Cloud Computing

Containers and Virtual Machines

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Outline of today's course

1. Quizz : do you remember something ?
2. Course Part 1 : Containers vs. Virtual Machines
3. Course Part 2 : Data security, Infrastucture Management and Service Level Agreement
4. Lab 1 follow-up

Do you remember something ?

What is Cloud Computing?

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2. A spreadsheet
3. A way to store data remotely
4. A technique for managing computer applications in companies
5. An OLAP cube

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6. The cost of managing the cloud’s IT infrastructure

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Which of the following statements could be used to describe a private cloud deployment?

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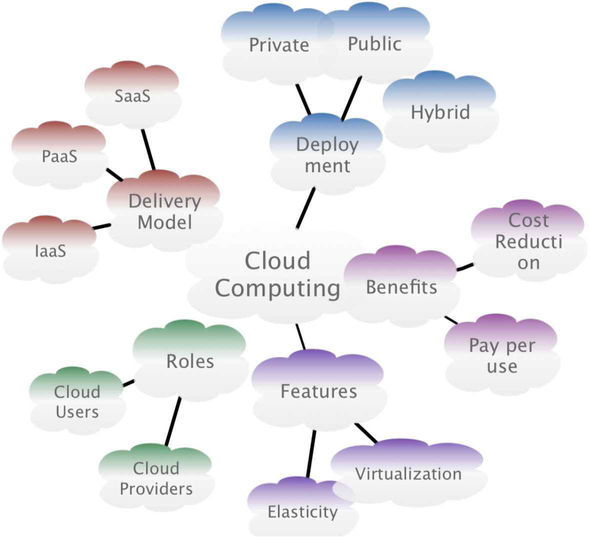
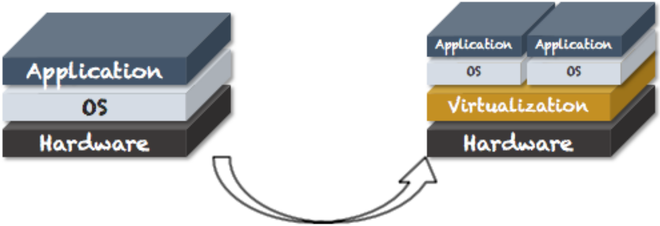
Overview


Private
Public
Hybrid
Deploy ment
SaaS
PaaS
Delivery Model
IaaS
Cloud Computing
Benefits
Cost Reducti on
Pay per use
Roles
Cloud Users
Cloud Providers
Features
Virtualization
Elasticity

Virtualization

Definition: running on the same physical machine, multiple systems as if they were running on separate physical machines

- a technology that transforms hardware into software
- allows to run multiple OS as **virtual machines**



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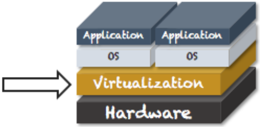
Roles of a hypervisor

- provides control of the processor and the resources of the host machine
- allocate to each virtual machine the resources it needs
- make sure that VM's do not interfere with each other



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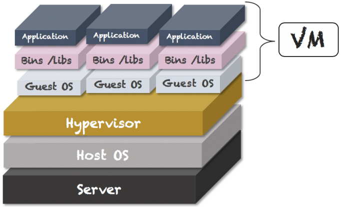

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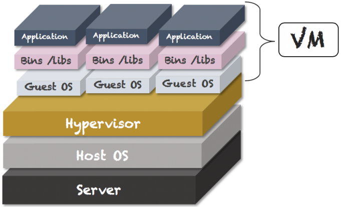

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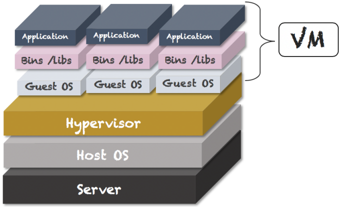

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- lower performance of the VM

Bare Metal Hypervisor (type 1)

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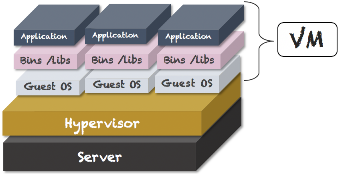

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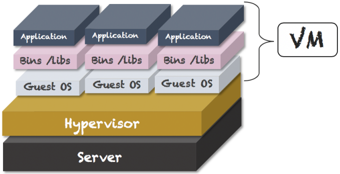

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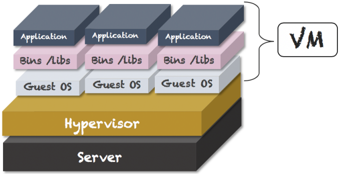

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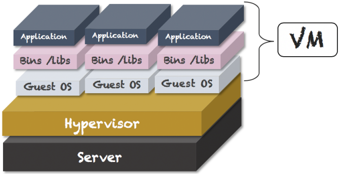
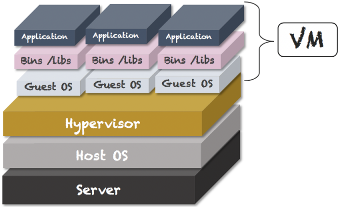
- hardware compatibility is limited

Virtual Machines and Hypervisor

Why do we need this additional hypervisor layer in between the VM and the host machine?





Examples of Bare-metal Virtualization Hypervisors (1)

VMware ESX and ESXi

- Belongs to Vmware
- Mature & Stable tool
- Free edition available with limited features
- 5 commercial editions
- Includes its own kernel

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Microsoft Hyper-V

- Belongs to Microsoft
- Good for Small-Medium Businesses
- Good for running windows
- Free edition available with limited features
- 4 commercial editions

Examples of Bare-metal Virtualization Hypervisors (2)

Citrix XenServer

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Oracle VM

- Belongs to Oracle Corporation
- Homegrown hypervisor tech. based on Xen
- Simple, no-frills hypervisor
- Lacks advanced features

Examples of Hosted Virtualization Hypervisors (1)

VMware Workstation/Fusion/Player

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- Good for labs and demonstration objectives
- Good Option for running Windows and Linux on Macs

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Oracle VM VirtualBox

- Belongs to Oracle Corporation
- Open source hypervisor
- Similar to VMware and Microsoft Hyper-V
- Mature and Stable
- Suitable for Small-Medium Business & Enterprises

Examples of Hosted Virtualization Hypervisors (2)

KVM

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- Contains features of Type 1 & Type 2
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Parallels Desktop

- Belongs to Parallels
- Good for running Windows on OS
- 3 commercial editions

How should I choose a hypervisor ?

- Understand your needs, i.e., flexibility, scalability, reliable support etc.
- Understand the features, i.e., live migration, storage migration, dynamic memory, automated workflows, etc.
- Investigate the ecosystem
  - Possible to evaluate every virtualization hypervisor for free
- Compare costs
- **Remember** : VMs are portable and easily convertible

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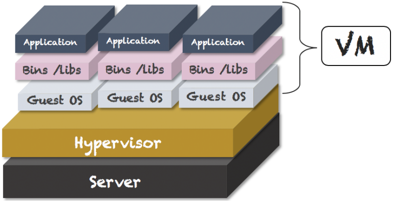
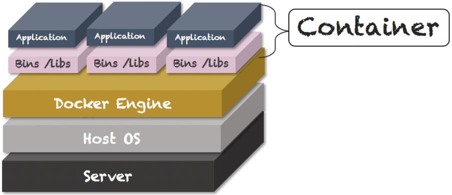
- **Main difference** : containers **share** the host system's kernel with other containers





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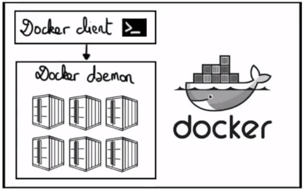
- **Modularity and Scalability** :
  - Easy to link containers together to create an app
  - Easy to scale or update components independently in the future

Fundamental Concepts of Docker

Docker engine is the layer on which Docker runs.

- A **Docker Daemon** that runs in the host computer.
- A **Docker Client** that then communicates with the Docker Daemon to execute commands.
- Can run on the same machine or on two different ones



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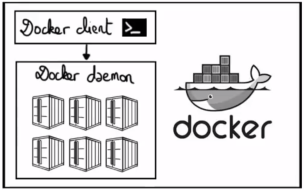

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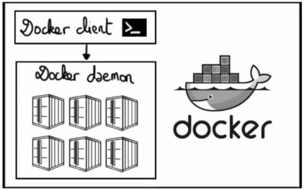

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Docker Image : read-only templates built from a set of instructions written in your Dockerfile.

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- **Kubernetes is an open source container orchestration platform**
  - Running containers across many different machines
  - Scaling up or down by adding or removing containers when demand changes
  - Keeping storage consistent with multiple instances of an application
  - Distributing load between the containers
  - Launching new containers on different machines if something fails

Summing-up

Benefits of virtualization

- For a company
  - Removal of special hardware and utility requirements
  - Effective management of resources
  - Better accessibility
  - Reduced risk of data loss
- For Data Centers
  - Maximization of server capabilities
  - Smaller footprint

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Connection to Cloud Computing

Virtualization in **cloud computing** allows you to run multiple applications and OS's on the same server, thereby providing for **efficient resource utilization** and reducing costs.

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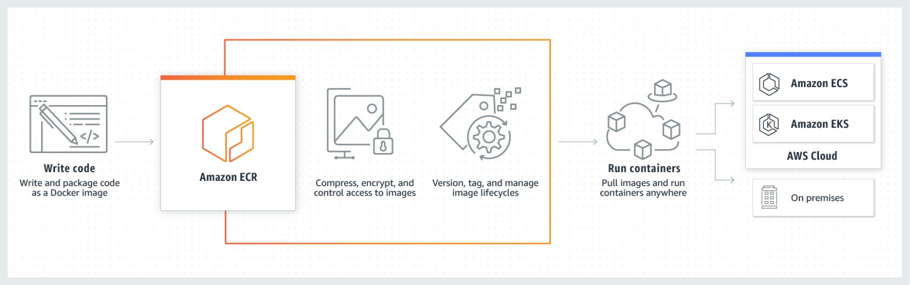
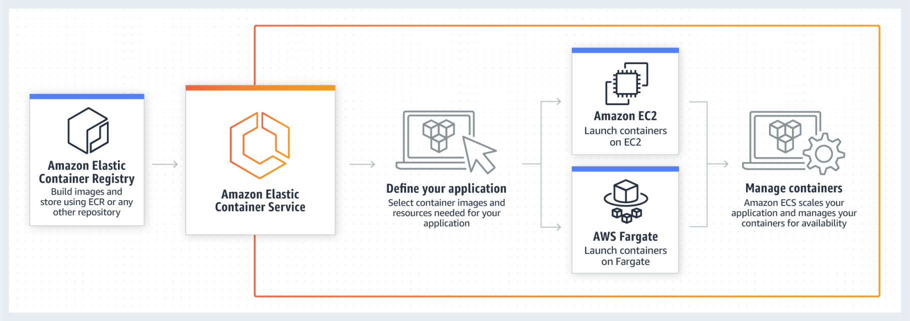
  - Compute: AWS Fargate and Amazon EC2

Registry: ECR


Write code
Write and package code as a Docker image
Amazon ECR
Compress, encrypt, and control access to images
Version, tag, and manage image lifecycles
Run containers
Pull images and run containers anywhere
Amazon ECS
Amazon EKS
AWS Cloud
On premises

Orchestration: ECS



Amazon Elastic Container Registry
Build images and store using ECR or any other repository

Amazon Elastic Container Service

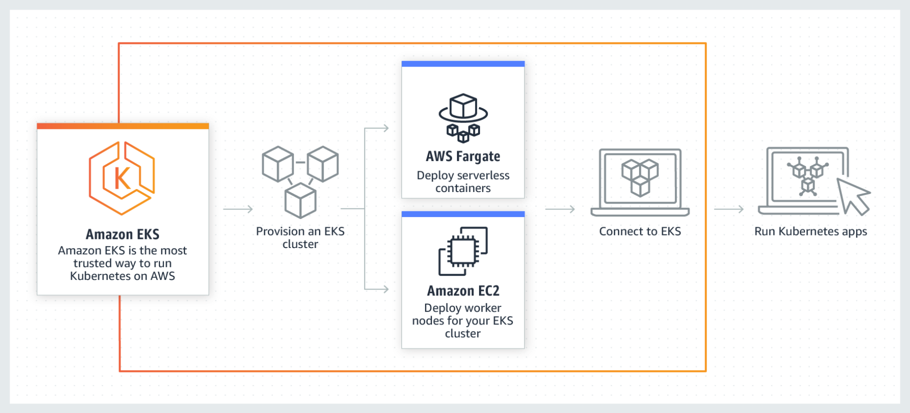
Define your application
Select container images and resources needed for your application

Amazon EC2
Launch containers on EC2

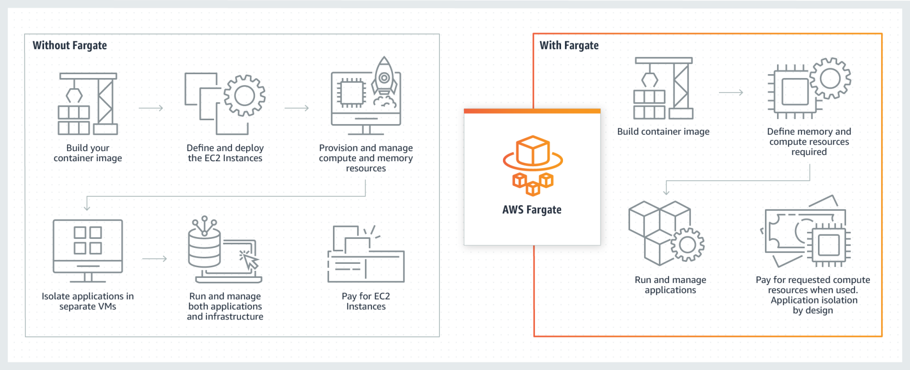
AWS Fargate
Launch containers on Fargate

Manage containers
Amazon ECS scales your application and manages your containers for availability

Orchestration: EKS


Amazon EKS
Amazon EKS is the most trusted way to run Kubernetes on AWS
Provision an EKS cluster
AWS Fargate
Deploy serverless containers
Amazon EC2
Deploy worker nodes for your EKS cluster
Connect to EKS
Run Kubernetes apps

Compute: EC2 / Fargate

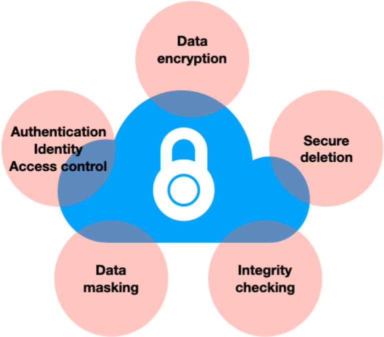

Without Fargate
Build your container image
Define and deploy the EC2 Instances
Provision and manage compute and memory resources
Isolate applications in separate VMs
Run and manage both applications and infrastructure
Pay for EC2 Instances
AWS Fargate
With Fargate
Build container image
Define memory and compute resources required
Run and manage applications
Pay for requested compute resources when used. Application isolation by design

Part 2

Data Security, Infrastructure Management and Service Level Agreement

Data Security in the cloud

- Similar to protecting data within a traditional data center



- Responsibility is shared between the provider and the client
- Cloud providers are providing you with the necessary tools to handle these questions

Privacy Protection

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  - Data encryption
  - Control who sees and can access what

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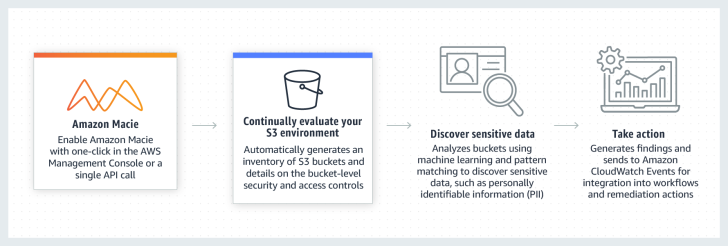
- Amazon Macie ! → inventory of Amazon S3 buckets



Amazon Macie
Enable Amazon Macie with one-click in the AWS Management Console or a single API call

Continually evaluate your S3 environment
Automatically generates an inventory of S3 buckets and details on the bucket-level security and access controls

Discover sensitive data
Analyzes buckets using machine learning and pattern matching to discover sensitive data, such as personally identifiable information (PII)

Take action
Generates findings and sends to Amazon CloudWatch Events for integration into workflows and remediation actions

Data Integrity

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- Authorization becomes crucial
  - Double authentication
  - Logging

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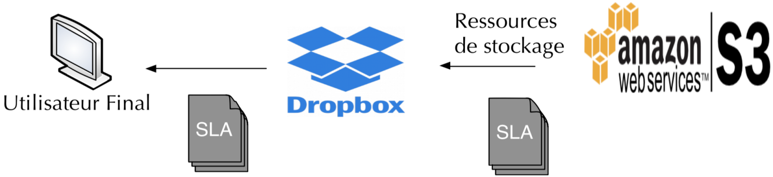
  - Logging
- AWS Key Management Service and EncryptionContext
  - Additional authenticated data (AAD)
  - Audit trail
  - Authorization context

Data Availability: Service Level Agreement (SLA)

- A Service Level Agreement is a document that defines the quality of service required between a provider and a client
- **Definition** : an explicit statement of expectations and obligations that exist in a business relationship between two organizations: the service provider and the customer
- There are several languages of SLA
  - WS-Agreement by OGF (Open Grid Forum)
  - WSLA by IBM
- An SLA is a document of a legal nature
  - if the SLA is not satisfied, there will be penalties to pay

SLA in the Cloud

- Often several SLAs because there are several actors involved
- Ideally, the SLA between a cloud provider and users must be negotiated.
- Unfortunately, often suppliers offer a single contract for everyone



Service Level Objective (SLO)

- A SLA is composed of a set of SLOs
- A SLO specifies the limits of the acceptable
  - availability$>$ 95%
  - response time t $<$5 millisecond
- A SLA Violation is Made When a SLO Is Not Respected
  - The penalty is often proportional to the violation
- Often SLOs are about non-functional requirements

Cloud Non-Functional Requirements

- **Availability:** an essential requirement, the service must be always present even in case of breakdown -
  - e.g. 99.99% during work days, 99.9% for nights/weekends)
- **Reliability: disaster Recovery expectations**
  - System operation must be consistent
  - Data must be stored in redundancy (e.g. RAID systems)
  - Multiple VMs must provide the same tasks
- **Performance**
  - Maximum response times
- **Location of the data**: consistent with local legislation
- **Portability of the data** (e.g. ability to move data to a different provider)

How to manage infrastructure state effectively ?

Visibility

- Do you know the state of your infrastructure ? (what, how, who)
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Flexibility

- Can you improve your configurations and scale up easily ?
- Can you add more complexity using the same tools?
- Do you share, review, and improve your configurations within your team?

AWS Configuration Management

AWS Console

- Web interface to control most of the functionalities
- When should we use the AWS console ?
  - Read-only usage
  - Workable for small systems and teams
  - Rare operations
- ! AWS console is not compatible with automation, reproducibility and team communication (documentation and standardization)

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AWS Command-Line tools (CLI)

- Most basic way to save and automate AWS operations
- ++ well-maintained and covers a large proportion of all AWS services
- Write simple Bash scripts that invoke aws with specific arguments
- Interactive (not scripted) use : aws-shell

AWS Configuration Management

APIs and SDKs

- **SDKs** for using AWS APIs are available in most major languages, with Go, iOS, Java, JavaScript, Python, Ruby, and PHP [a]
- ! **Don't use APIs directly** -> use the SDKs for your preferred language to access APIs.

[a] (see https://github.com/donnemartin/awesome-aws)

Amazon SDK for Python : Boto3

- Allows to automate operations
- Contains a variety of APIs that operate at either a high level or a low level
- When should I use boto ? -> If you find yourself writing bash script with more than 2 CLI.

Visibility

General Visibility

- Tagging Essential practice to better understand the resource usage
- Through automation or convention, you can add tags
  - For the developer that “owns” that resource
  - For the product that resource supports
  - To label lifecycles, such as temporary resources
  - To distinguish resources with special security or compliance needs
  - To distinguish production-critical infrastructure

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AWS Services for visibility

- Access management : IAM
- Monitoring resources : **Cloud Watch**
- Monitoring team : Cloud trail

CloudWatch

Monitors resources and **application**s, captures **logs**, and **sends events**.

- Standard service for **keeping tabs on AWS resources** :
  - **EC2** : percentage of allocated EC2 compute units, number CPU credits spent/earned by the instance etc.
  - **Bucket storage** : amount of data (in bytes), number of objects, number of HTTP requests made to bucket etc.

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- Allows to create time based graphs, alarms, and dashboards
  - Alarms to **trigger notifications** from any given metric.
  - Trigger SNS notifications, Auto Scaling actions, or EC2 actions.
  - Publish and share graphs of metrics by creating customizable dashboard views.

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Limitations

- Limited to one metric for an alarm.
- Alarm's notification do not have any contextual detail;
- Data about metrics is kept in CloudWatch for 15 months.

CloudWatch

CloudWatch Events

- Mechanism to **automate actions** in various services on AWS.
- Can create **event rules** from instance states, AWS APIs, Auto Scaling, Run commands, deployments or time-based schedules.
- **Triggered events** can invoke Lambda functions, send messages, or perform instance actions.

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CloudWatch Logs

- Streaming log storage system
- A log agent installed on your servers will process logs over time and send them to CloudWatch Logs.
- Can export logged data to S3 or stream results to other AWS services.
- CloudWatch Logs can be encrypted using keys managed through KMS.

AWS Billing and Cost Management

- AWS offers a **free tier of service**, that allows very limited usage of resources at no cost.
- **Pay your AWS bill**, **monitor** your usage and **budget** your costs. Provides features that you can use to
  - Estimate and plan your AWS costs
  - Receive alerts if your costs exceed a threshold that you set
  - Assess your biggest investments in AWS resources
- Set **billing alerts** to be notified of unexpected costs

Cost Explorer

- Tool that enables you to view and analyze your costs and usage.
- View data for up to the last 13 months
- Forecast for the next 3 months

– For large accounts, the AWS billing console can **time out** or be **too slow** to use.

Other tools for cost management

Tools

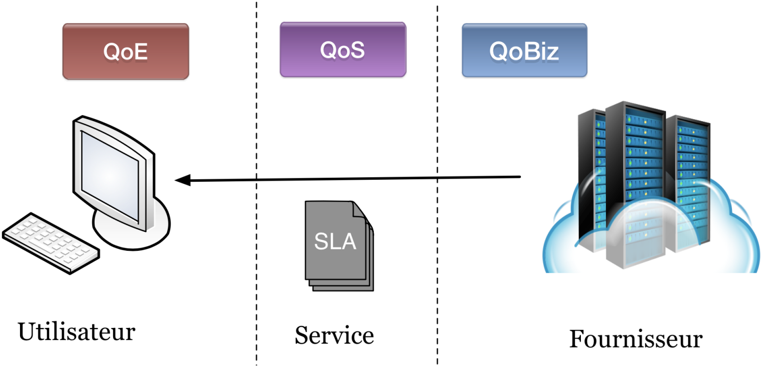
- Teevity Ice (Netflix) - Docker Ice
- Security Monkey and Cloud Custodian.
- AWS Simple Monthly Calculator to get an estimate of usage charges for AWS based on your actual usage of AWS services.

Third-Party Services

- Cloudability
- CloudHealth Technologies
- ParkMyCloud.
- ! Some of these charge a percentage of your bill

The Quality Management in the Cloud

- Three visions of the quality



Quality of Business (QoBiz)

- A provider-centric quality metric
- It expresses the profit of supplier
  - service price
  - revenue per user
  - revenue per transaction
  - budget
- A good QoBiz expresses the prosperity of the provider
- Decides the pricing policy of the suppliers: rate per hour, rate per month, etc.

Quality of Experience (QoE)

- According to subjective tests
- QoS is not sufficient to ensure user satisfaction
- Quality of experience (QoE) is a subjective metric that expresses quality of service as perceived by the user
- QoE is influenced by several factors:
    - The context of use
    - The personality and preferences of the user
    - The system used to consume the service