

AN INTRODUCTION TO CLOUD COMPUTING AND AMAZON WEB SERVICES

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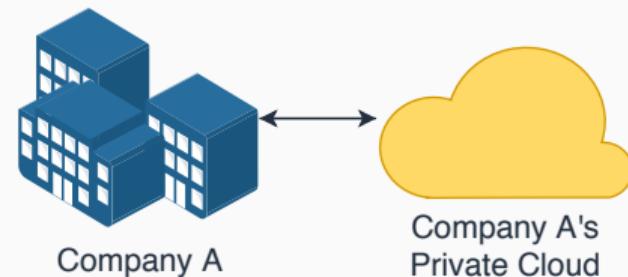
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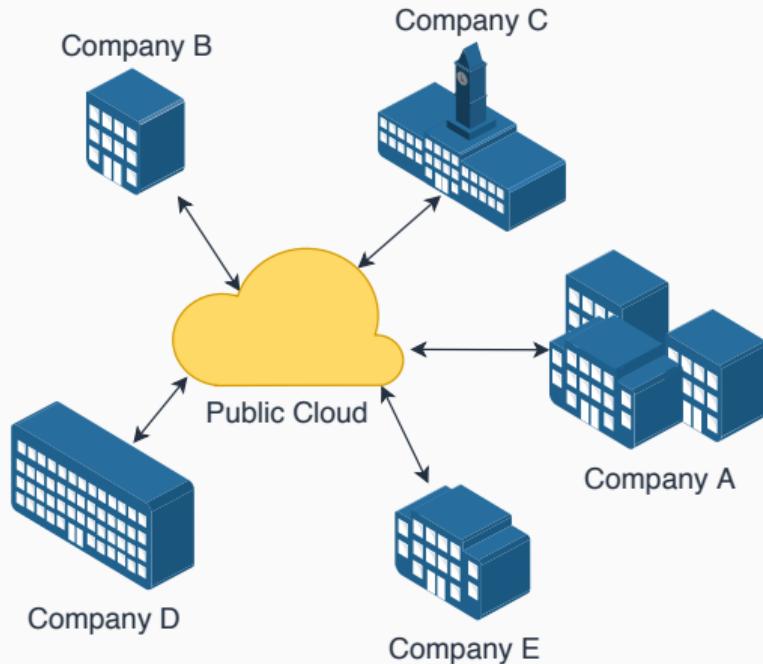
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■ Private Cloud



PRIVATE AND PUBLIC CLOUD

- Private Cloud
- Public Cloud



THE BIGWIGS IN PUBLIC CLOUD

- Google



Google Cloud

THE BIGWIGS IN PUBLIC CLOUD

- Google
- IBM



IBM Cloud

THE BIGWIGS IN PUBLIC CLOUD

- Google
- IBM
- Microsoft



THE BIGWIGS IN PUBLIC CLOUD

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- 84% of these enterprises have a multi-cloud strategy
 - they buy cloud services from different providers;
 - some of them also combine public and private clouds (**hybrid cloud** approach).

PUBLIC CLOUD ADOPTION

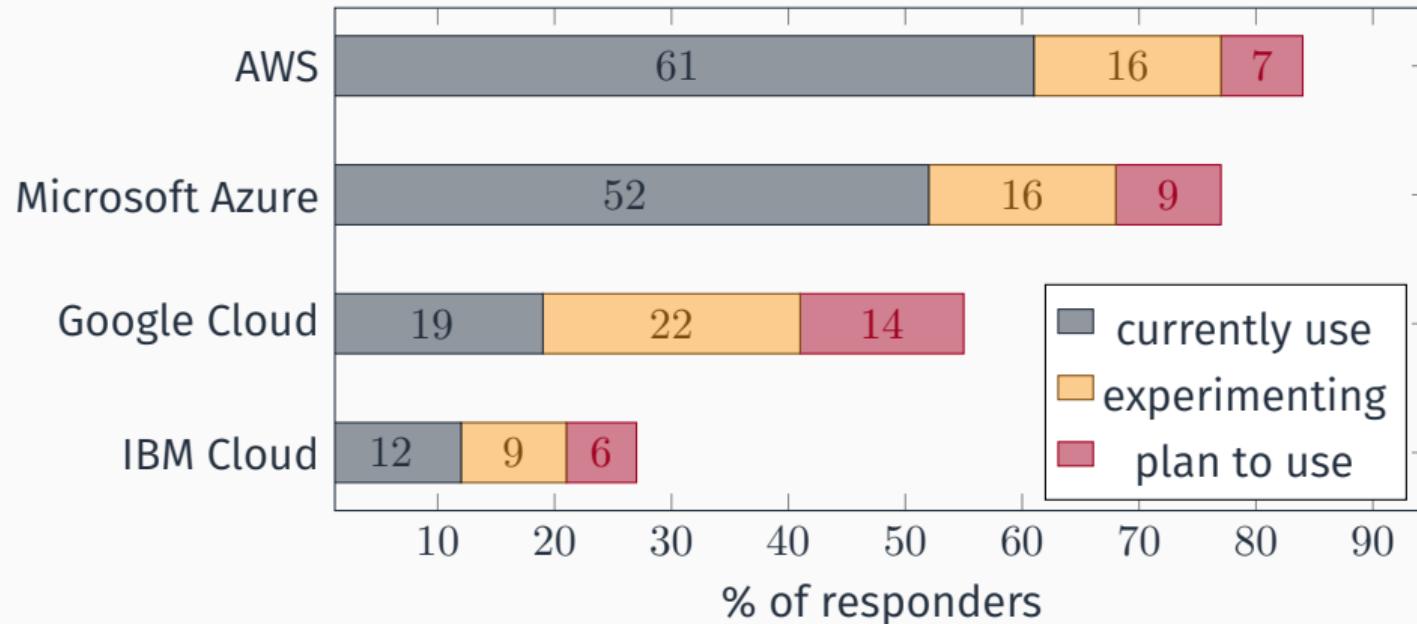


Figure 1: Public cloud adoption [Fle19]

WHY MIGHT ONE USE CLOUD COMPUTING?

Suppose you have a great business idea.

What steps do you take to start making money?

STARTING A BUSINESS: THE TRADITIONAL APPROACH

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STARTING A BUSINESS: ISSUES WITH THE TRADITIONAL APPROACH

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- **What if the estimations were wrong?**

STARTING A BUSINESS: USING CLOUD COMPUTING

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4. Pay for what you use.

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Traditional process

- ✗ High investment risk;

With Cloud Computing

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- ✓ Shorter time-to-market;
- ✗ Trust the vendor?
- ✗ Dependant from a specific vendor?

The traditional approach lacks **Elasticity**.

■ What is Elasticity?

The ability to grow or shrink infrastructure resources dynamically as needed to adapt to workload changes, possibly in an autonomic manner.

Public Cloud providers manage to offer services at very low prices, thanks to:

- Economies of scale.
- Reduced Hardware costs.
- **Huge** data centers.

Containerized data centers

<https://www.ibm.com/us-en/marketplace/prefabricated-modular-data-center>



Google data center in Hamina, Finland

<https://www.google.com/about/datacenters/locations/hamina/>



Microsoft's underwater data center

<https://news.microsoft.com/innovation-stories/project-natick-underwater-datacenter/>



- Software as a Service (SaaS)

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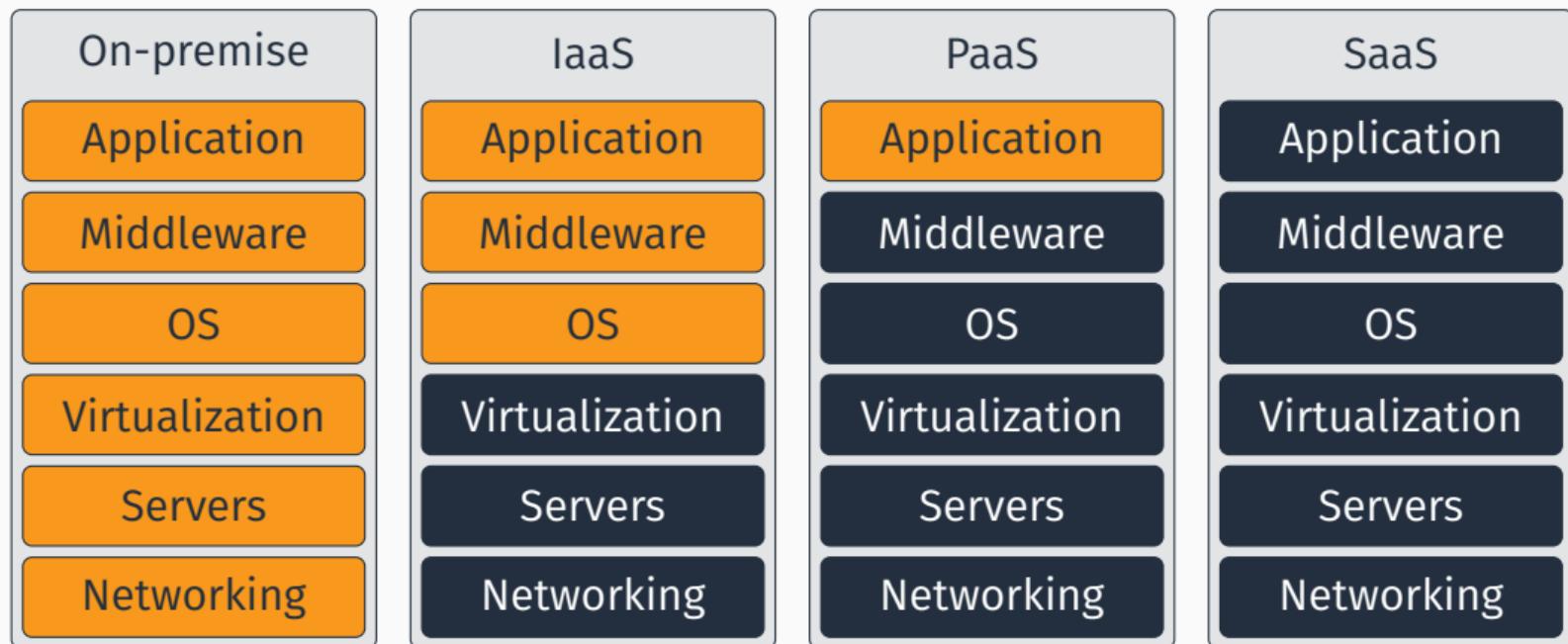
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- **Infrastructure as a Service (IaaS)**

The service vendor provides users access to computing resources such as servers, storage and networking.

SERVICE MODELS: A VISUAL COMPARISON



User manages



Someone else manages

AWS INFRASTRUCTURE

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- An availability zone can be multiple data centers, with up to hundreds of thousands of servers.
- 216 points of presence for effective caching and content delivery.



CORE AWS SERVICES



Amazon Web Services is a collection of cloud-based services.



Amazon Web Services is a collection of cloud-based services. **A very big one.**



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Periodic Table of Amazon Web Services

by [@awsgeek](#)

A athena	S3 simple storage service
Cs cloudsearch	Sg storage gateway
Gs ground station	
Mr elastic map reduce	V virtual private cloud
G glue	Bs elastic block store
Analytics	Amplify
Application Integration	Amplify
AR & VR	Virtual Private Cloud
AWS Cost Management	CloudFront
Blockchain	Cr cloudfront
Business Applications	Fs elastic file system
Compute	S3 simple storage service
Customer Engagement	Sg storage gateway
Database	
Developer Tools	
End User Computing	
Mobile	
Game Tech	
Internet of Things	
Machine Learning	
Media Services	
Migration & Transfer	
Management & Governance	
Network & Content Delivery	
Robotics	
Satellite	
Storage	
Security, Identity & Compliance	
Wa well-architected tool	Lm license manager
Lm license manager	Et elastic transcoder
Et elastic transcoder	Mh migration hub
Mh migration hub	Am amplify
Am amplify	V virtual private cloud
V virtual private cloud	Bs elastic block store
Bs elastic block store	Cr cloudfront
Cr cloudfront	Fs elastic file system
Ad application discovery service	S3 simple storage service
Ag app gateway	Po pinpoint
Po pinpoint	53 route 53
53 route 53	Fx fsx for lustre
Es elasticsearch	As appsync
Lf lake formation	Fw fsx for windows file server
Ce cost explorer	Pl vpc privatelab
Ax amazon for business	Gl s3 glacier
Cs elastic container service	
L lambda	
Co connect	
Cb codebuild	
Au aurora	
Ds dynamodb	
I iot core	
Dd iot device defender	
Ac auto scaling	
Ms managed services	
Mc elemental mediaconnect	
Dm iot device management	
Cf cloudformation	
Ow opsworks	
Mv elemental mediavoice	
Ds datasync	
As appsync	
Kinesis	
SF step functions	
Bu budgets	
Ch chime	
Ks elastic kinesis stream for lambda	
O outposts	
Pi pinpoint	
Cc codecommit	
D dynamodb	
Rs redshift	
Os iot freeRTOS	
Dm iot device management	
Cf cloudformation	
Ow opsworks	
Mv elemental mediavoice	
Ds datasync	
As appsync	
Ka managed streaming for kafka	
Mq activemq	
Cu cost & usage report	
Wm workmail	
Ls lightsail	
Sa serverless application repository	
E single sign-on service	
Cd codedeploy	
Do documentdb	
Ti timestream	
Gg iot greengrass	
Ev iot events	
Ct cloudtrail	
Ph personal health dashboard	
MI elemental mediavoice	
Sm server migration service	
Df device farm	
Am App Mesh	
R redshift	
N simple notification service	
Ri reserved instance reporting	
C elastic cloud compute	
Ba batch	
Lb elastic load balancing	
Cs codestar	
Cp codepipeline	
Ec elasticache	
Ms database migration service	
Ic iot 1-click	
Sw iot sitewise	
Co config	
Sc service catalog	
Mp elemental mediapackage	
Sn snow family	
Ga global accelerator	
Cm cloud map	
Ba backup	
Qs quicksight	
Q simple queue service	
Bc managed blockchain	
Au elastic auto scaling	
Eb elastic beanstalk	
Vm vmware cloud on aws	
Co corretto	
Cli command line interface	
Ne neptune	
Gl gamelift	
An iot analytics	
Tg iot things graph	
Ct control tower	
Sm systems manager	
Ms elemental mediastore	
Sf transfer for sftp	
Tg transit gateway	
Dc direct connect	
Sn snow family	
Dp data pipeline	
Ap appsync	
Su sumerian	
Cr elastic container registry	
F fargate	
Rm remastered	
Cg cloud9	
Sd tools & skills	
Oi quantum ledger db	
Ly lumberyard	
Bu int button	
Dc iot partner device catalog	
Cm console mobile app	
Ta trusted advisor	
Mt elemental mediastore	
Wd workdocs	
Wo worklink	
Ws workspaces	
As appstream 2.0	
Sm sagemaker	
Co comprehend	
Ei elastic inference	
Fc forecast	
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Pe personalize	
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Rk recognition	
Gt semantic ground truth	
Tx textract	
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Ta transcribe	
DI deep learning studio	
DI deepinsights	
Dr deepspeech	
If inferentia	
Mx apache maxcompute on aws	
Tf textractorflow on aws	
Im identity & access management	
Cd cloud directory	
Co cognito	
Gd guardduty	
I inspector	
M macie	
Ar artifact	
Cm certificate manager	
Hs cloudhsm	
Ds directory service	
Fm firewall manager	
Km key management service	
O organizations	
Sm secrets manager	
Sh security hub	
S shield	
Ss single sign-on	
Wf web application firewall	

CORE AWS SERVICES

COMPUTING AND STORAGE

AMAZON ELASTIC COMPUTE CLOUD (EC2)

- (Virtual) Servers on demand



EC2 pricing [↗ web](#)

Azure: Virtual Machines [↗ web](#)

Google Cloud: Compute Engine [↗ web](#)

AMAZON ELASTIC COMPUTE CLOUD (EC2)

- (Virtual) Servers on demand
- Different types of instances to suit computing needs



EC2 pricing [↗ web](#)

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AMAZON ELASTIC COMPUTE CLOUD (EC2)

- (Virtual) Servers on demand
- Different types of instances to suit computing needs
- Per-second (or per-hour) billing



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- Persistent storage **not** included!
- Elasticity **not** included!

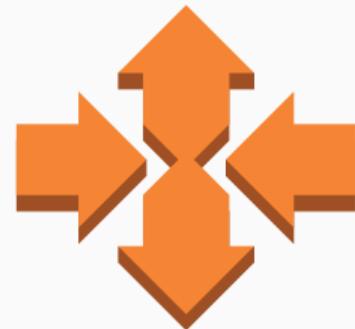


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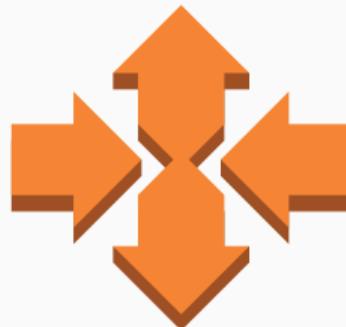
- *Scaling is the ability to increase or decrease the compute capacity of your application*



Azure: Virtual Machine Scale Sets [\[web\]](#)
Google Cloud: Load Balancing [\[web\]](#)

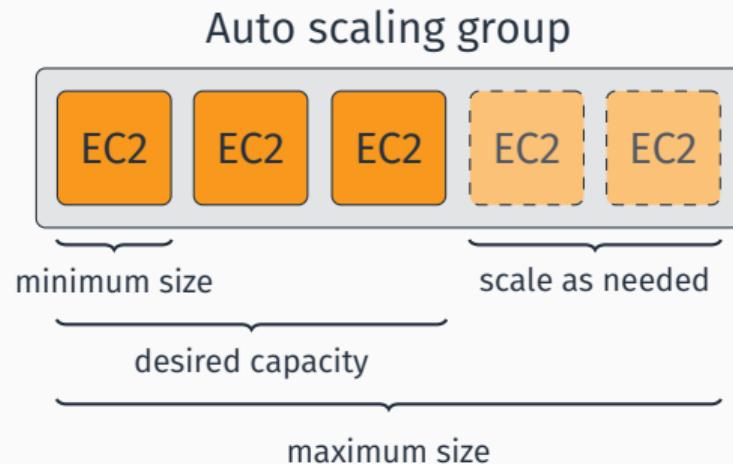
AMAZON EC2 AUTO SCALING

- *Scaling is the ability to increase or decrease the compute capacity of your application*
- Scale your application manually, on a scheduled basis or on demand



Azure: Virtual Machine Scale Sets  web
Google Cloud: Load Balancing  web

AMAZON EC2 AUTO SCALING: DETAILS



AMAZON ELASTIC LOAD BALANCING (ELB)

- Distributes incoming traffic across multiple EC2 instances



Azure: Load Balancer  web

AMAZON ELASTIC LOAD BALANCING (ELB)

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- Pay-per-use billing



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AMAZON ELASTIC LOAD BALANCING (ELB)

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- Pay-per-use billing
 - Execution time



Azure: Load Balancer  web

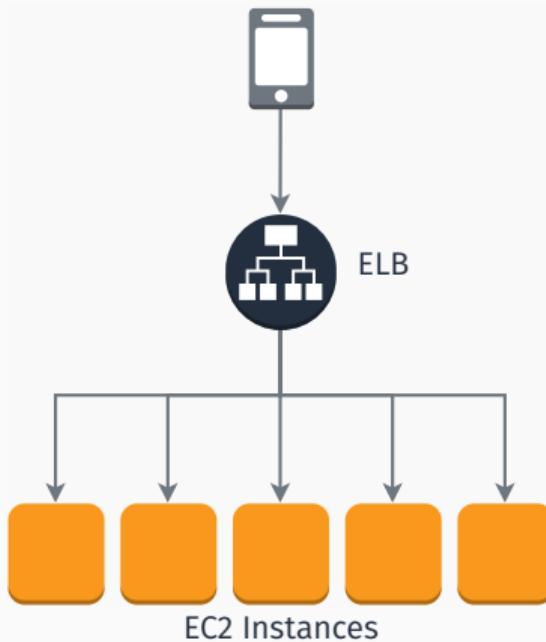
AMAZON ELASTIC LOAD BALANCING (ELB)

- Distributes incoming traffic across multiple EC2 instances
- Pay-per-use billing
 - Execution time
 - Number of requests / traffic

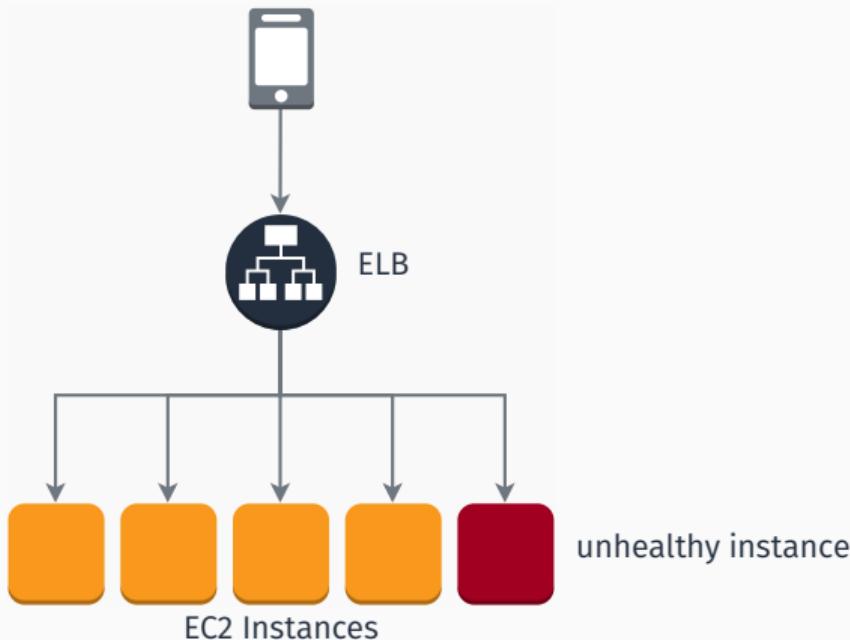


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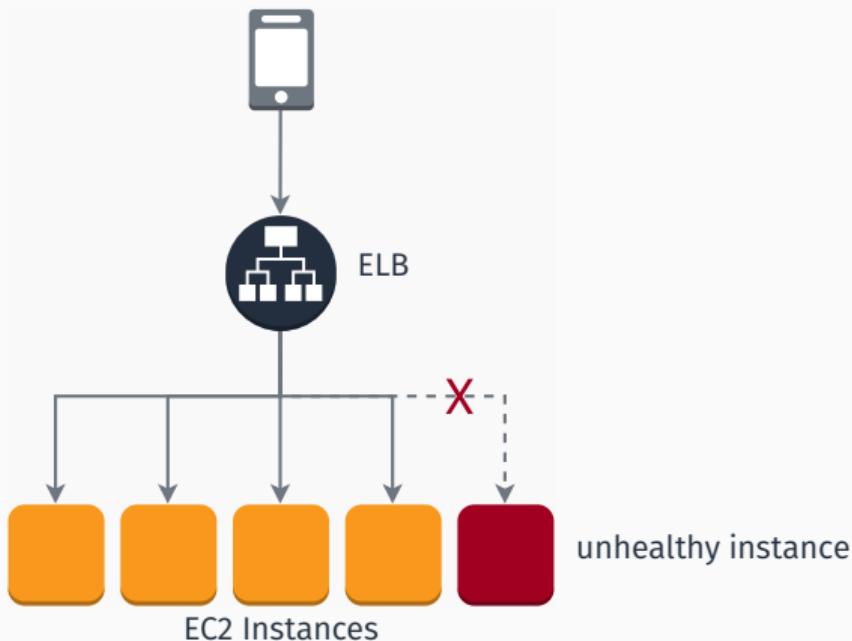
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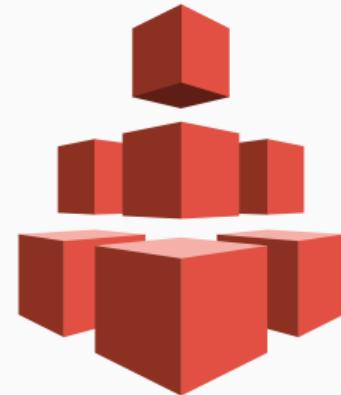
CLOUD STORAGE PRODUCTS

- Elastic Block Storage (EBS)
 - Persistent local storage for EC2 instances.

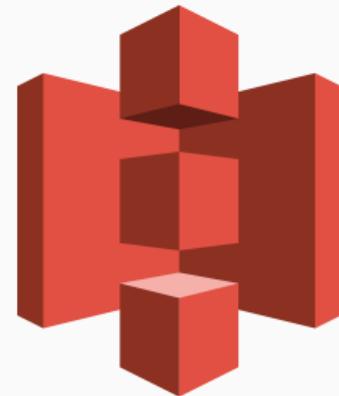


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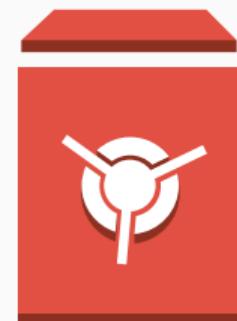


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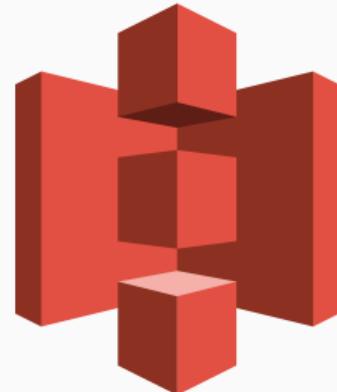
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 - Durable and cheap long-term storage.



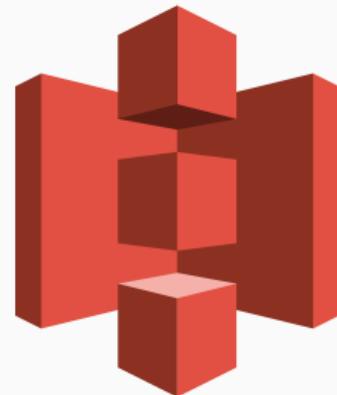
AMAZON SIMPLE STORAGE SERVICE (S3)

- *store and retrieve any amount of data from anywhere*



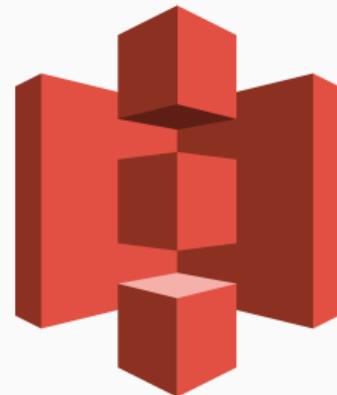
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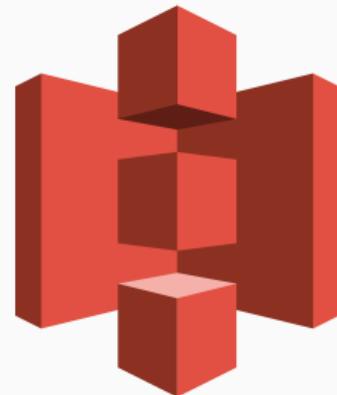
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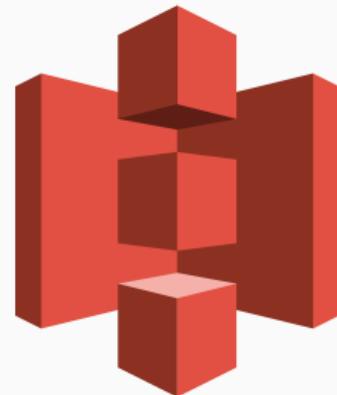
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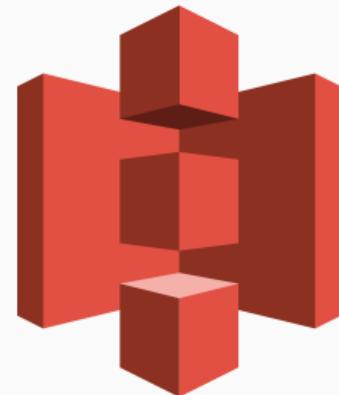
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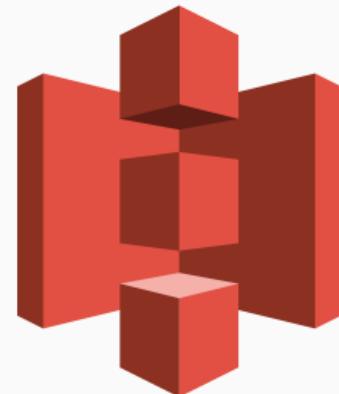
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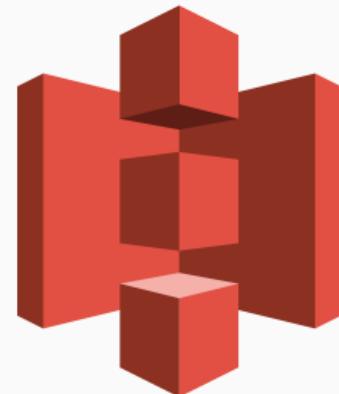
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 - Infrequent Access



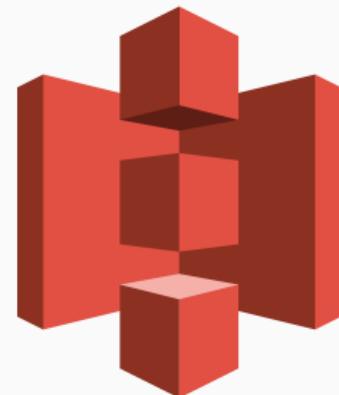
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 - Infrequent Access
 - One zone-Infrequent Access



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 - Standard
 - Infrequent Access
 - One zone-Infrequent Access
 - Amazon Glacier



AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

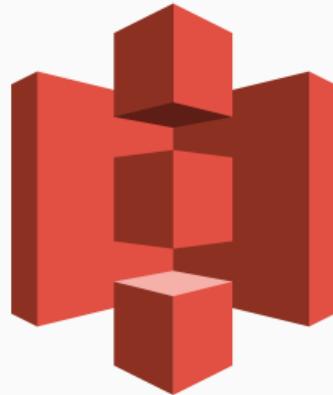
Pricing:

Storage class	Storage (per month)	Retrieval (per 1K req.)
Standard	\$0.022 per GB	\$0.0004
Infrequent access	\$0.0125 per GB	\$0.001
IA single zone	\$0.01 per GB	\$0.001
Glacier	\$0.004 per GB	\$0.0004

Table 1: S3 pricing (Ireland)

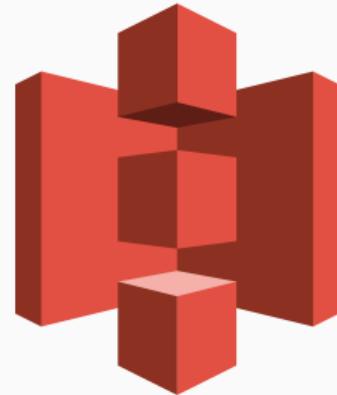
AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

- Well-integrated with other services



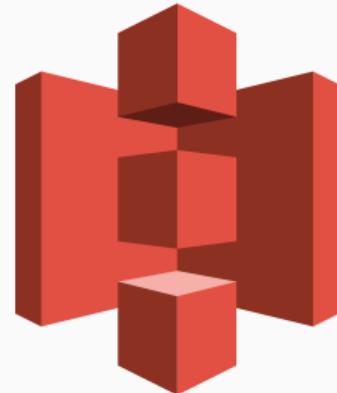
AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

- Well-integrated with other services
 - Machine Learning



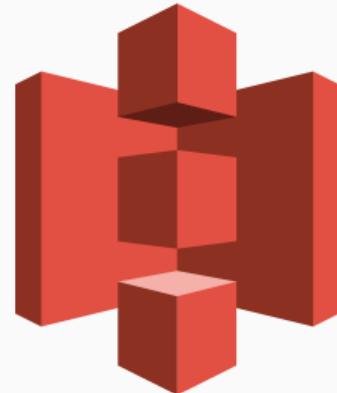
AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

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 - Machine Learning
 - Big Data Analysis



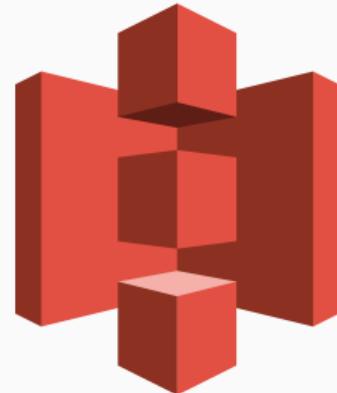
AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

- Well-integrated with other services
 - Machine Learning
 - Big Data Analysis
- REST API

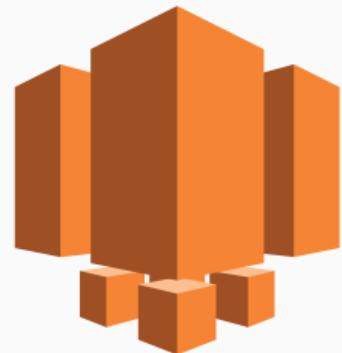


AMAZON SIMPLE STORAGE SERVICE (S3) - MORE

- Well-integrated with other services
 - Machine Learning
 - Big Data Analysis
- REST API
- Can be used to host static websites



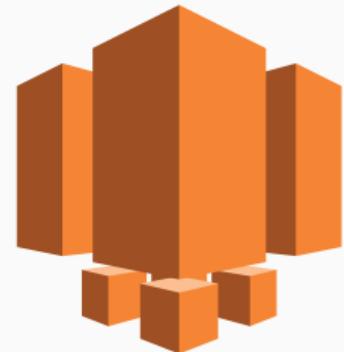
- A lightweight, simplified offer



Websites: [EC2](#) [Lightsail](#)

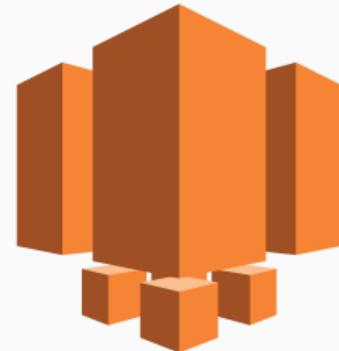
AMAZON LIGHTSAIL

- A lightweight, simplified offer
- Bundles computing, storage, and networking capacity



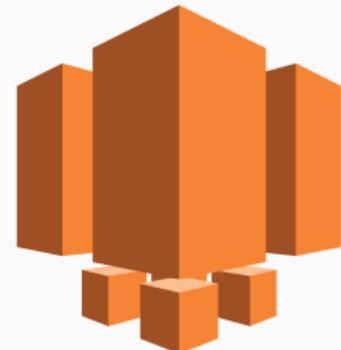
Websites: [EC2](#) [Lightsail](#)

- A lightweight, simplified offer
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- Preconfigured instances for



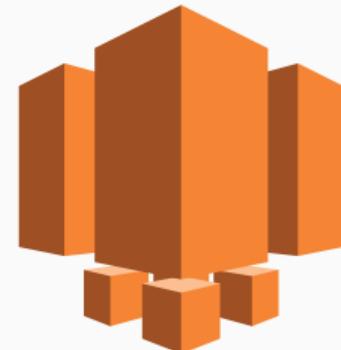
Websites: [EC2](#) [Lightsail](#)

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- Bundles computing, storage, and networking capacity
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 - Debian, Windows Server, ...



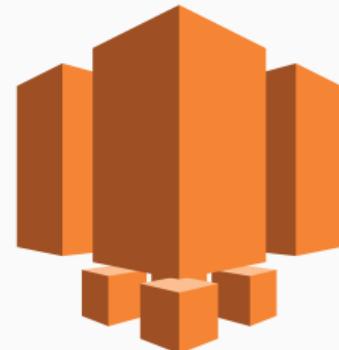
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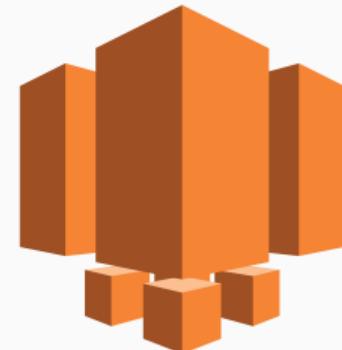
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 - LAMP stack, Nginx, ...



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- A lightweight, simplified offer
- Bundles computing, storage, and networking capacity
- Preconfigured instances for
 - Debian, Windows Server, ...
 - Wordpress, Magento, Redmine, ...
 - LAMP stack, Nginx, ...
- Low and **predictable** monthly costs



Websites: [EC2](#) [Lightsail](#)

AMAZON ELASTIC BEANSTALK

- “Easy to begin, impossible to outgrow”



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- “*Easy to begin, impossible to outgrow*”
- Easy-to-use service to deploy web apps



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- Easy-to-use service to deploy web apps
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- Manages auto-scaling, load balancing, health monitoring
- Customizable
- Free of charge. Pay only for the AWS resources you use.



CORE AWS SERVICES

DATABASE SERVICES

RELATIONAL DATABASE SERVICE (RDS)

- Set up, operate a relational database in the cloud.



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- Takes care of backups, patching.



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 - Amazon Aurora



NON RELATIONAL DATABASE SERVICES

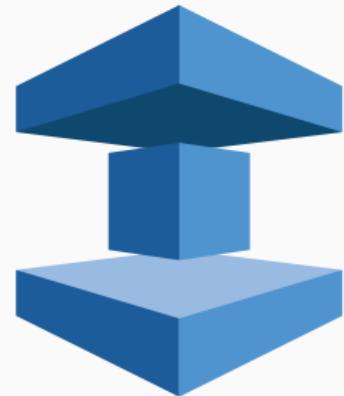
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- *Fast and flexible NoSQL database service for any scale.*



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 - In memory data store.
 - Supports memcached, Redis



NON RELATIONAL DATABASE SERVICES

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 - *Fast and flexible NoSQL database service for any scale.*
- ElastiCache
 - In memory data store.
 - Supports memcached, Redis
- Neptune
 - Graph database service
 - Supports RDF, SPARQL, ...



CORE AWS SERVICES

DEVELOPER TOOLS

- CodeCommit



- CodeCommit
 - Managed, scalable, private *git* server



■ CodeCommit

- Managed, scalable, private *git* server
- Pricing based on active users (5 free, 1\$ for each additional user)



- CodeStar



- CodeStar
 - Wrapper around developer tools to simplify setup



- CodeStar

- Wrapper around developer tools to simplify setup
- Templates



- CodeStar

- Wrapper around developer tools to simplify setup
- Templates
- Team Management



■ CodeStar

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- Templates
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- Central Project Dashboard



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- Cloud9

- Cloud-based full-fledged IDE



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- Cloud-based full-fledged IDE
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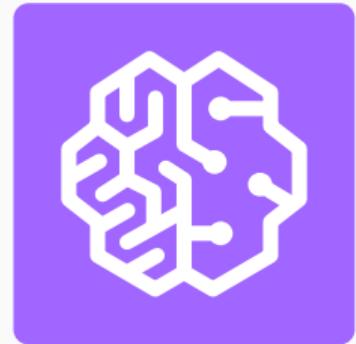


CORE AWS SERVICES

MACHINE LEARNING: APPLICATION SERVICES

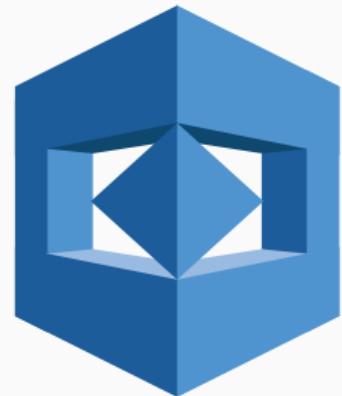
MACHINE LEARNING: APPLICATION SERVICES

- Comprehend (for NLP) [!\[\]\(3d2680bcb75a0931a87e144794fbf5fb_img.jpg\) website](#)



MACHINE LEARNING: APPLICATION SERVICES

- Comprehend (for NLP) [website](#)
- Rekognition (Visual Analysis) [website](#)



MACHINE LEARNING: APPLICATION SERVICES

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- Rekognition (Visual Analysis) [!\[\]\(f0c223996a152397b515d5b97a38c184_img.jpg\) website](#)
- Translate

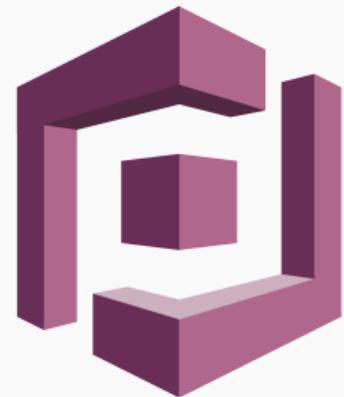
- Comprehend (for NLP) [!\[\]\(b94f71ec5b9e9720ad3def35f2f73163_img.jpg\) website](#)
- Rekognition (Visual Analysis) [!\[\]\(e385ffb9209d89fd96f4da755edc0038_img.jpg\) website](#)
- Translate
- Polly (text-to-speech)

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- Rekognition (Visual Analysis) [!\[\]\(e1298da5ad7a3f27ee5e4d867cb2bc0d_img.jpg\) website](#)
- Translate
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- Transcribe (speech-to-text)

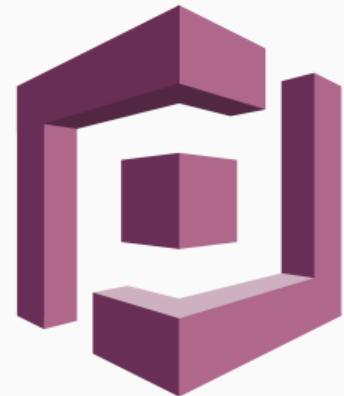
CORE AWS SERVICES

MISCELLANEA

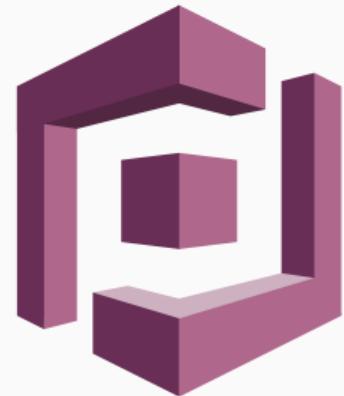
- Cognito



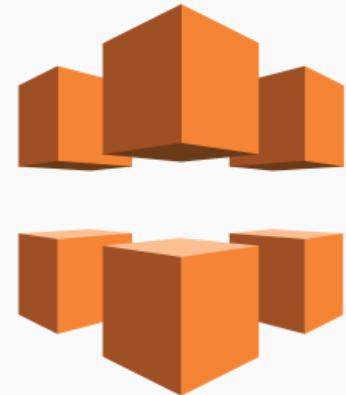
- Cognito
 - Sign-up and authentication



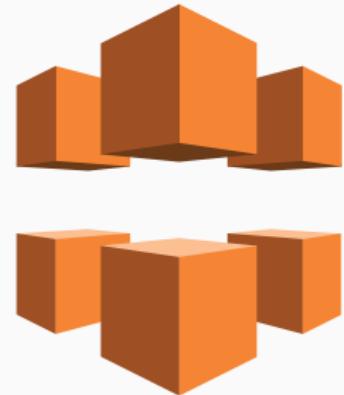
- Cognito
 - Sign-up and authentication
 - Federated identities



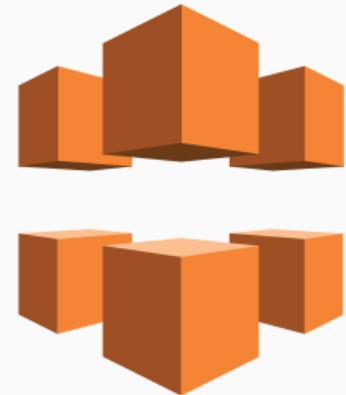
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- Cognito
 - Sign-up and authentication
 - Federated identities
- CloudFront
 - Content Delivery Network



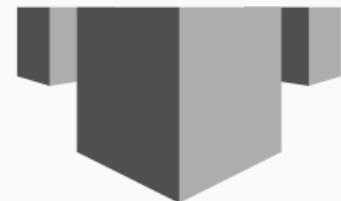
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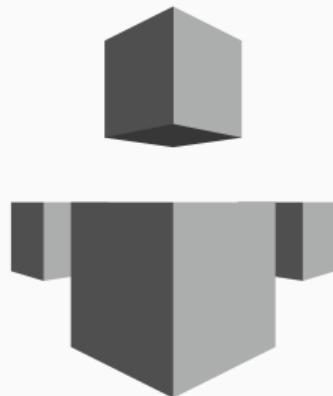
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- Mechanical Turk



- ???

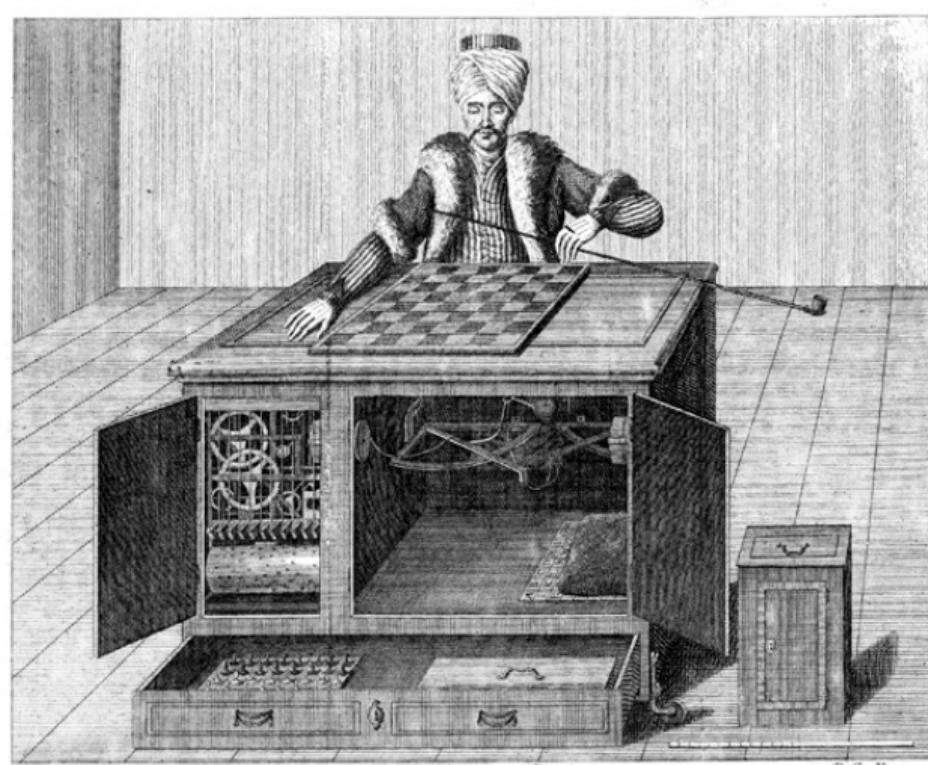


THE TURK

The Turk was a chess-playing automaton built in 1770.

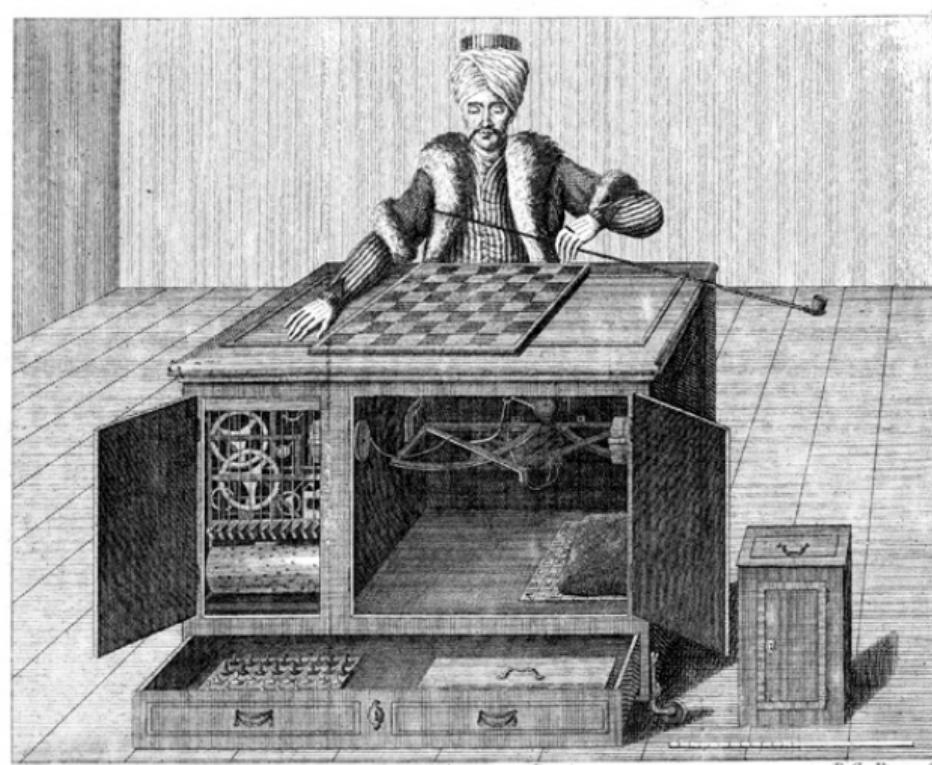
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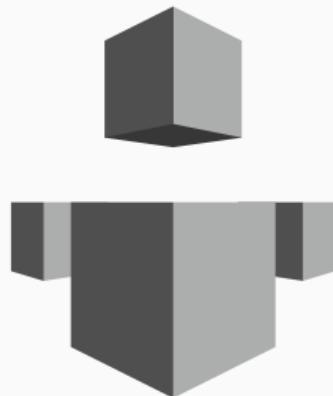


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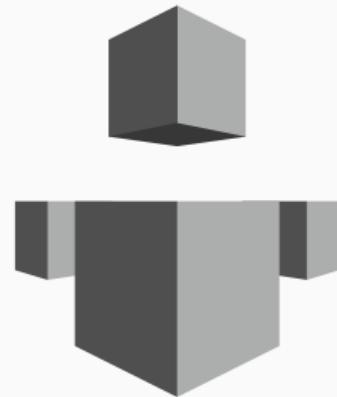
The Turk was a chess-playing automaton built in 1770. Obviously it was a fraud.



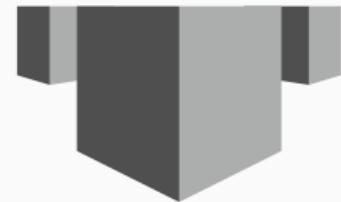
- ???



- Human Intelligence through an API



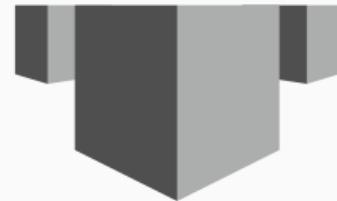
- Human Intelligence through an API
- Create HIT (Human Intelligence Task)



- Human Intelligence through an API
- Create HIT (Human Intelligence Task)
- Elastic, on-demand workforce



- Human Intelligence through an API
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Practice time!

SCENARIO

- You just had a million dollar idea.

SCENARIO

- You just had a million dollar idea.
- Your web application is finished. It looks great and works like a charm.

SCENARIO

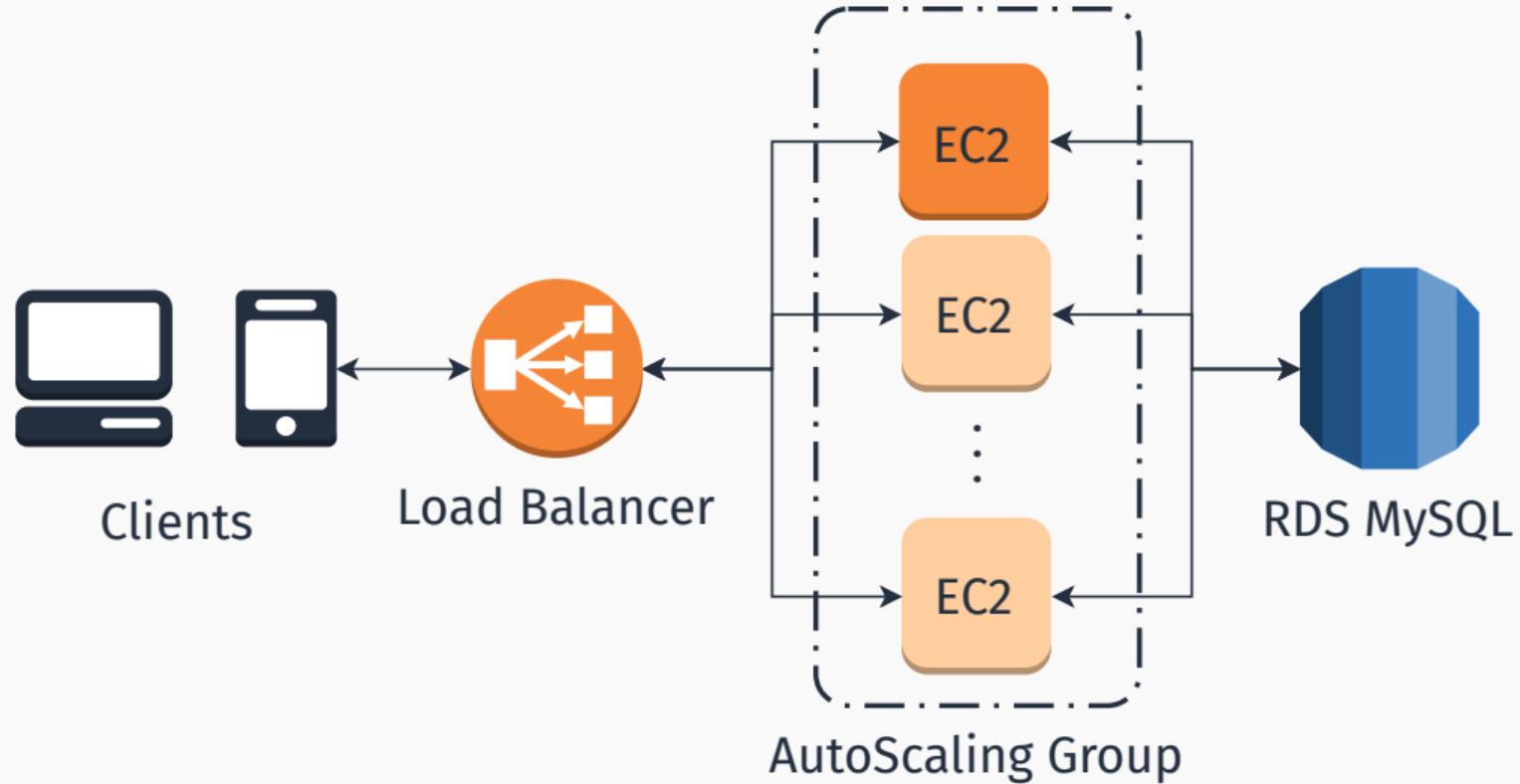
- You just had a million dollar idea.
- Your web application is finished. It looks great and works like a charm.
- You're ready to start earning some dough!

The web app is built with a classic LAMP stack:

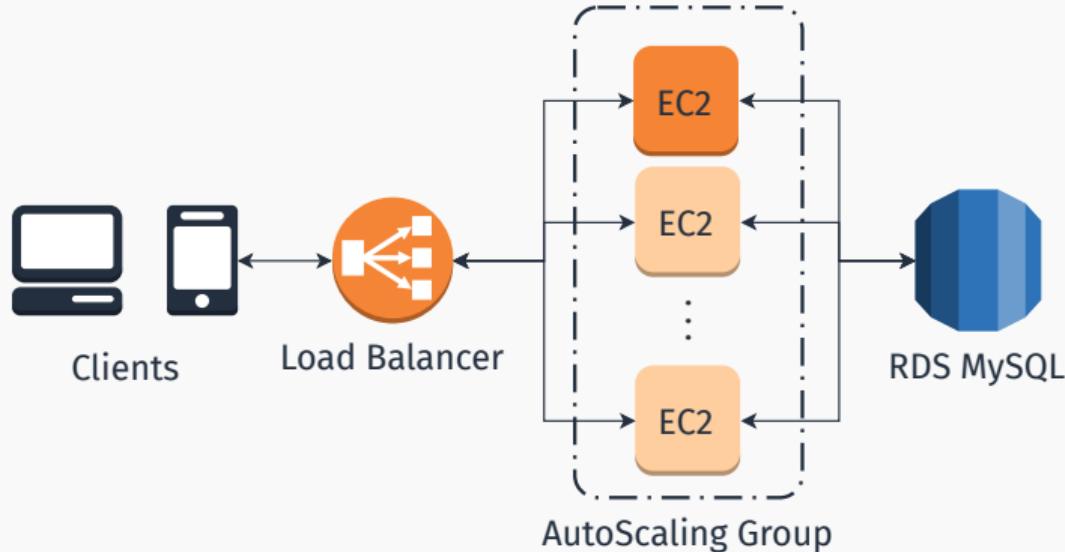
- Linux
- Apache web server
- MySQL relational database
- PHP

How WOULD YOU DO IT?

PROPOSED ARCHITECTURE



PROPOSED ARCHITECTURE



- Is this *really* scalable?

TAKE HOME MESSAGES

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- Cloud computing and service models

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- Core AWS services:

TAKE HOME MESSAGES

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TAKE HOME MESSAGES

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 - Machine Learning - Application Services: Comprehend, Rekognition;
 - Others: Cognito, MechanicalTurk
- A cloud architecture for a classic web application on AWS

ANY QUESTIONS?

REFERENCES I

- [Fle19] Flexera. *Cloud Computing Trends: 2019 State of the Cloud Survey*. Feb. 27, 2019. URL:
<https://www.flexera.com/blog/cloud/2019/02/cloud-computing-trends-2019-state-of-the-cloud-survey/>
(visited on 03/21/2020).