management-tool which give you control over AWS infrastructure.
- Integrates with Cloudwatch allowing you view your dashboards, view operation data & detect problems.
- Includes Run command which automates operational tasks across resources - f.e. security patches, package installs.
- Organize your inventorym grouping resources together by application or environment (including on-premise)

Run-command

- Allow you to run pre-defined command on one or more EC2 instances.
- Stop, restart, terminate, resize instance
- Attach/detatch EBS volumes
- Create snapshots, backup DynamoDB tables
- Apply patches and updates
- Run an Ansible playbook
- Run shell scripts

Use

- Create role in IAM for EC2 (EC2RoleforSSM)
- Attach role to EC2
- In SSM, find resource group (create resource group)
    - Build-in insights
        - view Cloudtrail
        - AWS Config
        - Personal Health Dashboard
        - Trusted Advisor
            - Cost optimizations
            - Performance

        - Security recommendations
        - Fault Tolerance
        - Service Limits
    - Dashboards in Cloudwatch
    - Inventory (Top OS, Top Services, ...)
    - Compliance (see patches applied)
    - Automation (Run commands on instances, automated/in steps, create your own documents)
    - Run command (pre-configured or own scripts f.e AWS-RunShellScript document)
        - SNS notification
        - Output to S3
        - Shell script box
        - Apply shows you the output
    - Patch Manager
    - Maintenance Windows (cron scheduler, duration)
    - State Manager (ensure consistent state - reapply when state is no compliant)
    - Managed instances
    - Activations (Register EC2 instances and on-premise - Install ssm agent)
    - Documents (Create your own documents / view existing)
    - Parameter Store (secrets)

Placement Groups

By default AWS places instances across different physical hardware. This minimizes the impact of a hardware failure. Not so great for low latency, high network throughput applications.

Types:

- Cluster: Instances are all created in a single AZ
    - Full line rate of 10 Gbps
    - Not for high availability
- Partition: Instances are created in logical segments called partitions, each located in a separate rack, with independent network and power. Some instances could be in the same rack.
    - Great for HDFS, HBase, and Cassandra

- Spread: Each instance is created in a separate rack, with independent network and power.
    - Maximum availability

Encryption & Downtime

EFS and RDS encryption has to be enabled at creation (Create new one for encrypting your data) With EBS it is the same, but you can rsync or robocopy to migrate data from one ebs to an encrypted one or use the snapshot strategy.

With S3 you can enbaled encryption at any moment.

KMS vs. CloudHSM

Both allow you to generate, store and manage cryptographic keys used to protect data in AWS.

HSM (Hardware Security Modules) are use to protect the confidentiality of you keys.

KMS:

- Shared hardware
- multi-tenant managed service
- generate, store and manage encryption keys
- EBS, S3, RDS, DynamoDB, etc.
- Symmetric keys

Cloud HSM:

- Dedicated instance
- generate, store and manage encryption keys
- HSM is under you exclusive control within your own VPC
- FIPS 140-2 Level 3 compliance
- Banking (don't use multi-tenant hardware)
- Use cases:
    - database encryption
    - Digital Rights Management (DRM)
    - Public Key Infrastructure (PKI)
    - Authentication and authorization

  - Document signing
  - Transaction processing
  - Encryption data in AWS
  - Symmetric (Same encryption key algorithm to encrypt and decrypt your data) and Assymetric keys

AMIs

AMI provides all the information:

- Template root volume (OS and Applications)
- Launch permissions (Which AWS accounts can use the AMI)
- Block device mapping to specify EBS volumes to attach

You must register an AMI before using it.

Copy AMI to another region to use it there.

Sharing AMIs

After creating an AMI, you can either keep it private by default, share it with a specified list of AWS accounts, make it publicly available or even sell you AMI to other AWS users.

You pay for storage for the AMI.

The owner of the source AMI must grant you read permissions for the storage that backs the AMI (EBS snapshot or S3)

You cannot directly copy an encrypted AMI shared by another account:

- Copy the snapshot and re-encrypt using your own key
- The sharing account must also share with you the underlying snapshot and encryption key used to create the AMI
- You'll own the copied snapshot and can register it as a new AMI

You can directly copy an AMI with an associated billingsProducts code (like Windows, Redhat and AMIs from AWS Marketplace.)

billingProducts code is used to bill the use of an AMI (Windows Server or SQL Server License)

Snowball & Snowball Edge

- Tamper-resistant enclosure for transporting data to one region specific
- 256-bit encryption
- install snowball-client

Snowball Edge

- 100 TB device
- s3 compatible endpoint, supports NFS and also capable of running lambda functions (comes pre-configured with it)
- Use this when require local processing

Storage Gateway

on premise software appliance:

- Install Storage Gateway Appliance in your datacenter (VM)
- Supports VMWare ESXi or Microsoft Hyper-V
- On-premises systems seamlessly integrate with AWS storage (f.e. S3)

Types:

- File Gateway:
  - files stored as objects in S3
  - Accessed using NFS or SMB
  - Include all benefits of S3 (bucket policies, s3 versioning, lifecycle, replication)
- Volume Gateway (iSCSI)
  - Stored Volumes
    - All data stored locally and backed up in AWS
    - off-site async backups as EBS snapshots and stored in S3
  - Cached Volumes
    - Use S3 as your primary storage and cache frequently accessed data in you Storage Gateway
- Tape Gateway (VTL)
  - Archive data in Glacier
  - Integrates with NetBacku, Backup Exec, Veeam etc. which connect to the VTL using iSCSI

Athena

- Query service that enables you to analyse and query data located in S3 using standard SQL
- Serverless (pay per query/ per TB scanned)
- Used for query logs stored in S3
- Run business reports
- Analyse AWS cost and usage reports
- Run queries on click-stream data

Lab:

- Cloudtrail => create Trail
- Select all S3 buckets in your account to record
- Storage location in S3 (create new)
- Go to Athena
- Create query (Create Database myathenadb)
- Create a table with a format attributes for cloudtrail logs
- Add the location of the s3 bucket in a query (LOCATION 's3://...')
- Run query for table creation
- Table should be populated with cloudtrail logs
- Now you can query the cloudtrail logs

EFS

- Has a lifecycle which allows you to automatically move files to EFS IA when it is not accessed for a period of time
- Configure encryption data at rest and in transit

Use FSx for Windows (other service than EFS)

High availability

Elasticity (Short term) & Scalability (Long term)

EC2:

- Scalability: Increase instance size
- Elasticity: Increase number of instances

DynamoDB:

- Scalability: Unlimited amount of storage
- Elasticity: Increase additional IOPS for additional spikes in traffic, decrease when spike stops.

RDS:

- Scalability: Increase instance size
- Elasticity: not very elastic, can scale RDS base on demand

Aurora => Scalability: Modify instance type, Elasticity: Aurora Serverless

RDS and Multi-AZ Failover

Automatically failover to other AZ (which already replicated) for Disaster Recovery. Small outage of 1 minute can happen during failover. It update the private DNS for the database endpoint.

MySQL, MariaDB, Oracle and PostgreSQL engines utilize synchronous physical replication

SQL Server engine uses synchronous logical replication.

Advantages:

- Backups are taken from secondary which avoids I/O suspension to the primary
- Restore's are taken from secondary which avoids I/O suspension to the primary

! You can force a failover from one AZ to another by rebooting your instance. Via AWS console or by using RebootDBInstance API call.

RDS & Using Read Replicas

Create a Read Replica via the AWS console or by CreateDBInstanceReadReplica API. It will use engine native asynchronous replication.

Useful for Read-heavy databases to scale. Point your application to read endpoint of the RDS instance. (Business reporting or data warehousing)

For Bi solutions => create read replica or import data into Redshift.

Aurora uses SSD backend virtualized storage layer for database workloads. Aurora replicas share the same underlying storage as the source instance, lowering the costs and avoiding to need to copy data to the replica nodes.

Creating Read Replicas

- AWS takes a snapshot of the database
- If Multi-Az is not enabled, AWS will take the snapshot of your primary database. This will create a brief I/O suspension for around 1 minute
- If Multi-Az is enabled, AWS will take the snapshot from your secondary database.

Read Replicas can be promoted to its own database. Will break the replication.

You can also create a read replica of a read replica in a other region. Can have latency.

You can have up to 5 Read replicas for Mysql, Postgresql and Mariadb

DB snapshots and Automated Backups cannot be taken of read replicas.

Key Metric to look for is REPLICA LAG (How long does the replication take)

RDS & Using Read Replicas

- Storage autoscaling (start storage and threshold)
- Deletion protection
- You can not create a read replica if automated backups are turned off
- creating mutli-az could have potential downtime.
- You cannot create read replica of read replica when automated backups are turned off

```
aws rds describe-db-instances --region eu-west-1
```

RDS - Encryption RDS Snaps

- Take a snap of existing RDS instance
- Copy the snap to the same/different region. (enable encyption)
- Encrypt the copy during the copy process.

- Restore the snap

You can share DB encrypted snapshot using AES-256 encryption with other AWS accounts:

- Create a Custom KMS encryption key
- create RDS snap using custom key
- share the custom AWS KMS encryption key
- Use AWS Management console, cli or rds api to share the encrypted snapshot.

You cant share the following:

- encrypted snapshot as public
- Oracle or Microsoft SQL Server snapshot that are encrypted using Transparent Data Encryption (TDE).
- Snapshots encrypted using default AWS KMS encryption key.

Which Services have Maintenance windows

- RDS
- Elasticache
- Redshift
- DynamoDB DAX
- Neptune
- Amazon DocumentDB

Elasticache

Redis has Master/Slave replication and Multi-AZ, Memcached doesn't

If your databases is stressed out by read operation, use ElastiCache or Redshift for OLAP transactions.

Aurora

Supports:

- MySQL (5 times better performance)
- PostgreSQL (3 times better performance)

Specs:

- Starts with 10 GB storage and increments per 10 GB up to 64 TB
- Compute resources can scale up to 64 vCPUs and 488 GiB Memory
- 2 copies of your data in each AZ, with minimum of 3 AZ. 6 copies of you data.
- Can lose 2 copies of your data without effecting write availability
- Can lose 3 copies of your data without effecting read availability
- Self Healing are continuously scanned for errors
- Cluster volume across AZ's

Aurora Replica:

- Aurora replicas (up to 15)
- Mysql read replicas (up to 15)

100% of CPU utilization?

- Write causing issue: Scale up (increase instance size)
- Read causing issue: Scale out (increase number of read replicas)

Aurora Serverless: Automatically scale up, shuts down base on capacity. You pay per second basis for database capacity, and you can migrate between standard and serverless configuration with a few clicks in the Amazon RDS Management Console.

Lowest number tier will be used for the failover (failover priority in configuration).

You can set up a read replica cross-region. Be aware to turn on Multi-AZ for this. If the replication is disrupted, you have to set this up again.

Encryption at is rest is set by default.

Troubleshooting Autoscaling

- Associated Key Pair does not exist
- Security group does not exist
- Autoscaling config is not working correctly
- Autoscaling group not found
- Instance type specified is not supported in the AZ
- AZ is no longer supported
- Invalid EBS device mapping

- Autoscaling service is not enabled on your account (check IAM)
- Attempting to attach an EBS block device to an instance store AMI

Cloud Front & Cache Hit Ratios

- Edge location: location where the content will be cached
- Origin
- Distribution: name given to the CDN
- Web Distribution: For websites
- RTMP: Used for media streaming

Maximize cache hit ratios:

- Specify how long cloudfront caches object (Cache-Control max-age)
- Caching Based on Query String parameters
- Caching Based on Cookie Values
- Caching Based on Request Headers
- Remove Accept-Encoding Header when compression is not needed
- Serving Media content using http

Storage & Data Management

S3

- Files can be from 0 Bytes to 5 TB
- Unlimited storage
- https://s3-eu-west-1.amazonaws.com/{yourname}

Objects consist of:

- Key
- Value
- Version ID (Important when versioning is enabled)
- Metadata (Data about data you are storing)
- Subresources (Bucket specific configuration)
  - Bucket policies, Access control lists
  - CORS

  - Transfer acceleration

Charged for:

- Storage per GB
- Requests (Get, Put, Copy, etc.)
- Storage Management pricing:
  - Inventory, Analytics, and Object tags
- Data Management pricing:
  - Data transferred out of S3
- Transfer Acceleration
  - Use Cloudfront to optimize

Example Life Cycle policies

- Transition objects to IA storage class 90 days after you created them (f.e. logs)
- Archive objects to Glacier 1 year after creation
- Expire object 1 year after creating them (S3 will auto-delete) => Server access logging in s3 can accumulate many log files

MFA Delete

- When versioning on a bucket is enabled, a delete action doesn't delete the object version, but applies a delete marker.
- To permanently delete, provide object version id in the delete request

MFA delete provides and additional layer of protection to s3 Versioning. Once enabled, MFA Delete will enforce 2 things:

- You will need a valid code form your MFA device in orderr to permanently delete an object version
- MFA also needed to suspend / reactivate versioning on an S3 Bucket

S3 Encryption

Types of encryption:

- In Transit (SSL/TLS)
- At Rest:
  - Server Side Encryption

        - S3 Managed keys - SSE-S3 (master key encryption + rotate)
        - AWS Key Management Service, Managed Keys, SSE-KMS (envelope key)
        - Server Side Encryption with Customer Provided Keys - SSE-C (you own key and rotation)
    - Client Side Encryption (encrypt before upload)

Enforce Encryption:

- x-amz-server-side-encryption:AES256 (SSE-S3)
- x-amz-server-side-encryption:aws:kms (SSE-S3)

=> Use a bucket policy which denies PUT requests which doesn't include x-amz-server-side-encryption

The Expect: 100-continue Header in the PUT request is for accept of deny the body sent to S3

EC2 Volume Types

- Instance store is know as ephemeral storage which is non-persistent
- EBS is Elastic Block storage which allows persistence

Root device can be EBS or Instance Store:

- Instance store root has maximum size of 10 Gb
- EBS can be up to 1 or 2 Tb
- All Instance store volumes are removed on termination of EC2
- Instance store persist with reboot of EC2

Upgrading EC2 Volume Types

Create ec2 will create all ebs on it in the same AZ. Change size and volume type on the fly. Snapshots exists on S3 (not visible), there incremental. Snapshots needs to be encrypted to be shared with other AWS accounts.

Migrating EBS to another AZ:

- create snapshot of EBS
- create volume from snapshot

Migrate to other region:

- Copy snapshot (select region)
- Create Image of ebs snapshot
- Launch EC2

Security & Compliance

Compliance on AWS

- FedRAMP
  - US
- ISO
  - ISO/IEC 27001:2005 Documented Information Security Management System
- HIPAA
  - Health Insurance Protability and Accountability Act (storage)
- NIST
  - US Cybersecurity
- PCI (Credit card information)
  i. Install and maintain firewall configuration to protect cardholder data
  ii. Do not use vendor-supplied defaults for system passwords and other security parameters
  iii. Protect and stored cardholder data (like encrypt database at rest)
  iv. Encrypt transmission of cardholder data across open, public networks (SSL)
  v. Protect all systems against malware and regularly update anti-virus software
  vi. Develop and maintain secure systems and applications
  vii. Restrict access to cardholder data by business need to know (sys admins do not need to know the data)
  viii. Identity and authenticate access to system components (IAM)
  ix. Restrict physical access to cardholder data (do not copy creditcards on paper f.e)
  x. Track and monitor all access to network resources and cardholder data (Cloudwatch, Cloudtrail, Config)
  xi. Regularly test security systems and processes (Penetration testing)
  xii. Maintain a policy that addresses information security for all personal
- SAS70 (Auditing standards)
- SOC1 (Service Organisation Controls - accounting standards)

- FISMA (Federal Information Security Modernization Act)
- FIPS (FIPS 140-2 cryptographic modules - CloudHSM is level 3)

DDoS

- NTP Amplification - Hacker sends packets with spoofed IP address source to the ntp server which replies with a greater payload to the victim (spoofed ip).
- Application Attacks - Flood of GET requests to webserver
- Slowloris - Hacker sends partial requests to the webserver to keep op as many connections open as possible. This keeps up until the concurrent connections pool is filled.

Mitigate DDoS

- Minimize the Attack Surface Area (WAF and ALB)
- Be ready to scale (Autoscaling groups)
- Safeguard Exposed Resources
- Learn Normal Behavior
- Create plan for attacks

AWS Shield

- Free service that protects all AWS customers on ELB, Cloudfront and Route53
- Protects against SYN/UDP Floods, Reflection attacks, and other layer 3/ layer 4 attacks.
- Advanced:
  - provides protection against larger and more sophisticated attack
  - $3000 per month
  - Always onm flow-based monitoring of network traffic and active application monitoring to provide near real-time notifications of DDoS attacks.
  - DDoS Response Team (DRT)
  - Protects your AWS bill against higher fees during DDoS attack.

AWS Marketplace - Security Products

- Kali Linux
- Ask permission to AWS for penetration testing (request form)

MFA & Reporting with IAM

In IAM you can select user and enable MFA.

```
aws iam create-virtual-mfa-device --virtual-mfa-device-name EC2-user --
outfile ./QRCode.png --bootstrap-method QRCodePNG
aws iam enable-mfa-device --user-name EC2-user --serial-number
arn:aws:iam::[username]:mfa/EC2-user \
--authentication-code-1 [code1] --authentication-code-2 [code2]
```

Look into IAM credentials report to verify users have MFA enabled.

Security Token Service (STS)

- Federation (typically Active Directory)
  - SAML
  - Temporary Access based of the users Active Directory credentials
  - SSO without assigning IAM credentials
- Federation with Mobile Apps
  - Use Facebook/Amazon/Google or other OpenId providers
- Cross Account Access

Flow

Image of instance types

Logging

- AWS Cloudtrails
- AWS Config
- AWS Cloudwatch Logs
- VPC Flow Logs

Control Access to Log Files

Prevent unauthorized access:

- IAM users, groups, roles and policies
- Amazon S3 bucket policies

- Multi Factor Authentication

Ensure role-based access:

- IAM users, groups, roles and policies
- Amazon S3 bucket policies

Alerts when logs are created or failed:

- Cloudtrail notifications
- AWS Config Rules

Alerts are specific, but don't divulge detail:

- Cloudtrail SNS notifications only point to log file location.

Log changes to system components:

- (AWS Config Rules)
- Cloudtrail

Controls exist to prevent modifications to logs:

- IAM and S3 controls and policies
- CloudTrail log file validation
- CloudTrail log file encryption

AWS WAF

- Allow all requests except the ones that you specify
- Block all requests execpt the ones that you specify
- Count the requests that match the properties that you specify

What you specify:

- originated ip addresses
- originated country
- Values in headers
- Strings via regex
- Length of requests
- Presence of SQL code (SQL injection)
- Presence of Script (cross-site-scripting)

WAF integrates with:

- ALB
- Cloudfront
- API Gateway

NOT: Classic loadbalancer or network loadbalancer (not Layer 7)

AWS Hypervisors

Choose HVM over PV where possible

EC2 runs on Xen Hypervisor

PV => paravirtualization

- ring 0: Xen Hypervisor
- ring 1: Guest OS (Ec2 instance)
- ring 3: Applications

Isolation

AWS does not have access to layer 1

Layers:

- Physical interface
- Firewall:
  - security groups (on hypervisor level)
- Virtual Interface
- Hypervisor
- EC2

Memory Scrubbing is performed on blocks storage (EBS) and memory (set to 0) before other customer can use it.

EC2 Dedicated Instances vs. Dedicated Hosts

Dedicated Instance

- physical isolated hardware

- Charged by the instance
- May share the same hardware with other AWS instances from the same account

Dedicated Hosts

- physical isolated hardware
- Charged by the host
- Choose when license conditions
- Visibility of sockets, cores, host ID

AWS Systems Manager EC2 Run Command

- Enables you to run patches, installations, ... on a number of EC2 instances and on premise systems without having to log in.
- Add a role to your EC2 instances (EC2 Role for SSM)
- SSM agent needs to be installed on the instances
- In SSM go to run Command
- Select Installation (f.e. Configure Cloudwatch)
- Specify tag or manually select instances
- Run

Pre-signed URLs with S3

- Use cli or SDK for creating pre-signed urls
- Default is 1 hour

```
aws s3 presign s3://[bucketname]/[file] --expires-in [time-in-seconds]
```

S3 - Restrict IP Addresses

- Create bucket policy with Condition

```
...
"Condition":{
  "IpAddress": {"aws:SourceIp": "10.0.12.0/24"},
  "NotIpAddress": {"aws:SourceIp": "54.240.143.188/32"}
}
```

AWS Config with S3

- Go to AWS Config
- Add Rule
- Add s3-bucket-public-read-prohibited and s3-bucket-public-write-prohibited

Inspector vs Trusted Advisor

AWS Inspector

- Go to Inspector
- Create a role with EC2:describeInstances
- Install agents on EC2 Instances
- Tag your ec2 instances
- Create Assessment Target (specify your tags)
- Create Assessment template
    - Rules packages
        - Common Vulnerabilities and Exposures
        - CIS Operating System Security Configuration Benchmarks
        - Security Best Practices
        - Runtime Behavior Analysis
    - Duration (1 hour recommended)
- Perform Assessment run
- Review Findings against Rules (Download Report - Explanation what was tested)

You can create a master template that will run every 24 hour (You can notify with SNS)

AWS Trusted Advisor

- Reduce costs
- Increase performance
- Improve Security
- Fault tolerance

You have basic plan and business plan

Service Limits

- Check Trusted Advisor for Service Limits

Other Security Aspects

AWS artifacts => submit security and compliance documents (SOC)

Instant encryption: S3 Encryption with migration: DynamoDB, RDS, EFS, EBS

Cloudtrail - Turning it on and validating logs

What is logged:

- Metadata API Call
- The identity of the API caller
- time
- Source ip
- request parameters
- response by the service

Stored in S3 => You have to manage policies (takes 5 minutes to 15 minutes). Not visible unless you create a trail.

You can aggregate logs across regions and accounts

By default enabled for 7 days.

Digest logs are being created inside the S3 bucket. It is used to check whether or not files in the cloudtrail bucket have been altered. It does this by storing hash (SHA-256 hasing).

Cloudtrail - Protecting Logs

Cloudtrail logs may contain personal data:

- Create s3 bucket policies
- Create IAM group to allow access to that s3 only for these users.
- You can use S3 MFA
- Add lifecycle policies to store older logs to Glacier
- Encryption is done by default

Networking

VPC Overview

VPC peering allows you to connect one VPC with another via a direct network route using private IP addresses. Also connect to VPC on other AWS account.

Peering is in a star configuration: 1 central VPC peers with 4 others (no transitive peering).

Build VPC

First 4 address and last 1 in a VPC subnet are reserved ip address.

Only 1 internet gateway can be assigned to 1 VPC.

After creating a route table for accessing the internet through the internet gateway for you public subnet. Select the subnet associated with that table and modify auto-assign IP => enable auto-assign public IPv4 address.

Nat Gateways operate via IPv4 and Egress Only Internet Gateways operate via IPv6.

1 Subnet can only be associated to 1 network ACL.

Be default all network rules are denied. You have to add rules inbound and outbound. Use ephemeral ports (1024-65...). Rules are in numerical order (lowest has most priority)

VPC endpoints

Make requests over the private network to f.e S3

2 Types:

- Interface
- Gateway (S3 and DynamoDB)

VPC Flow Logs

Flow logs can be created at 3 levels:

- VPC

- Subnet
- Network Interface Level

Create by selecting VPC => Actions => Create Flow Log (All, Accepted or Rejected) => Create a role to store to Cloudwatch => Create log group

You can streams logs to Lambda or ElasticSearch

Once created, you cannot modify IAM role.

Not monitored:

- Traffic generated by instances to contact Amazon DNS (unless your own DNS)
- Windows License activation
- Traffic to instance metadata 169.254.169.254
- DHCP traffic
- Traffic to reserved IP address for the default VPC router

Direct Connect

Customer network connects trough the AWS backbone network via AWS Direct Connect on a Private Virtual interface.

With multiple regions you can use Direct Connect Gateway (Like a NAT gateway). Virtual private interface is connect to Direct Connect Gateway.

DNS

ALIAS record can point to apex records (CNAME can't)

Types of Routing policies:

- Simple Routing Policy
  - 1 record can hold multiple ip addresses (Shown in random order)
- Weighted Routing Policy
  - f.e. 20% to one region, 80% to other region
  - Multiple records (apex records) with weights
- Latency Routing Policy
  - Routing based on lowest network latency (can depend on location of user)
- Failover Routing Policy

  - Create Health checks in route53 first
  - You can create an alarm as well
  - Select primary and secondary
  - Assign your primary record with a healthcheck
- Geolocation Routing Policy
  - Based on users location routing to maybe a specific website for that continent
  - Create a default one as well
- Multivalue Routing Policy
  - Create more records with each their own ip address (with health checks)

Automation

Cloudformation

- Upload template in json or yaml to S3
- Sections:
  - Optional Description
  - Optional Metadata
  - Optional Parameters (f.e. Env type with allowed values prod stag)
  - Optional Conditions
  - Optional Mappings (f.e ami per region)
  - Optional Transform (to include template snippets for re-use in S3 or reference code for Lambda)
  - Mandatory Resources section
  - Optional Outputs
- You can rollback on failure (default it is checked)

Elastic Beanstalk

Programming languages:

- Java
- .NET
- PHP
- Node.js
- Python

- Ruby
- Go
- Docker

Server platforms:

- Apache
- Tomcat
- Nginx
- Passenger
- IIS

Automatically updates OS, Java, PHP, ...

OpsWork

- Puppet
- Chef

Updates based on Student Feedback

Service Catalog

- Create product (like create private s3 Bucket defined in Cloudformation Template)
- Create portfolio
- Add product to portfolio
- Create user
  - allow access to the portfolio (AWSServiceCatalogEndUserFullAccess)
  - allow s3 bucket access (S3FullAccess)
- Add user to portfolio
- You can share portfolios with other AWS accounts

Cloudfront Error Messages

- 400 => Malformed request
- 403 => Access denied, files must be accesible f.e. s3
- 404 => File not found

- 502 => Bad Gateway, Cloudfront cant connect to server
- 503 => Service unavailable, performance issue on the server
- 504 => Gateway Timeout, Request timeout

Multi-account to Direct Connect

up to 10 VPC and same payer account

Inter-regin VPC peering

VPC peering request, change routing table, can be done in 2 accounts in different regions. CIDR ranges need to be unique.

HTTPS & Storing SSL Certificates

- Certificate Manager
- Free
- Upload existing certificates

Cloudformation Best Practices

- IAM
- Be aware of service limits
- Avoid manual updates => chance of mismatch
- Use Cloudtrail to monitor the changes
- Stack policy (describe update policy on critical resources f.e. production database)