

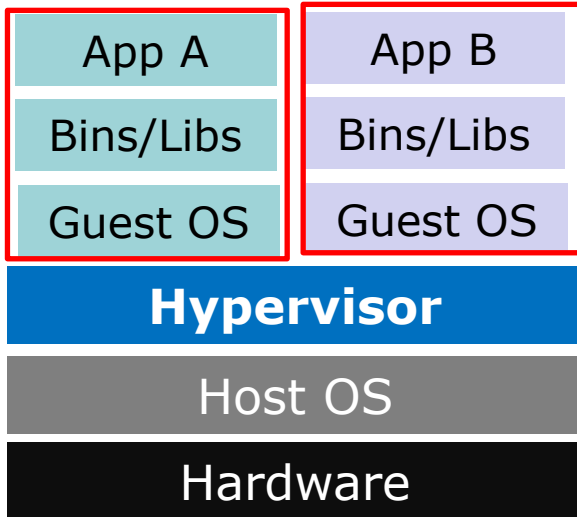
Infrastructure as a Service (IaaS)

Antonio Brogi

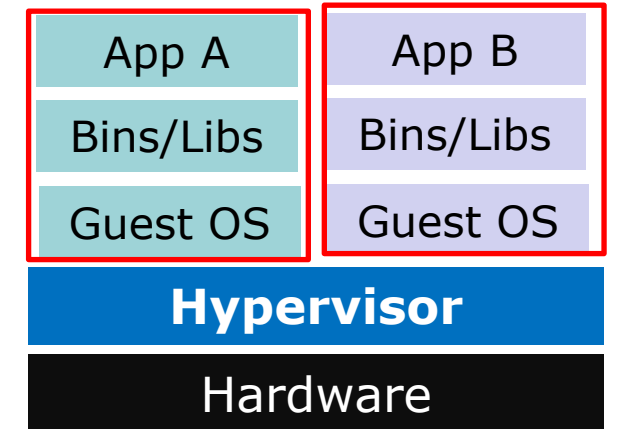
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University of Pisa

Server virtualization & hypervisors

Server Virtualization & Hypervisors



The **hypervisor** creates a virtualization layer that allows a server to run multiple guest **virtual machines**



Two **types** of hypervisors

“Type 2”

- loaded on OS running on the HW
- lower consolidation ratio
- for desktop/laptop

“Type 1”

- loaded directly on the HW
- higher consolidation ratio
- for datacenters

(consolidation ratio = #VMs that can run on physical server)

Ok but ... where is the cloud?



Server virtualization & hypervisors
IaaS/Compute: Amazon EC2

Amazon Elastic Compute Cloud (EC2)



Amazon Elastic Compute Cloud (EC2)

- Mette a disposizione server virtuali (istanze)
- Scelta tipo istanza e template da utilizzare (Windows/Linux) e numero istanze con AWS management console (o via API usando librerie SDK)
- Ampia gamma di istanze (CPU, memoria, storage, GPU)
- Opzioni di pagamento: on demand, istanze riservate, istanze spot, ...
- Sicurezza (Virtual Private Cloud - VPC)
- Storage persistente: Amazon Elastic Block Store (EBS)
- Autoscaling

AMAZON EC2



EC2: Pricing

On demand

Viewing 288 of 288 available instances

<

1

2

3

4

5

6

7

...

15

>

Instance name ▾	On-Demand hourly rate ▲	vCPU ▾	Memory ▾	Storage ▾	Network performance ▾
t4g.nano	\$0.0048	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t3a.nano	\$0.0054	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t3.nano	\$0.006	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t4g.micro	\$0.0096	2	1 GiB	EBS Only	Up to 5 Gigabit
t3a.micro	\$0.0108	2	1 GiB	EBS Only	Up to 5 Gigabit
t3.micro	\$0.012	2	1 GiB	EBS Only	Up to 5 Gigabit
t4g.small	\$0.0192	2	2 GiB	EBS Only	Up to 5 Gigabit
t3a.small	\$0.0216	2	2 GiB	EBS Only	Up to 5 Gigabit

Spot instances *to request spare EC2 computing capacity for up to 90% off the On-Demand price*

Instance Type ▲	Linux/UNIX Usage ▾	Windows Usage ▾	Instance Family ▾
a1.2xlarge	\$0.0956	N/A*	General Purpose - Current Generation
a1.4xlarge	\$0.211	N/A*	General Purpose - Current Generation
a1.large	\$0.0244	N/A*	General Purpose - Current Generation
a1.medium	\$0.011	N/A*	General Purpose - Current Generation
a1.metal	\$0.1807	N/A*	General Purpose - Current Generation
a1.xlarge	\$0.0592	N/A*	General Purpose - Current Generation
c1.medium	\$0.0441	\$0.1205	Compute Optimized - Previous Generation
c1.xlarge	\$0.1869	\$0.4901	Compute Optimized - Previous Generation
c3.2xlarge	\$0.2055	\$0.5029	Compute Optimized - Current Generation

...

Dedicated hosts

Physical server with EC2 instance capacity fully dedicated to your use

750 hours per month
for 12 months with the [AWS Free Tier](#)

Example: How To Launch A Linux Server on AWS EC2



<https://www.youtube.com/watch?v=XvESEdap-4E&enablejsapi=1>

Server virtualization & hypervisors

IaaS/Compute: Amazon EC2

IaaS market share

IaaS market share

2022

AWS	40.0	%
Microsoft	21.5	%
Alibaba	7.7	%
Google	7.7	%
Huawei	4.4	%

Server virtualization & hypervisors

IaaS/Compute: Amazon EC2

IaaS market share

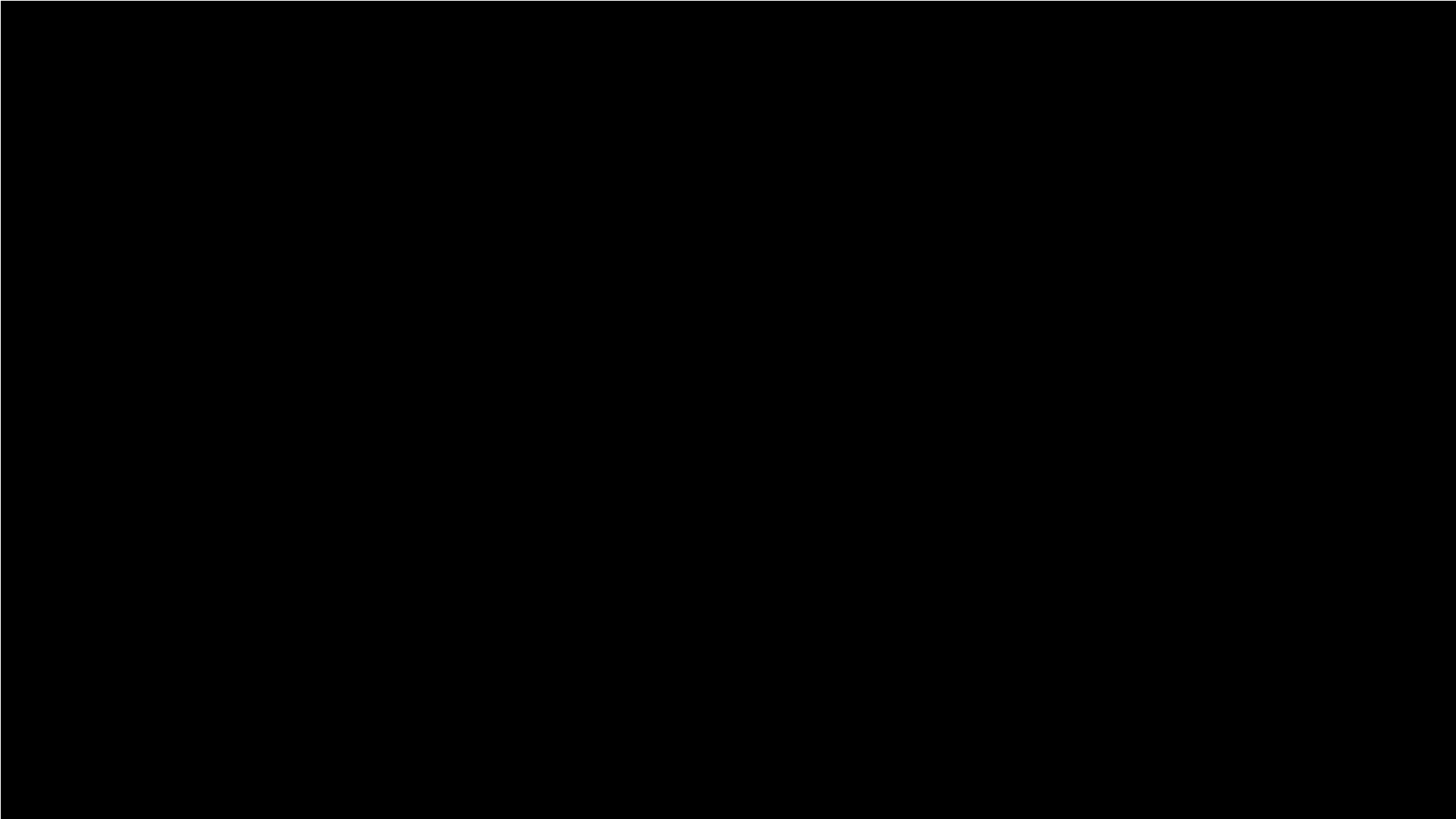
IaaS/Storage: Amazon S3

Amazon Simple Storage Service (S3)

“Everything must be made as simple as possible. But not simpler.”



Amazon Simple Storage Server (S3)



Amazon Simple Storage Server (S3)

- Fornisce uno storage sicuro e facile da usare
- "Bucket", "regione geografica»
- Affidabilità: più copie su server diversi in DC diversi, versioning
- Diverse classi di memorizzazione (standard / standard infrequent access / glacier)
- Controllo configurabile dell'accesso ai dati (politiche identità, liste accesso, endpoint SSL)



S3: Pricing

Storage pricing	
S3 Standard - General purpose storage for any type of data, typically used for frequently accessed data	
First 50 TB / Month	\$0.023 per GB
Next 450 TB / Month	\$0.022 per GB
Over 500 TB / Month	\$0.021 per GB
S3 Intelligent - Tiering* - Automatic cost savings for data with unknown or changing access patterns	
Monitoring and Automation, All Storage / Month (Objects > 128 KB)	\$0.0025 per 1,000 objects
Frequent Access Tier, First 50 TB / Month	\$0.023 per GB
Frequent Access Tier, Next 450 TB / Month	\$0.022 per GB
Frequent Access Tier, Over 500 TB / Month	\$0.021 per GB
Infrequent Access Tier, All Storage / Month	\$0.0125 per GB
Archive Instant Access Tier, All Storage / Month	\$0.004 per GB
S3 Intelligent - Tiering* - Optional asynchronous Archive Access tiers	
Archive Access Tier, All Storage / Month	\$0.0036 per GB
Deep Archive Access Tier, All Storage / Month	\$0.00099 per GB
S3 Standard - Infrequent Access** - For long lived but infrequently accessed data that needs millisecond access	
All Storage / Month	\$0.0125 per GB
S3 One Zone - Infrequent Access** - For re-createable infrequently accessed data that needs millisecond access	
All Storage / Month	\$0.01 per GB
S3 Glacier Instant Retrieval*** - For long-lived archive data accessed once a quarter with instant retrieval in milliseconds	
All Storage / Month	\$0.004 per GB
S3 Glacier Flexible Retrieval (Formerly S3 Glacier)*** - For long-term backups and archives with retrieval option from 1 minute to 12 hours	
All Storage / Month	\$0.0036 per GB
S3 Glacier Deep Archive*** - For long-term data archiving that is accessed once or twice in a year and can be restored within 12 hours	
All Storage / Month	\$0.00099 per GB

AWS Free Tier

As part of the [AWS Free Tier](#), you can get started with Amazon S3 for free. Upon sign-up, new AWS customers receive 5GB of Amazon S3 storage in the S3 Standard storage class; 20,000 GET Requests; 2,000 PUT, COPY, POST, or LIST Requests; and 100 GB of Data Transfer Out each month.

Your usage for the free tier is calculated each month across all AWS Regions except the AWS GovCloud Region and automatically applied to your bill; unused monthly usage will not roll over. Restrictions apply; see [offer terms](#) for more details.

Amazon Elastic Block Store (EBS)

- Persistent block storage volumes for use with Amazon EC2 instances in the AWS Cloud
- Each Amazon EBS volume is automatically replicated within its Availability Zone to protect you from component failure, offering high availability and durability
- Designed for application workloads that benefit from fine tuning for performance, cost and capacity (e.g., big data analytics, stream processing, data warehousing)



Server virtualization & hypervisors

IaaS/Compute: Amazon EC2

IaaS market share

IaaS/Storage: Amazon S3

Dropbox

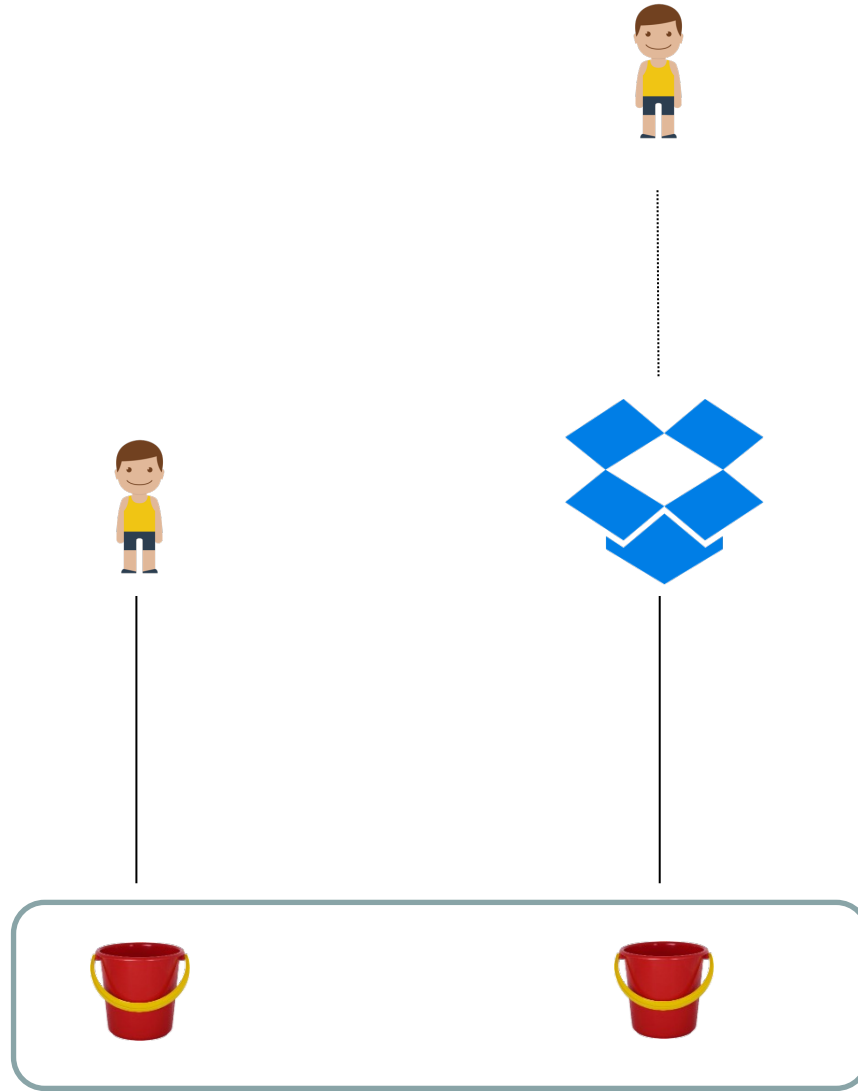
What if ...

we provide free storage to everybody?





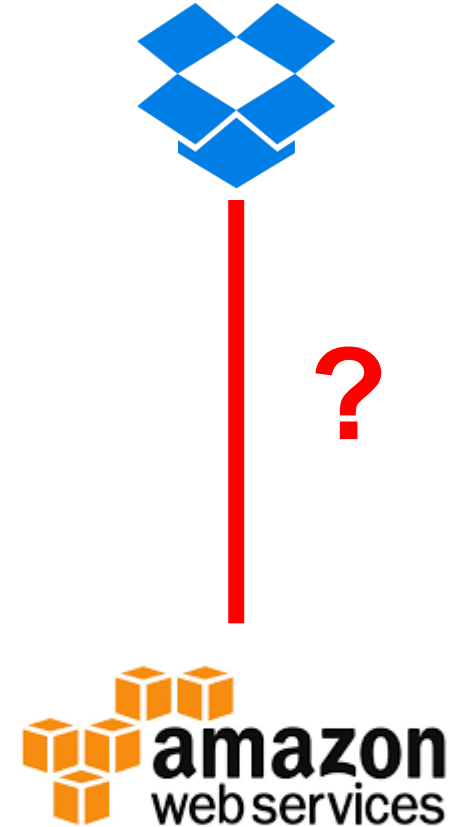
<https://www.youtube.com/watch?v=fq7DVQImqVg>



For the first eight years of its life,
Dropbox stored billions and billions of
files on Amazons S3
(files on S3, metadata on its own machines)



Stay with AWS or
leave?



Dropbox's exodus

- Between 2014 and 2016, Dropbox built its own vast computer network and shifted its service onto a new breed of machines designed by its own engineers
- Big technical and logistical challenge
 - Custom-built hardware (“Diskotech”) holding a petabyte of data
 - New code (“Magic Pocket”)
 - Moving that many data
 - Petabytes of data across the Internet (\approx 1day to transfer 4 petabytes of data)
 - Moving that many machines into data centers
 - Installing 40-50 racks of hardware a day
 - Ill-timed crashes: In one 24 hour period, trucks carrying machines to Dropbox data centers in different parts of the country had accidents
 - Need of completing exodus before expiration of main contracts with Amazon (to avoid renewal)
 - Do something like changing a tire while still driving
 - Magic Pocket didn't quite fit new hardware, Magic Pocket rebuilt
 - Dropbox made it!

Dropbox's Exodus: Was it a good idea?



Pros

...

...

Cons

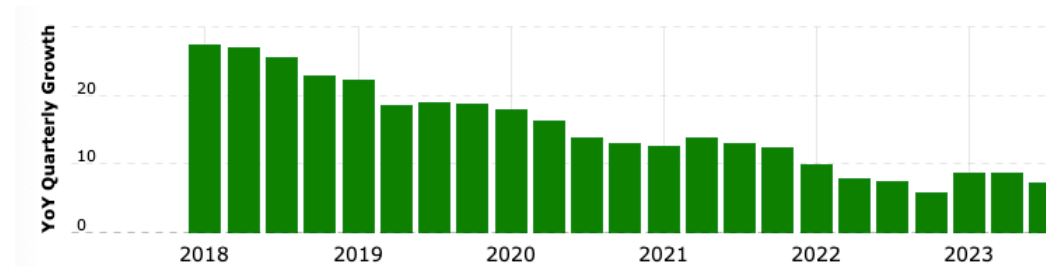
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Poll: Would you have decided to migrate out of AWS?

- *Yes*
- *Don't know*
- *No*

Dropbox Annual Revenue (Millions of US \$)	
2022	\$2,325
2021	\$2,158
2020	\$1,914
2019	\$1,661
2018	\$1,392
2017	\$1,107
2016	\$845
2015	\$604



www.macrotrends.net

Leading vendors' share in the file sharing software market worldwide in 2023

Google Drive	31.2	%
Dropbox	18.6	%
Box	13.0	%
...		

www.statista.com

Server virtualization & hypervisors

IaaS/Compute: Amazon EC2

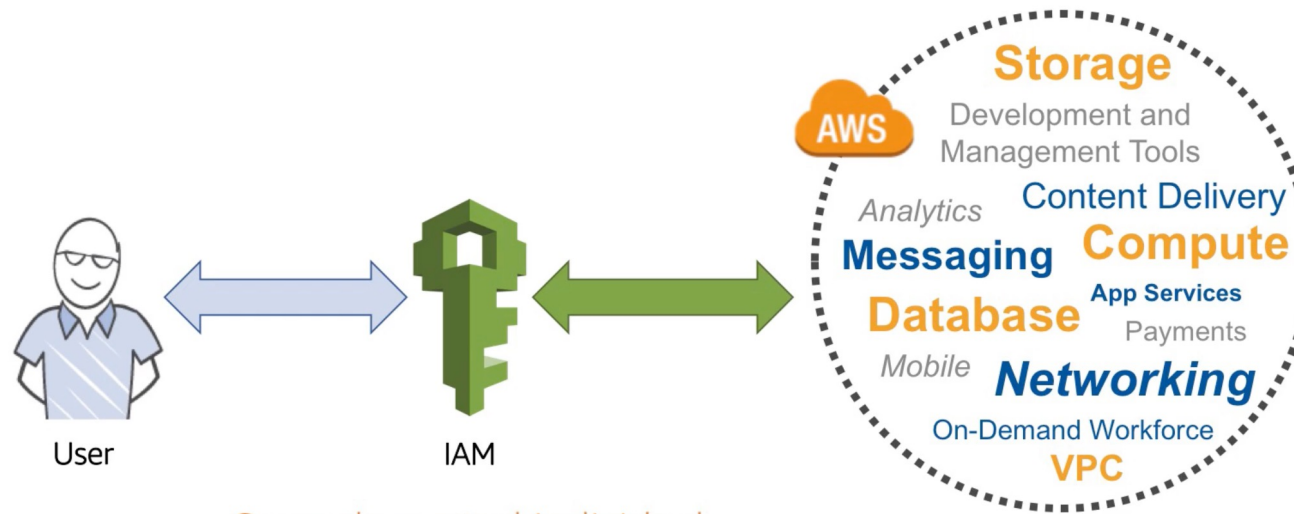
IaaS market share

IaaS/Storage: Amazon S3

Dropbox

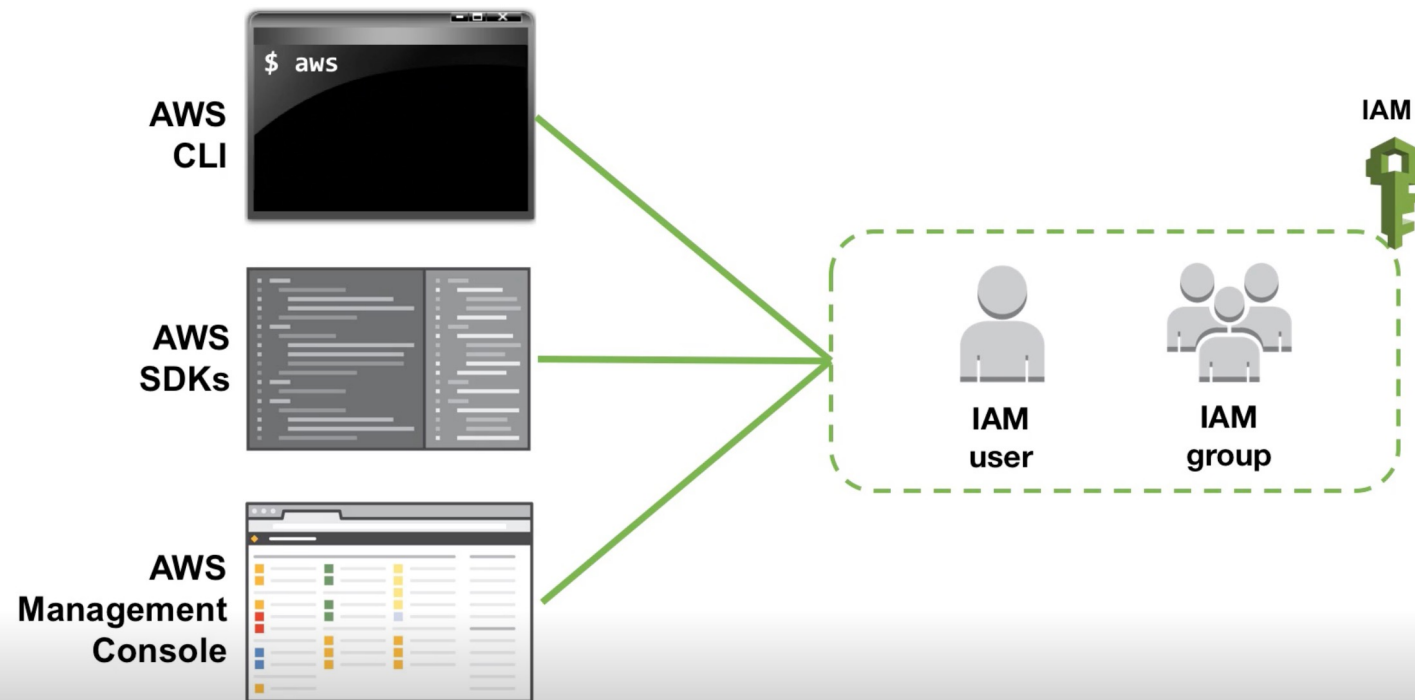
AWS IAM (Identity and Access Management)

Introducing AWS IAM



Securely control individual
and group access
to your AWS resources.

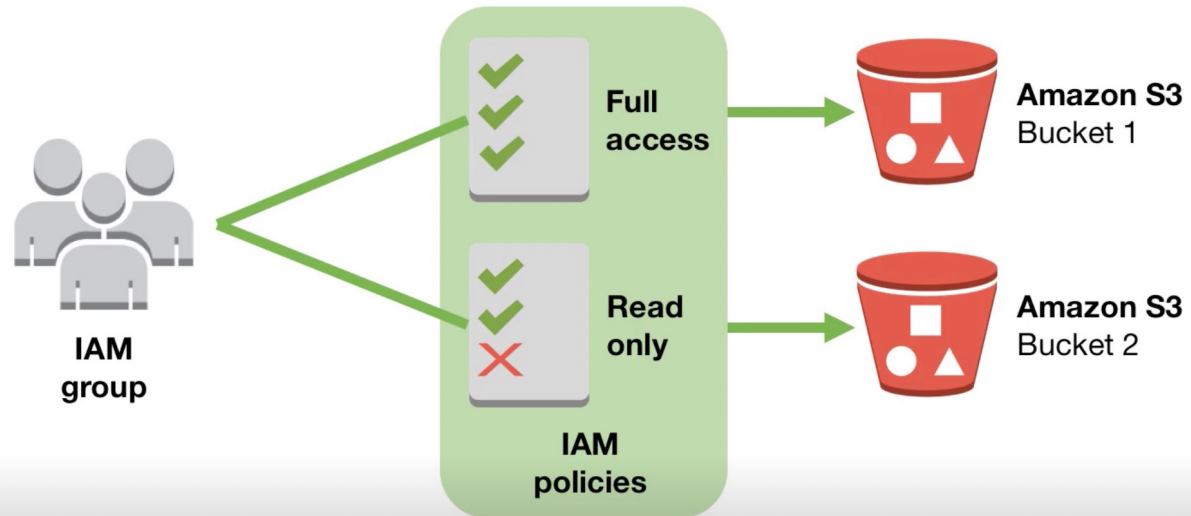
AWS IAM Authentication



IAM Authorization



IAM Policies are JSON documents used to describe permissions within AWS.



Sample Policy



IAM Policies are JSON documents used to describe permissions within AWS.

```

{
  "Sid": "Stmt1505076701000",
  "Effect": "Allow",
  "Action": [
    "s3:DeleteObject",
    "s3:GetObject"
  ],
  "Condition": {
    "IpAddress": {
      "aws:SourceIP": "10.14.8.0/24"
    }
  },
  "Resource": [
    "arn:aws:s3:::billing-marketing",
    "arn:aws:s3:::billing-sales"
  ]
}
```

Who/what is authorized

Which task(s) are allowed

Which condition(s) need to be met for authorization

Resources to which authorized tasks are performed

Bringing it all Together



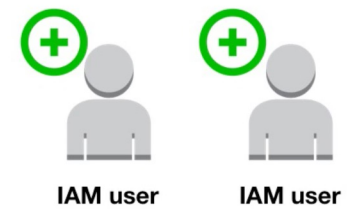
STEP 1



STEP 2



STEP 3



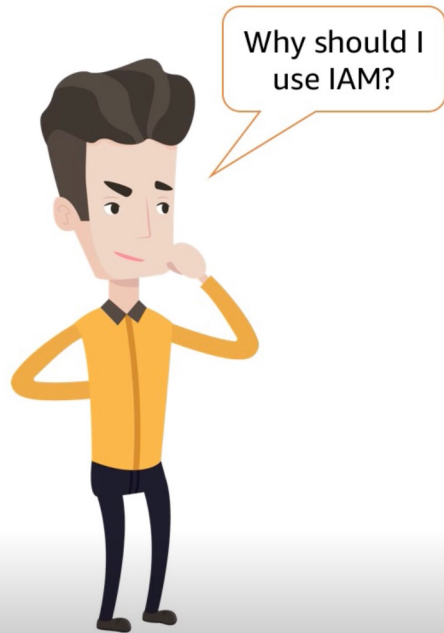
IAM Roles



IAM Role

- ❏ IAM users, applications, and services may assume IAM roles
- ❏ Uses an IAM policy for permissions

Users, Groups, and Roles



1

Manage IAM users and their access

2

Manage IAM roles and their permissions

3

Manage federated users and their permissions