Databases Section

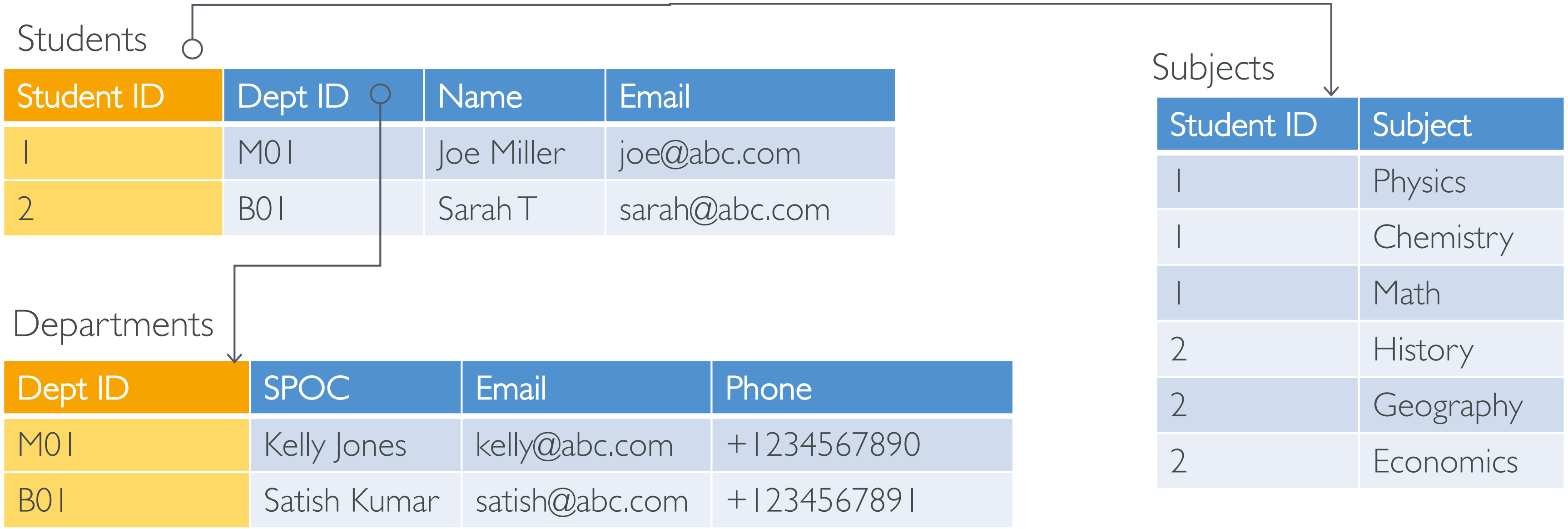
Databases Intro

- Storing data on disk (EFS, EBS, EC2 Instance Store, S3) can have its limits
- Sometimes, you want to store data in a database…
- You can **structure** the data
- You build **indexes** to efficiently **query** / **search** through the data
- You define **relationships** between your **datasets**

- Databases are **optimized for a purpose** and come with different features, shapes and constraints

Relational Databases

- Looks just like Excel spreadsheets, with links between them!
- Can use the SQL language to perform queries / lookups



Students

Student ID	Dept ID	Name	Email
1	M01	Joe Miller	joe@abc.com
2	B01	Sarah T	sarah@abc.com

Departments

Dept ID	SPOC	Email	Phone
M01	Kelly Jones	kelly@abc.com	+1234567890
B01	Satish Kumar	satish@abc.com	+1234567891

Subjects

Student ID	Subject
1	Physics
1	Chemistry
1	Math
2	History
2	Geography
2	Economics

NoSQL Databases

- NoSQL = non-SQL = non relational databases
- NoSQL databases are purpose built for specific data models and have flexible schemas for building modern applications.
- Benefits:
  - Flexibility: easy to evolve data model
  - Scalability: designed to scale-out by using distributed clusters
  - High-performance: optimized for a specific data model
  - Highly functional: types optimized for the data model
- Examples: Key-value, document, graph, in-memory, search databases

NoSQL data example: JSON

- JSON = JavaScript Object Notation
- JSON is a common form of data that fits into a NoSQL model
- Data can be **nested**
- Fields can **change** over time
- Support for new types: **arrays**, etc…

```
{
    "name": "John",
    "age": 30,
    "cars": [
        "Ford",
        "BMW",
        "Fiat"
    ],
    "address": {
        "type": "house",
        "number": 23,
        "street": "Dream Road"
    }
}
```

Databases & Shared Responsibility on AWS

- AWS offers use to **manage** different databases
- **Benefits** include:
  - Quick Provisioning, High Availability,Vertical and Horizontal Scaling
  - Automated Backup & Restore, Operations, Upgrades
  - Operating System Patching is handled by AWS
  - Monitoring, alerting

- Note: many databases technologies could be run on EC2, but you must handle yourself the resiliency, backup, patching, high availability, fault tolerance, scaling…

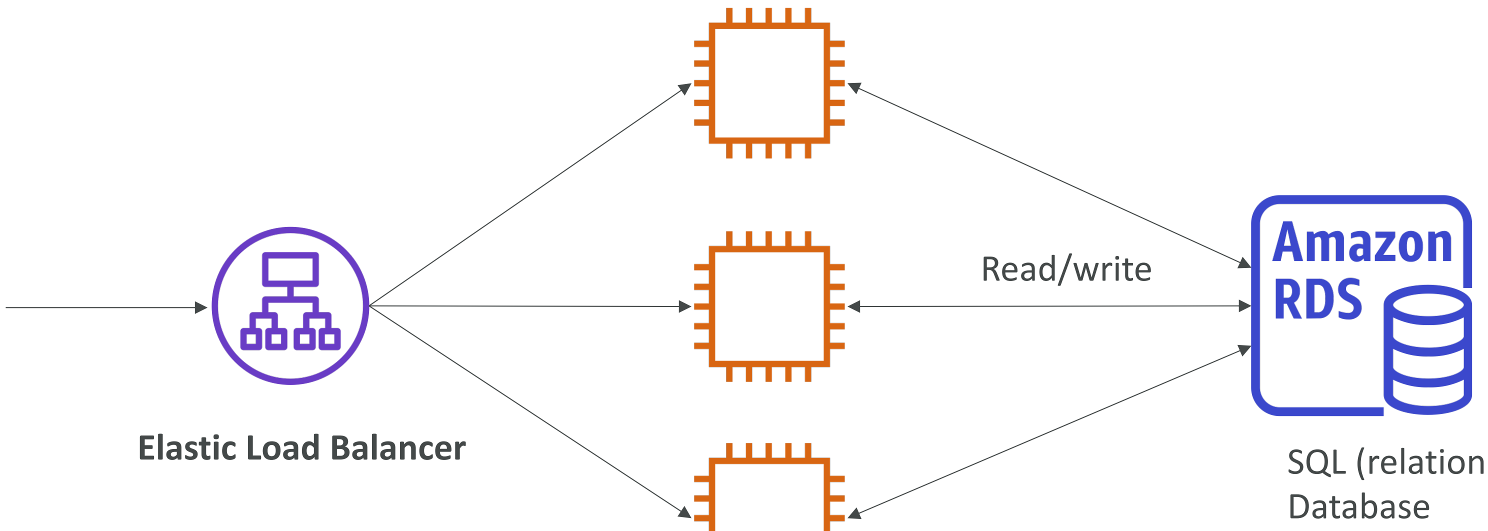
AWS RDS Overview

- RDS stands for **Relational** Database Service
- It's a managed DB service for DB use **SQL** as a query language.
- It allows you to create databases in the cloud that are managed by AWS
  - Postgres
  - MySQL
  - MariaDB
  - Oracle
  - Microsoft SQL Server
  - Aurora (AWS Proprietary database)

Advantage over using RDS versus deploying DB on EC2

- RDS is a managed service:
  - Automated provisioning, OS patching
  - Continuous backups and restore to specific timestamp (Point in Time Restore)!
  - Monitoring dashboards
  - Read replicas for improved read performance
  - Multi AZ setup for DR (Disaster Recovery)
  - Maintenance windows for upgrades
  - Scaling capability (vertical and horizontal)
  - Storage backed by EBS (gp2 or io1)
- BUT you can't SSH into your instances

RDS Solution Architecture



EC2 Instances
Possibly in an ASG

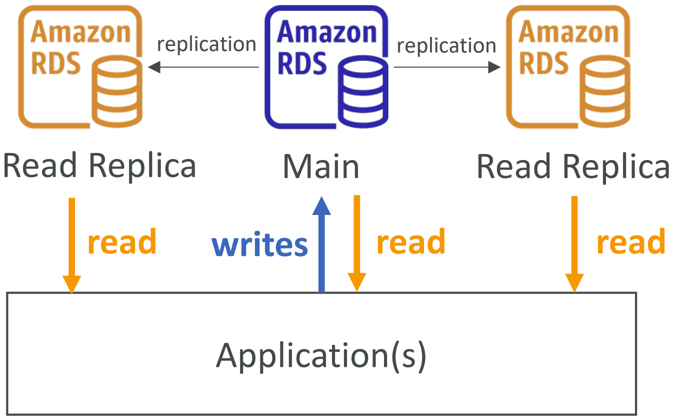
Amazon Aurora

- Aurora is a proprietary technology from AWS (not open sourced)
- **PostgreSQL and MySQL** are both supported as Aurora DB
- Aurora is "AWS cloud optimized" and claims 5x performance improvement over MySQL on RDS, over 3x the performance of Postgres on RDS
- Aurora storage automatically grows in increments of 10GB, up to 64 TB.
- Aurora costs more than RDS (20% more) – but is more efficient
- Not in the free tier

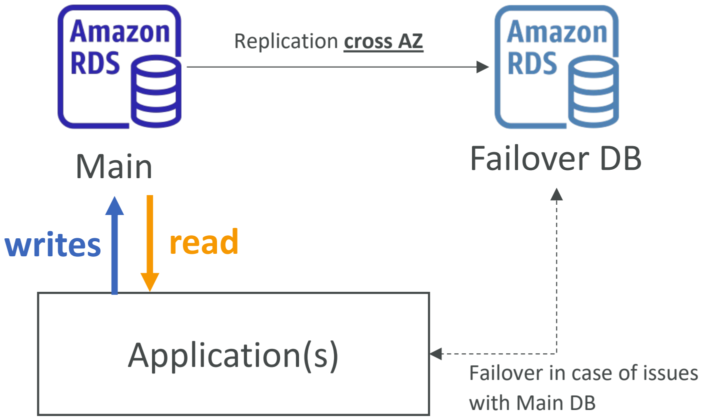
Amazon Aurora

RDS Deployments: Read Replicas, Multi-AZ

- Read Replicas:
  - **Scale** the read workload of your DB
  - Can create up to 5 Read Replicas
  - Data is only written to the main DB

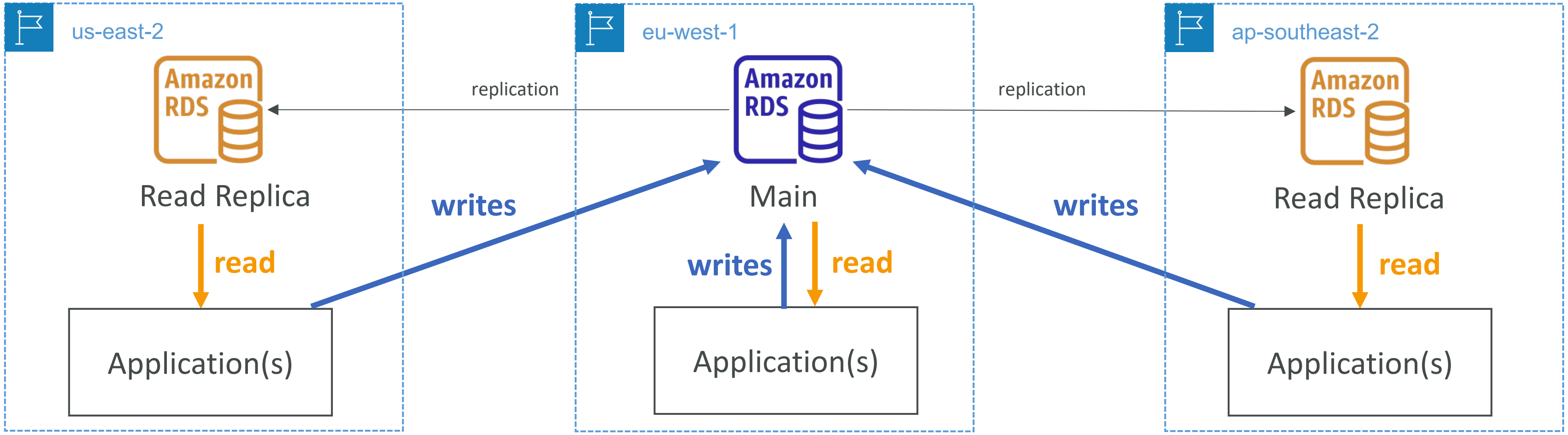


- Multi-AZ:
  - **Failover** in case of AZ outage (high availability)
  - Data is only read/written to the main database
  - Can only have 1 other AZ as failover



RDS Deployments: Multi-Region

- Multi-Region (Read Replicas)
  - **Disaster recovery** in case of region issue
  - **Local performance** for global reads
  - Replication cost

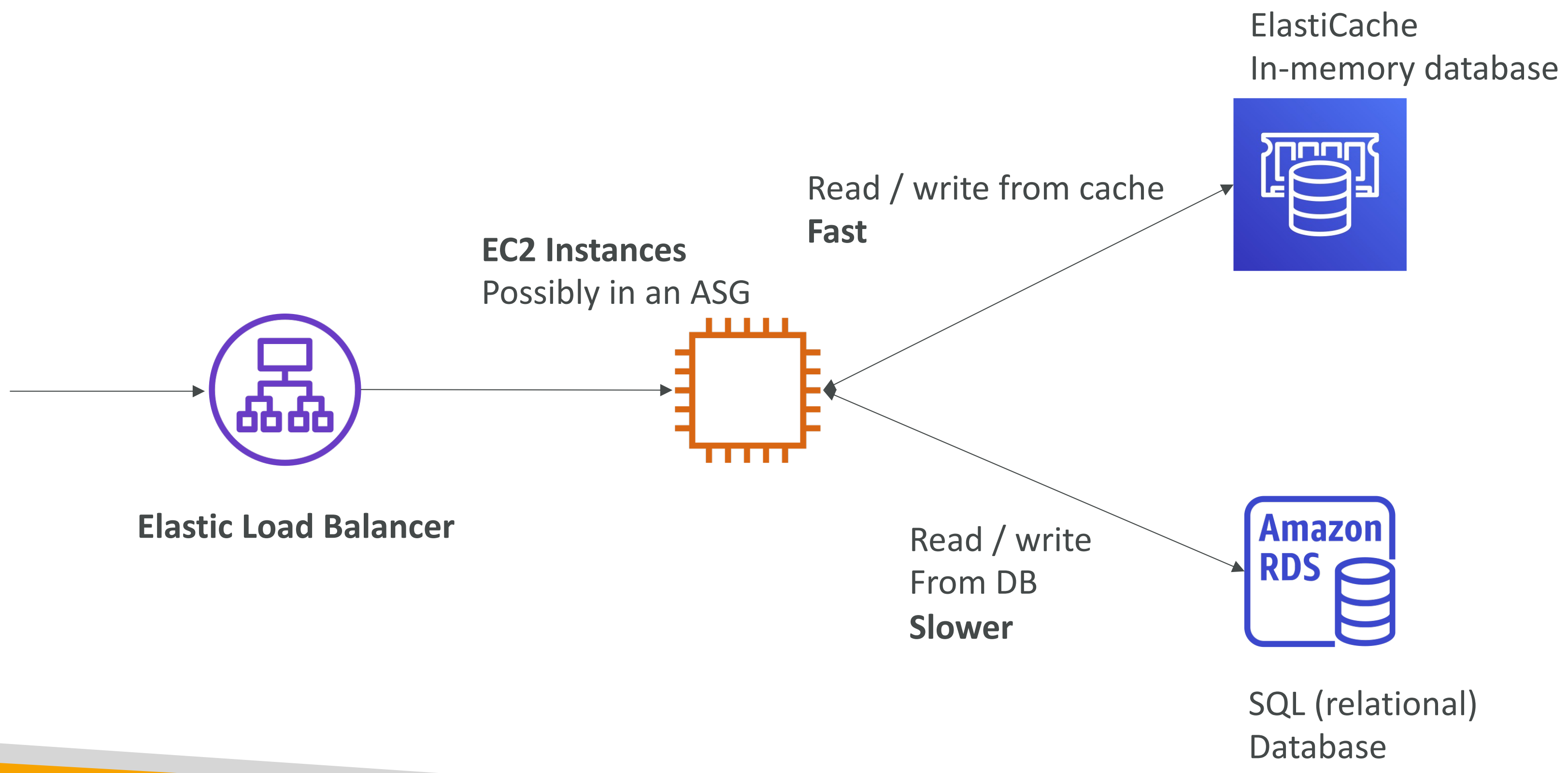


Amazon ElastiCache Overview

- The same way RDS is to get managed Relational Databases…
- ElastiCache is to get managed Redis or Memcached
- Caches are **in-memory databases** with high performance, low latency
- Helps **reduce load off databases for read intensive workloads**

- AWS takes care of OS maintenance / patching, optimizations, setup, configuration, monitoring, failure recovery and backups

ElastiCache
Solution Architecture - Cache

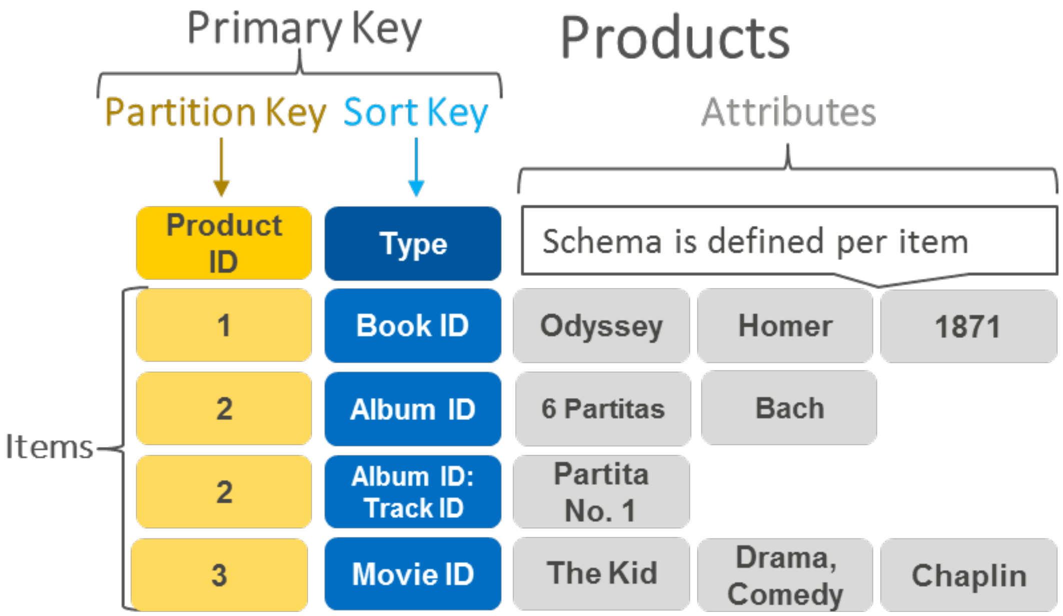


DynamoDB

- Fully Managed Highly available with replication across 3 AZ
- **NoSQL database - not a relational database**
- Scales to massive workloads, distributed "**serverless**" database
- Millions of requests per seconds, trillions of row, 100s of TB of storage
- Fast and consistent in performance
- **Single-digit millisecond latency – low latency retrieval**
- Integrated with IAM for security, authorization and administration
- Low cost and auto scaling capabilities
- Standard & Infrequent Access (IA) Table Class

DynamoDB – type of data

- DynamoDB is a key/value database



Primary Key

Products

Partition Key Sort Key

Attributes

Schema is defined per item

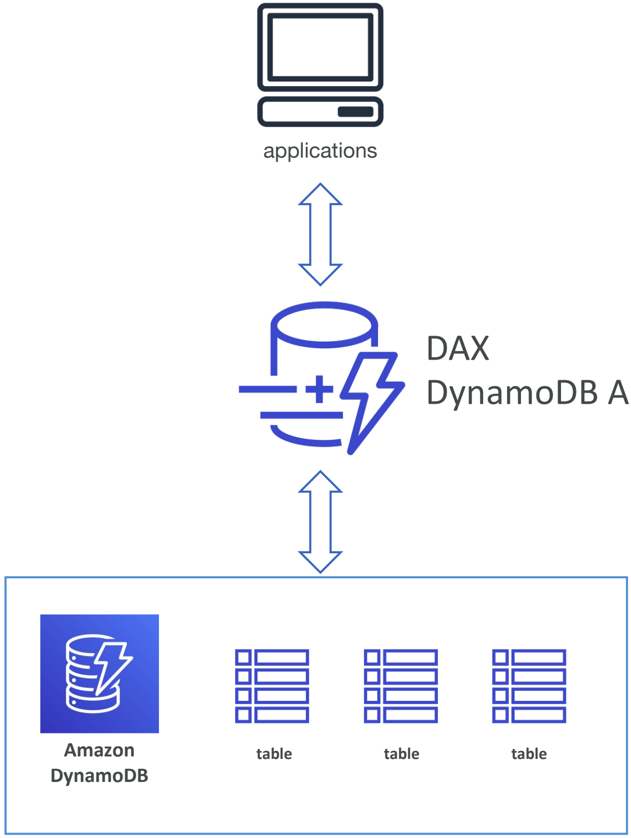
Items

Product ID	Type			
1	Book ID	Odyssey	Homer	1871
2	Album ID	6 Partitas	Bach	
2	Album ID: Track ID	Partita No. 1		
3	Movie ID	The Kid	Drama, Comedy	Chaplin

https://aws.amazon.com/nosql/key-value/

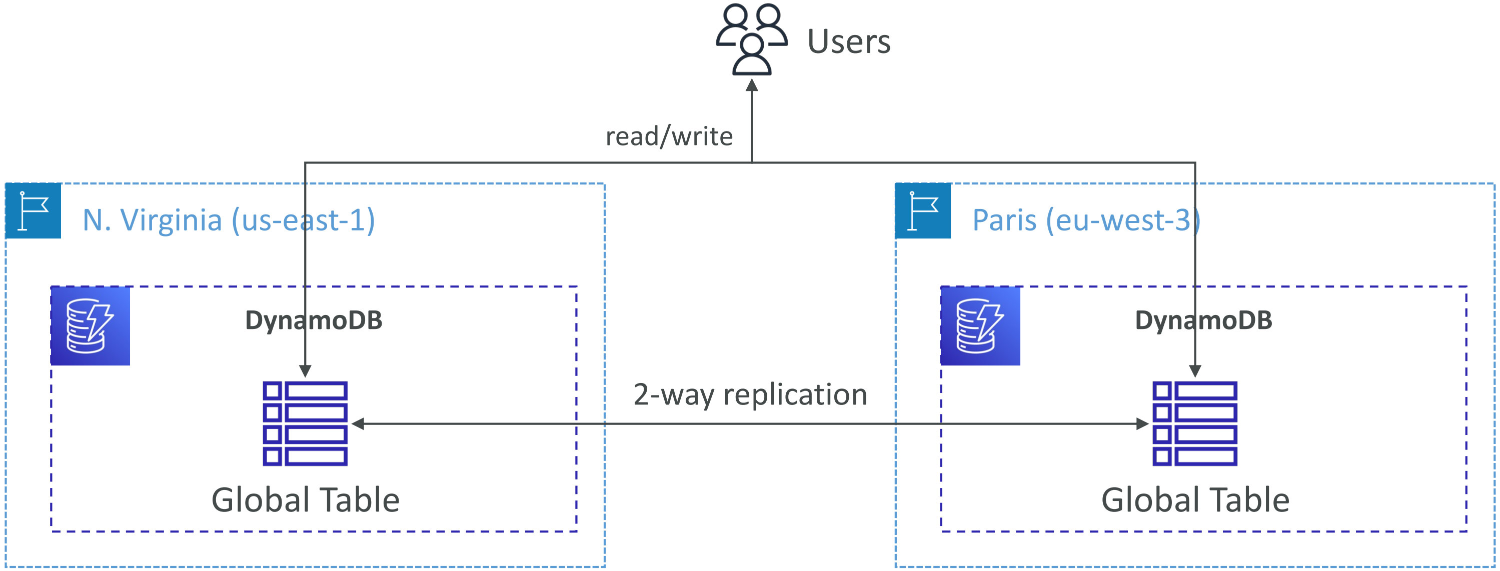
DynamoDB Accelerator - DAX

- Fully Managed **in-memory cache** for DynamoDB
- **10x performance improvement** – single-digit millisecond latency to microseconds latency – when accessing your DynamoDB tables
- Secure, highly scalable & highly available
- Difference with ElastiCache at the CCP level: **DAX is only used for and is integrated with DynamoDB**, while ElastiCache can be used for other databases



DynamoDB – Global Tables

- Make a DynamoDB table accessible with **low latency** in multiple-regions
- **Active-Active** replication (**read/write** to any AWS Region)



Redshift Overview

- Redshift is based on PostgreSQL, but **it's not used for OLTP**
- **It's OLAP – online analytical processing (analytics and data warehousing)**
- Load data once every hour, not every second
- 10x better performance than other data warehouses, scale to PBs of data
- **Columnar** storage of data (instead of row based)
- Massively Parallel Query Execution (MPP), highly available
- Pay as you go based on the instances provisioned
- Has a SQL interface for performing the queries
- BI tools such as AWS Quicksight or Tableau integrate with it

Amazon EMR

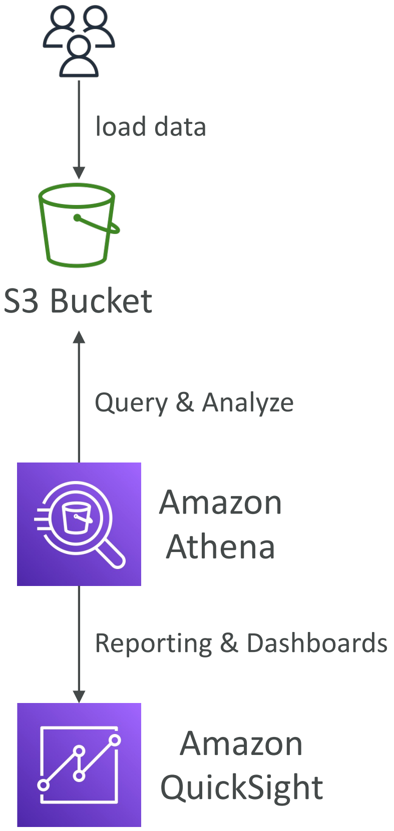
- EMR stands for "Elastic MapReduce"
- EMR helps creating **Hadoop clusters (Big Data)** to analyze and process vast amount of data
- The clusters can be made of **hundreds of EC2 instances**
- Also supports Apache Spark, HBase, Presto, Flink…
- EMR takes care of all the provisioning and configuration
- Auto-scaling and integrated with Spot instances
- **Use cases: data processing, machine learning, web indexing, big data…**

Amazon Athena

- **Serverless** query service to analyze data stored in Amazon S3
- Uses standard SQL language to query the files
- Supports CSV, JSON, ORC, Avro, and Parquet (built on Presto)
- Pricing: $5.00 per TB of data scanned
- Use compressed or columnar data for cost-savings (less scan)

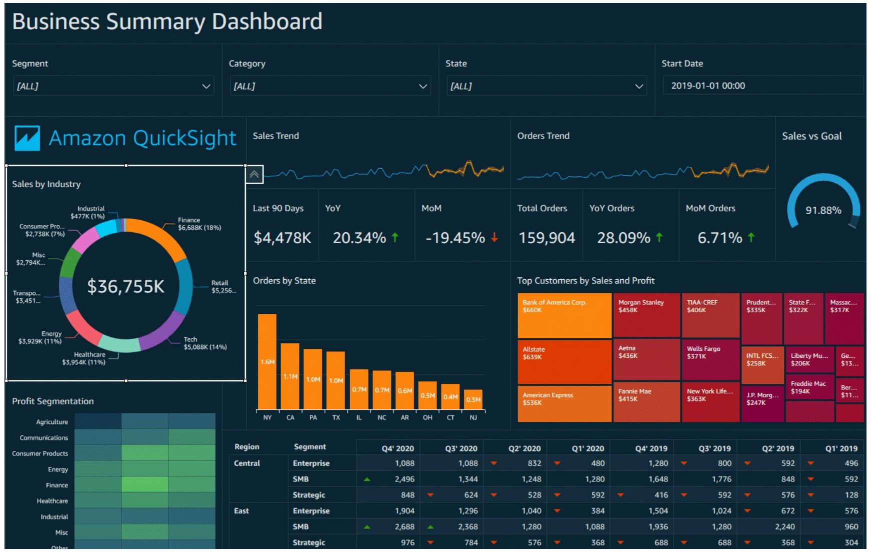
- Use cases: Business intelligence / analytics / reporting, analyze & query VPC Flow Logs, ELB Logs, CloudTrail trails, etc...

- Exam Tip: analyze data in S3 using serverless SQL, use Athena



Amazon QuickSight

- **Serverless machine learning-powered business intelligence service to create interactive dashboards**
- Fast, automatically scalable, embeddable, with per-session pricing
- Use cases:
  - Business analytics
  - Building visualizations
  - Perform ad-hoc analysis
  - Get business insights using data
- Integrated with RDS, Aurora, Athena, Redshift, S3…



Business Summary Dashboard

Segment: [ALL]

Category: [ALL]

State: [ALL]

Start Date: 2019-01-01 00:00

Amazon QuickSight

Last 90 Days	YoY	MoM	Total Orders	YoY Orders	MoM Orders
$4,478K	20.34% ↑	-19.45% ↓	159,904	28.09% ↑	6.71% ↑

Region	Segment	Q4' 2020	Q3' 2020	Q2' 2020	Q1' 2020	Q4' 2019	Q3' 2019	Q2' 2019	Q1' 2019
Central	Enterprise	1,088	1,088	▼ 832	▼ 480	1,280	▼ 800	▼ 592	▼ 496
	SMB	▲ 2,496	1,344	1,248	1,280	1,648	1,776	848	▼ 592
	Strategic	848	▼ 624	▼ 528	▼ 592	▼ 416	▼ 592	▼ 576	▼ 128
East	Enterprise	1,904	1,296	1,040	▼ 384	1,504	1,024	▼ 672	▼ 576
	SMB	▲ 2,688	▲ 2,368	1,280	1,088	1,936	1,280	2,240	960
	Strategic	976	▼ 784	▼ 576	▼ 368	▼ 688	▼ 688	▼ 368	▼ 304

https://aws.amazon.com/quicksight/

DocumentDB

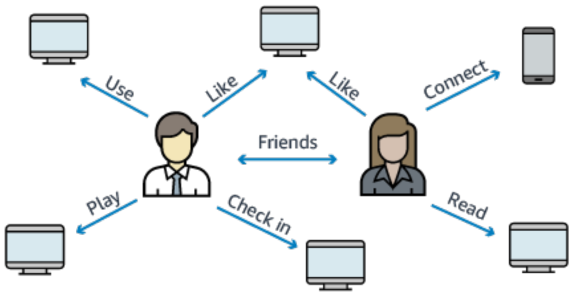
- Aurora is an "AWS-implementation" of PostgreSQL / MySQL …
- **DocumentDB is the same for MongoDB (which is a NoSQL database)**

- MongoDB is used to store, query, and index JSON data
- Similar "deployment concepts" as Aurora
- Fully Managed, highly available with replication across 3 AZ
- Aurora storage automatically grows in increments of 10GB, up to 64 TB.

- Automatically scales to workloads with millions of requests per seconds

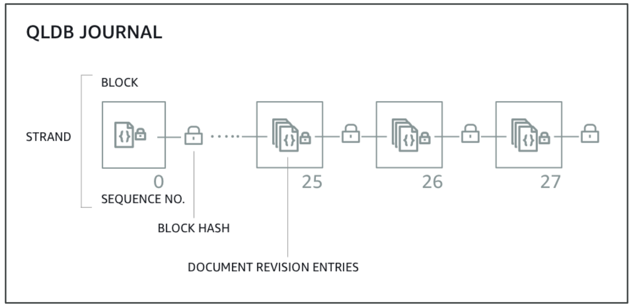
Amazon Neptune

- Fully managed **graph** database
- A popular **graph dataset** would be a **social network**
  - Users have friends
  - Posts have comments
  - Comments have likes from users
  - Users share and like posts…
- Highly available across 3 AZ, with up to 15 read replicas
- Build and run applications working with highly connected datasets – optimized for these complex and hard queries
- Can store up to billions of relations and query the graph with milliseconds latency
- Highly available with replications across multiple AZs
- Great for knowledge graphs (Wikipedia), fraud detection, recommendation engines, social networking



Amazon QLDB

- QLDB stands for "Quantum Ledger Database"
- A ledger is a book **recording financial transactions**
- Fully Managed, Serverless, High available, Replication across 3 AZ
- Used to **review history of all the changes made to your application data** over time
- **Immutable** system: no entry can be removed or modified, cryptographically verifiable



- 2-3x better performance than common ledger blockchain frameworks, manipulate data using SQL
- Difference with Amazon Managed Blockchain: **no decentralization component**, in accordance with financial regulation rules

https://docs.aws.amazon.com/qldb/latest/developerguide/ledger-structure.html

Amazon Managed Blockchain

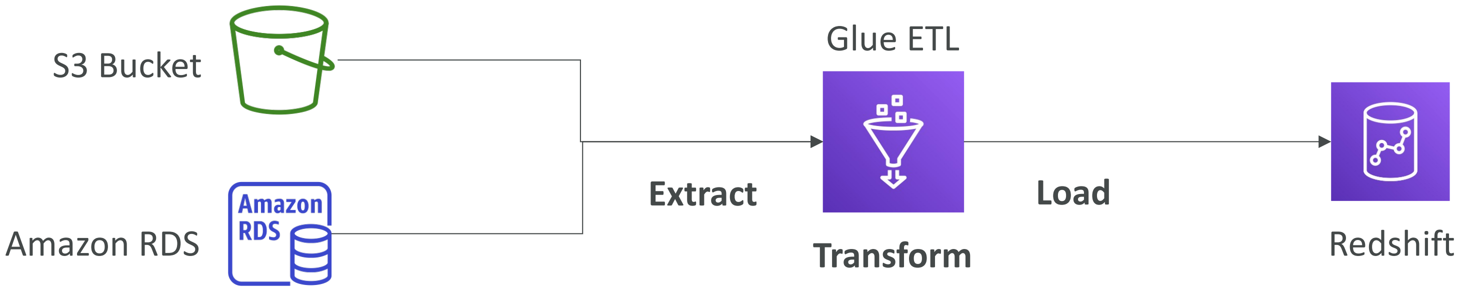
- Blockchain makes it possible to build applications where multiple parties can execute transactions **without the need for a trusted, central authority.**
- Amazon Managed Blockchain is a managed service to:
  - Join public blockchain networks
  - Or create your own scalable private network
- Compatible with the frameworks Hyperledger Fabric & Ethereum

HYPERLEDGER FABRIC

ethereum

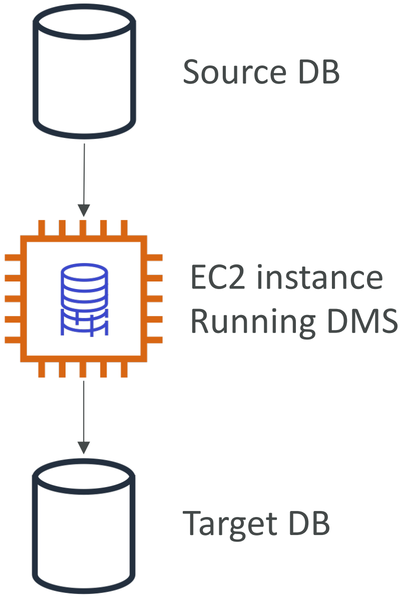
AWS Glue

- Managed **extract, transform, and load (ETL)** service
- Useful to prepare and transform data for analytics
- Fully **serverless** service



- Glue Data Catalog: catalog of datasets
  - can be used by Athena, Redshift, EMR

DMS – Database Migration Service



- Quickly and securely migrate databases to AWS, resilient, self healing
- The source database remains available during the migration
- Supports:
  - Homogeneous migrations: ex Oracle to Oracle
  - Heterogeneous migrations: ex Microsoft SQL Server to Aurora

Databases & Analytics Summary in AWS

- Relational Databases - OLTP: RDS & Aurora (SQL)
- Differences between Multi-AZ, Read Replicas, Multi-Region
- In-memory Database: ElastiCache
- Key/Value Database: DynamoDB (serverless) & DAX (cache for DynamoDB)
- Warehouse - OLAP: Redshift (SQL)
- Hadoop Cluster: EMR
- Athena: query data on Amazon S3 (serverless & SQL)
- QuickSight: dashboards on your data (serverless)
- DocumentDB: "Aurora for MongoDB" (JSON – NoSQL database)
- Amazon QLDB: Financial Transactions Ledger (immutable journal, cryptographically verifiable)
- Amazon Managed Blockchain: managed Hyperledger Fabric & Ethereum blockchains
- Glue: Managed ETL (Extract Transform Load) and Data Catalog service
- Database Migration: DMS
- Neptune: graph database