



RT0904 – Cloud Programming



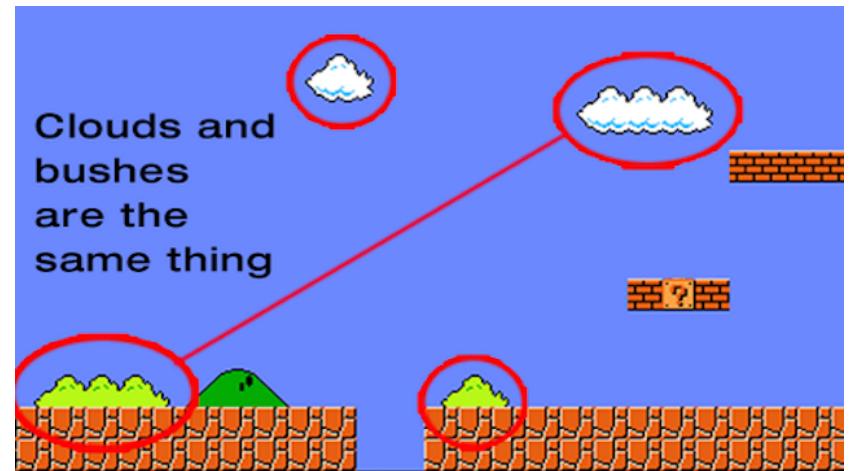
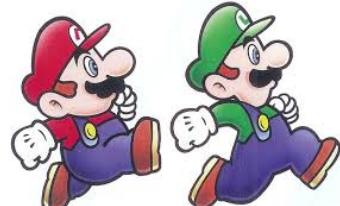
Introduction to cloud computing

What makes the cloud?

What makes the cloud?

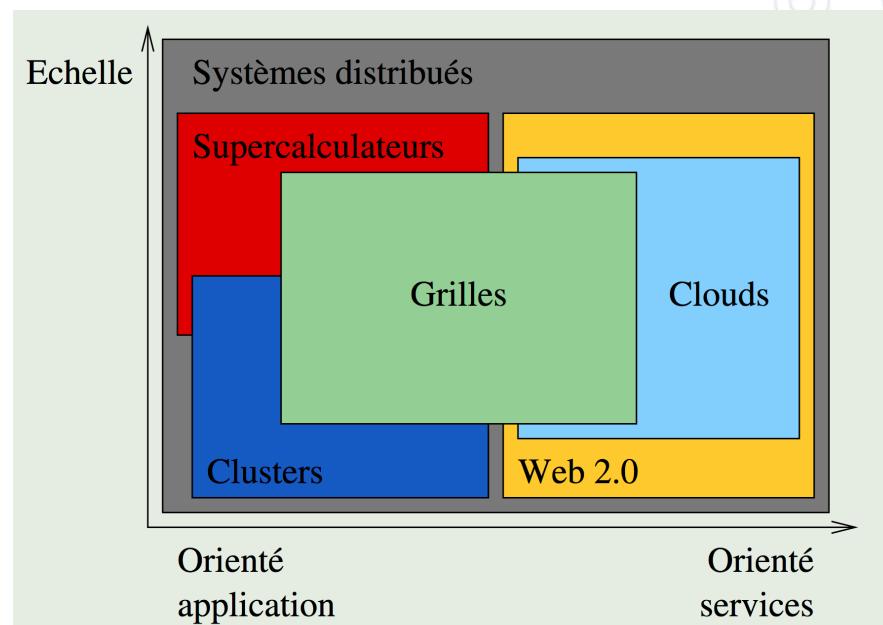
◎ Questions

- For me, what is the cloud?
- What I really think the cloud is made of?



Something new?

- ◎ How "new" is the cloud computing
 - It is a new technology?
 - It is a new architecture?
 - It is a new paradigm?
 - How different it is from previous systems/architectures?



Cloud Computing

NIST Definition

“Cloud computing is a model for enabling **ubiquitous**, convenient, **on-demand network access** to a **shared pool of configurable computing resources** (e.g., networks, servers, storage, applications, and services) that can be **rapidly provisioned and released** with **minimal management effort** or service provider interaction”



We know the business model

“

*Why to buy a taxi when you
just need to pay the bill?*

Business Services, Orange

*Cloud computing → distant computing
All operations are executed in a remote environment*



There is no cloud
it's just someone else's computer

Dad, what's the difference
between mainframe computing
and cloud computing?

Well... we used to get
billed by IBM. Now the bills
come from Amazon.

TROELBOB 2016

What are the pillars of cloud computing

- ◎ Several well-known technologies that together can bring more flexibility and transparency
 - Outsourcing
 - Third-part development and maintenance
 - Standard Internet protocols
 - Virtualization



Other reasons to use the cloud?

- ◎ Costs!!!!
 - The electricity consumption/bill grows 5% per year
 - Electricity represents 10% of an IT department
- ◎ When we think about...
 - Most servers are underused: 20% in average
 - A datacenter is often at 10-40% of its capacity
- ◎ The cloud helps sharing the charge, reducing the cost
- ◎ More than this, the cloud gives us flexibility



Adapting to the needs



Characteristics

- ◎ Resources available through Internet
- ◎ Shared infrastructure:
 - Reduced cost
 - Better usage of existing nodes
- ◎ Elasticity:
 - One can expand/reduce as needed
- ◎ Transparent monitoring solutions:
 - For the providers
 - For the clients
- ◎ Clouds can be fully automatized:
 - No need for human intervention
 - Hardware as a Service
 - APIs allow the software to add or remove hardware
 - ***DevOps jobs***



Inconvenients

- ◎ Security problems:
 - Sensitive data
 - Risks of storage and transmission over the network
- ◎ Who can access the data:
 - Depends on the location
 - Local laws may vary a lot
- ◎ Require a good network connection:
 - No network, no cloud
 - How to deal with a network blackout?
 - How to handle data losses?

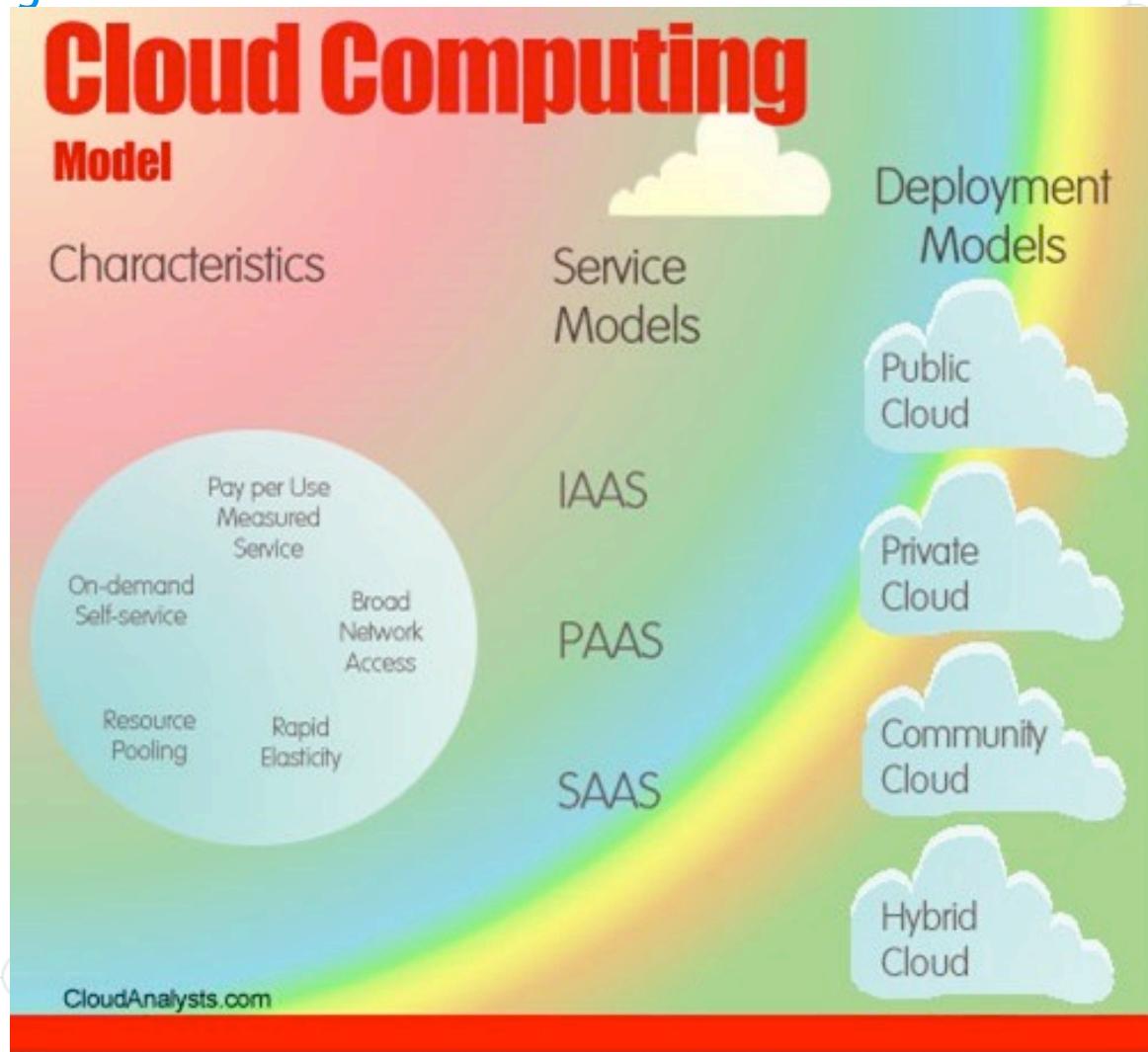


THE cloud or the clouds ?

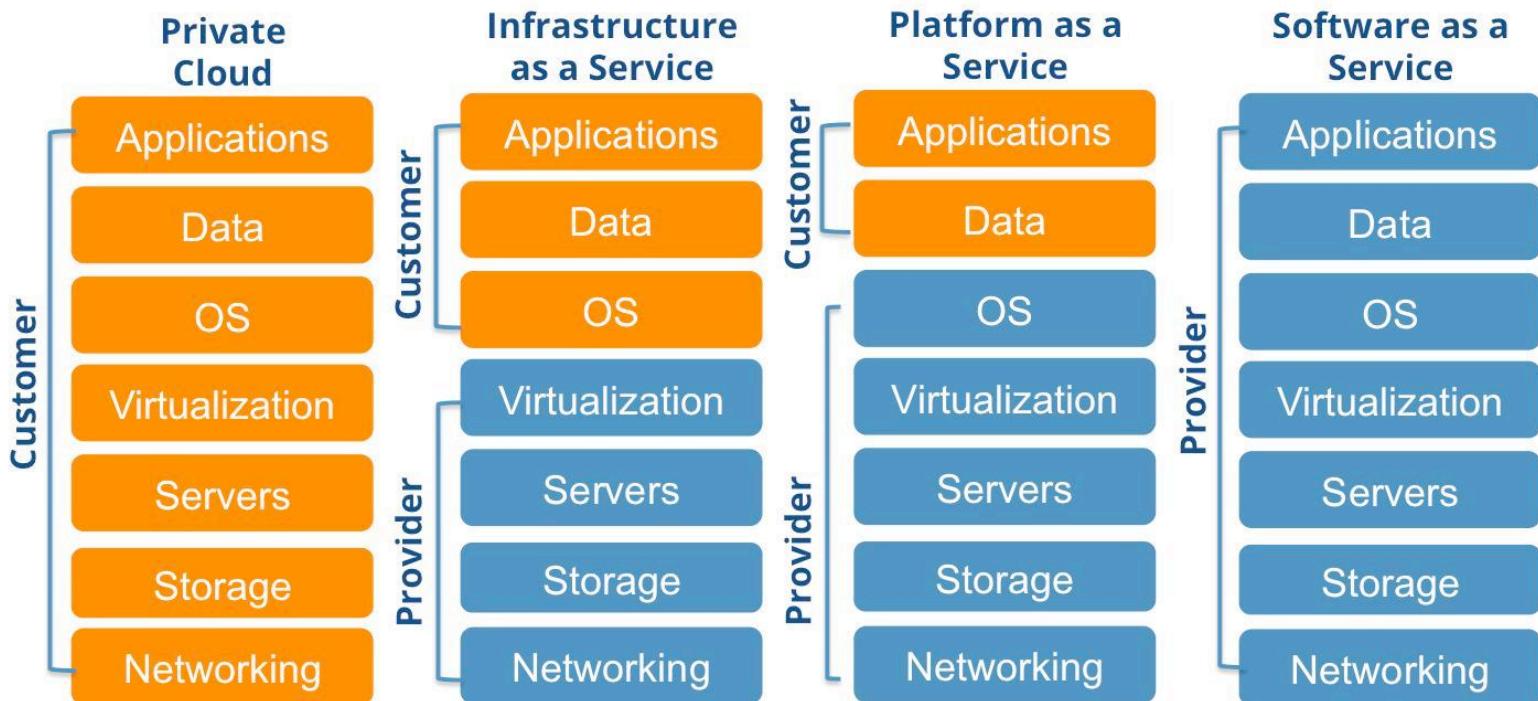
- ◎ The media sees the cloud as a single entity
- ◎ This vision is too restrictive
 - The cloud can host very different concepts
- ◎ Some classifications:
 - SPI model (how much access/control do I have)
 - SaaS, PaaS, IaaS
 - Accessibility
 - Public
 - Private
 - Hybrid
 - Community



Cloud Computing Models



SPI models



The IaaS model

- ⦿ You have full control of a **virtual machine**
 - ⦿ Several levels of resources (configurable)
 - ⦿ Different OS and network options
 - ⦿ Full VM or container-based (ex. Docker)
 - ⦿ The client has full control of the virtual machine
 - ⦿ OS configuration
 - ⦿ Install of new software
 - ⦿ Direct connection (mostly through SSH)
 - ⦿ The provider can offer extra services
 - ⦿ Storage (SSD, replication), cache services
 - ⦿ Databases
 - ⦿ Specific applications, management APIs

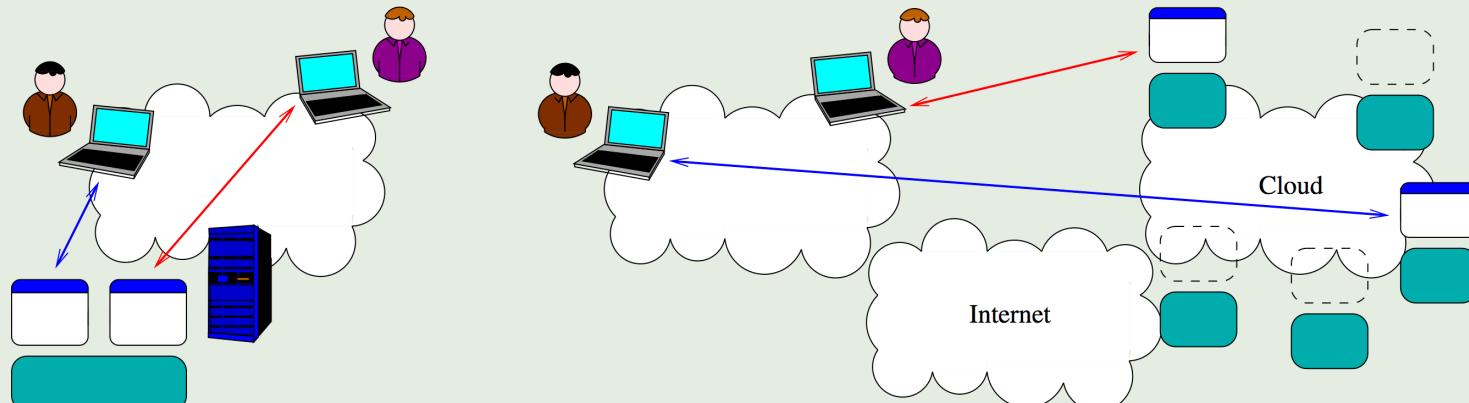
Examples

Amazon AWS, Microsoft Azure

The PaaS model

- ◎ The applications are made by your enterprise
 - The provider enters with the platform:
 - Web languages, Java, Python, .NET, ...
- ◎ Several development kits (DB, etc) available
- ◎ Examples
 - Google App Engine, OpenShift, Azure PaaS, Heroku

Illustration

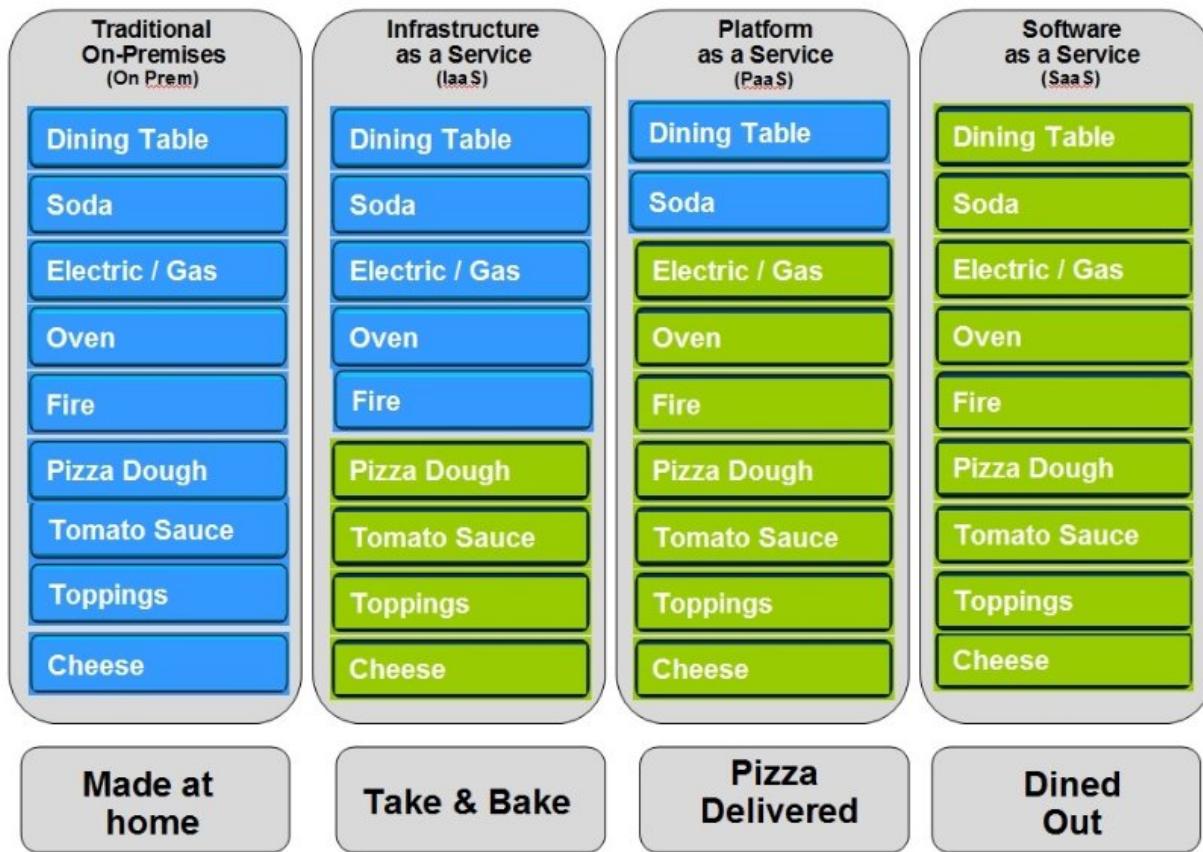


The SaaS model

- ◎ Only the data belongs to the user
- ◎ The provider offers a suite of components, applications and services
- ◎ Advantages
 - Billing based on the usage rate
 - **cost reductions, specially in the case of licenses**
 - Requires a lightweight client (web browser)

SPI "easy to remember"

Pizza as a Service



Are there other models?

- Not really, but people appreciate the "aaS" suffix
- STaaS - STorage as a Service
- DaaS - Data as a Service
 - Database with users data (statistics, polls)
- SECaS - SECurity as a Service
 - Security tools (antivirus, watchdogs, intrusion detection)
- Network as a Service
- Desktop as a Service
- Workplace as a Service
- Business Process as a Service
- MicroPaaS

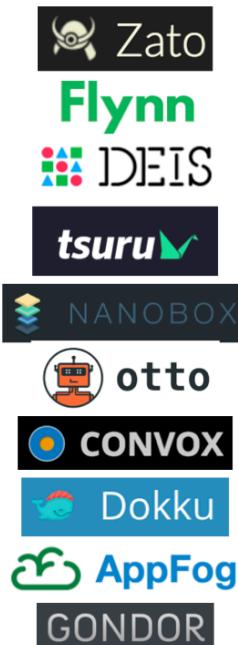
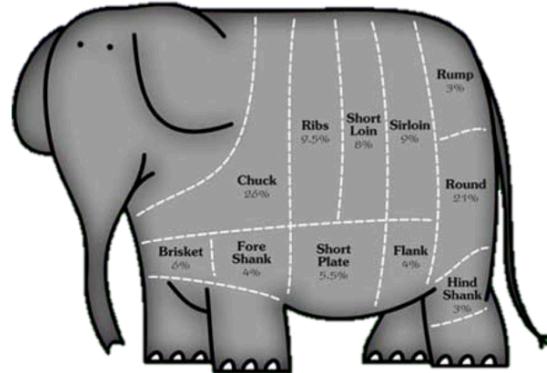


Microservices

- Lightweight IaaS/PaaS based on containers (ex Docker)
- For IaaS, one can launch one-shot applications on linux
- For PaaS, one can define workflows associating several microservices

*“How do you eat an elephant?
One bite at a time.”*

Development
Dependency Management
Testing
Deployment, CI/CD
Security
Middleware Stack
On-Cloud/On-Premise Runtimes
Backups
Monitoring
Scaling



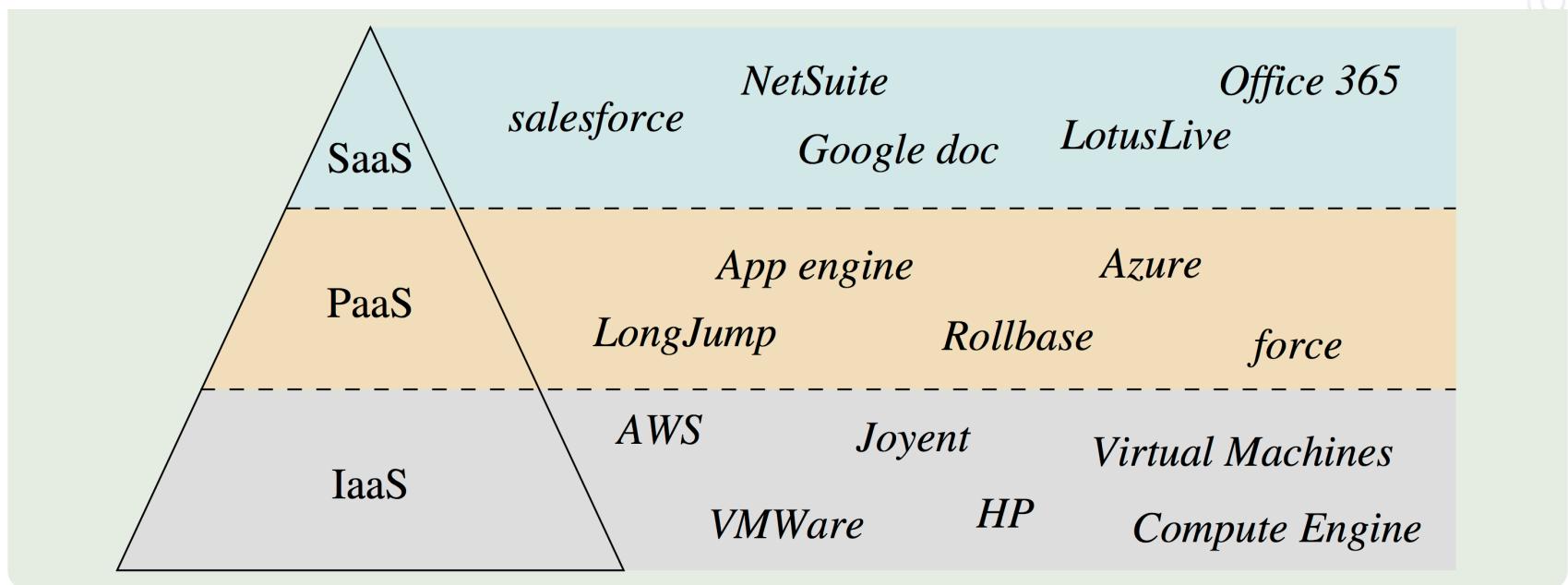
But now people talk about serverless!!

- ◎ What is a "serverless" application????
- ◎ The TRUTH → it runs in a server
 - "FaaS" – Function as a Server
- ◎ The idea of serverless is to have
**microservices that are not
always running**
 - Ex : authentication
- ◎ Instead of a "full-time" server, these "functions" are triggered and execute on demand



"If your PaaS can efficiently start instances in 20ms that run for half a second, then call it serverless." - Adrian Cockcroft (AWS VP - 2016)

Commercial solutions



Amazon AWS

- ◎ Amazon Web Services
- ◎ A strong reference in the cloud world: the first cloud provider
- ◎ All hosted in Amazon datacenters
 - Several sites over the world
- ◎ Multiple services:
 - Computing
 - Storage
 - Databases
 - Security
 - IoT
 - Big data



Most known services

- ◎ Computing: EC2 → Elastic Compute Cloud
 - Configurable and scalable virtual machines
 - AMI Instances (Amazon Machine Image)
- ◎ Storage: S3 → Simple Storage Service
 - Abstract data overlay → objects and compartments
 - Accessible from the cloud or outside
 - Can be shared among VM instances
 - Redundancy in several datacenters
- ◎ Storage: EBS → Elastic Block Storage
 - Traditional data representation:
 - filesystem
 - Data available only to machines in the same datacenter
 - Cannot be shared with other VM instances

Microsoft

- ◎ Initially provided a PaaS based on .NET
 - Microsoft Azure
 - Several associate services (databases, etc.)
 - Later opened to other programming languages
- ◎ SaaS: Office online
 - Office 365
 - Other tools for communication, mail, collaboration, etc.
- ◎ At last, started an IaaS Cloud based on VMs
 - Special VMs with GPU support

Google

- ◎ *Google Cloud Platform*
 - Initially only online applications: Google Apps
 - Spreadsheet, text editor, agenda, mail
 - Later included a PaaS: *Google App Engine*
- ◎ As AWS, several services:
 - Big data, analytics, databases, etc.
- ◎ Services grouped in four domains
- 1. Computing:
 - *App Engine*: PaaS
 - *Compute Engine*: IaaS
- Kubernetes Engine*: lightweight IaaS (containers/microservices)

- 
2. Storage:
 - Cloud Storage: long term storage
 - Bigtable: Massive noSQL database
 3. Big Data:
 - BigQuery : data analysis
 - Cloud Dataflow: ETL workflow
 - Cloud Pub/Sub: message queuing
 - Artificial Intelligence:
 - AI platform (workflow for TensorFlow/machine learning)
 - Recommandations IA
 - Natural Language
 - Vision
2. Services:
 - Translate API : online translation
 - All other google APIs like maps, geolocation, mobile services

How much it costs?

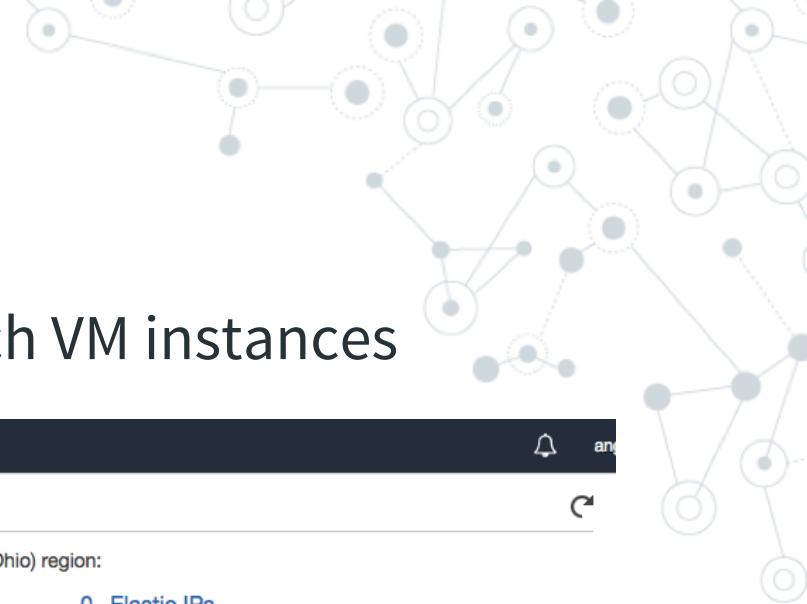
- ◎ Amazon
 - <https://calculator.s3.amazonaws.com/index.html>
- ◎ Google
 - <https://cloud.google.com/products/calculator/>
- ◎ **Question : How much would cost one cloud server similar to your PC?**
 - **Which provider is currently the cheaper?**

ATTENTION

- ◎ Unfortunately, most providers require a credit card to open accounts (and I cannot ask you to do that)
- ◎ Two solutions:
 - Amazon Educate
 - <https://aws.amazon.com/fr/education/awseducate/>
 - You can ask for an education account
 - You need to register with an etudiant.univ-reims.fr email
 - 100 USD to use on amazon cloud
 - access to all certification program and tutorials
 - Takes some time to activate
 - Google Cloud Educate program
 - Use the provided link to obtain your 50USD voucher
 - Instantaneous :D
 - Tutorials available on QwikLabs or Coursera

DEMO

Using the AWS console to launch VM instances



The screenshot shows the AWS EC2 Dashboard. The left sidebar lists navigation options: EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES (with sub-options Instances, Spot Requests, Reserved Instances, Dedicated Hosts), IMAGES (with sub-options AMIs, Bundle Tasks), ELASTIC BLOCK STORE (with sub-options Volumes, Snapshots), NETWORK & SECURITY (with sub-options Security Groups, Elastic IPs, Placement Groups, Key Pairs, Network Interfaces), and LOAD BALANCING. The main content area is titled "Resources" and displays resource counts for the US East (Ohio) region: 0 Running Instances, 0 Dedicated Hosts, 0 Volumes, 1 Key Pairs, 0 Placement Groups, 0 Elastic IPs, 1 Snapshots, 0 Load Balancers, and 4 Security Groups. A callout box suggests trying Amazon Lightsail for free. Below this is a "Create Instance" section with a "Launch Instance" button. A note states that instances will launch in the US East (Ohio) region. The "Service Health" section shows the US East (Ohio) service operating normally and the "us-east-2a" availability zone also operating normally. The "Scheduled Events" section indicates no events.

aws Services Resource Groups

Resources

You are using the following Amazon EC2 resources in the US East (Ohio) region:

0 Running Instances	0 Elastic IPs
0 Dedicated Hosts	1 Snapshots
0 Volumes	0 Load Balancers
1 Key Pairs	4 Security Groups
0 Placement Groups	

Just need a simple virtual private server? Get everything you need to jumpstart your project - compute, storage, and networking – for a low, predictable price. [Try Amazon Lightsail for free.](#)

Create Instance

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

Launch Instance

Note: Your instances will launch in the US East (Ohio) region

Service Health

Service Status:

- US East (Ohio):
This service is operating normally

Availability Zone Status:

- us-east-2a:
Availability zone is operating normally

Scheduled Events

US East (Ohio):
No events

DEMO

Using the GCP console to launch VM instances

The screenshot shows the Google Cloud Platform (GCP) console interface for creating a new VM instance. The top navigation bar includes the 'Google Cloud Platform' logo, a dropdown for 'Fog CloudFIT', a search bar, and a dropdown menu.

Créer une instance

Pour créer une instance de VM, sélectionnez l'une de ces options :

- Nouvelle instance de VM** (selected): Créez entièrement une instance de VM unique.
- Nouvelle instance de VM à partir d'un modèle**: Créez une instance de VM unique à partir d'un modèle existant.
- Marketplace**: Déployez une solution prête à l'emploi sur une instance de VM.

Détails de la configuration de l'instance

Nom: instance-1

Région: us-central1 (Iowa)

Zone: us-central1-a

Estimation mensuelle : 24,67 \$

Soit un coût horaire d'environ 0,034 \$

Vous payez ce que vous consommez : facturation à la demande

Configuration de la machine

Famille de machines: Usage général (selected), Mémoire optimisée

Types de machines pour les charges de travail courantes permettant d'optimiser les coûts et la flexibilité

Série: N1

Fourni par la plate-forme de processeur Intel Skylake ou l'un de ses prédecesseurs

Type de machine: n1-standard-1 (1 processeur virtuel, 3,75 Go de mémoire)

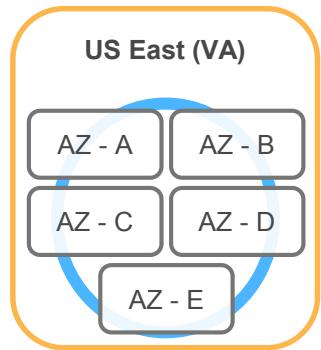
Plate-forme du processeur et GPU

Processeur virtuel	Mémoire
1	3,75 Go

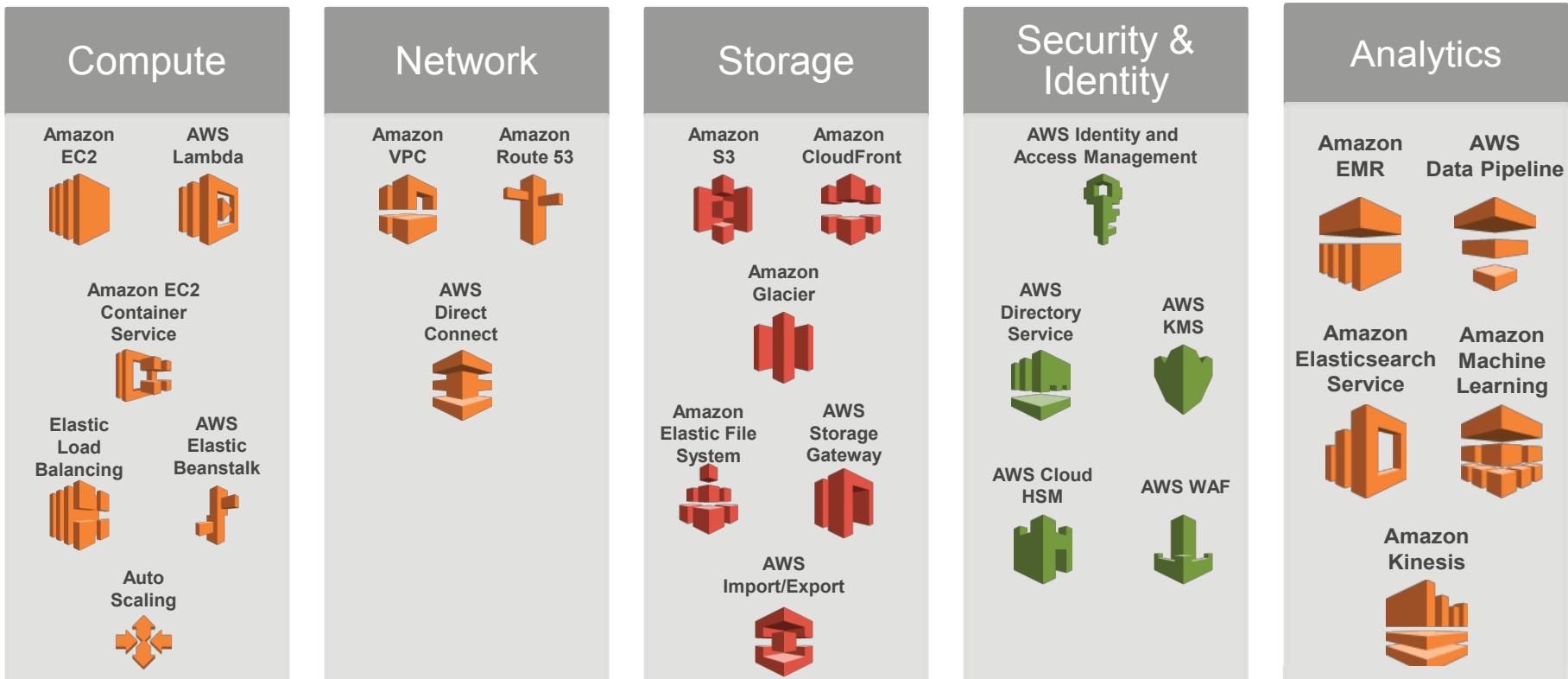
AWS basics

Infrastructure

- At least 2 Availability Zones per region.
- Examples:
 - US East (N. Virginia) - us-east-1a, us-east-1b, us-east-1c, ...
- Allows both fault tolerance (replication) and data locality control



Core Services



Amazon Elastic Compute Cloud (EC2)

- ◎ Resizable compute capacity
 - Complete control of your computing resources (IaaS)
 - Reduced time to obtain and boot new instances
- ◎ Allows Linux and Windows images (AMI)
 - Several images available for free
 - You can create your own images
- ◎ Possibility to choose the instance type based on several parameters (and costs)
 - CPU, memory, storage, and network requirements

AWS instance families

- ◎ General purpose
 - Ex : t2.small (Xeon Processor 1 vCPU, 2 GB RAM)
 - a1.large (Arm processor, 2 vCPUs, 4 GB RAM)
 - a1.metal (Arm, 16 physical cores, 32 GB RAM)
- ◎ Computing optimized instances – HPC, analytics
 - Ex: c5 – Xeon Cascade Lake or Platinum 8000 (Skylake-SP)
 -
- ◎ Memory Optimized instances
 - Ex: r5 – up to 768 GB of RAM
- ◎ GPU instances
 - Ex: p3 (up to 8 GPU NVIDIA Tesla V100)
 - g4 (NVIDIA T4 Tensor core)



Need to ask
a quota
extension

Launching an instance from Console

1. Determine the AWS Region in which you want to launch the Amazon EC2 instance
2. Launch an Amazon EC2 instance from a pre-configured Amazon Machine Image (AMI)
3. Choose an instance type based on CPU, memory, storage, and network requirements
4. Configure network, IP address, security groups (firewall rules), storage volume, tags, and **key pair**
 - Yep, access is not simply ssh with "user/password"
 - But we can create an image allowing it

EC2 Purchase Options

On-Demand Instances

Pay by the hour.

Reserved Instances

Purchase, at a significant **discount**, instances that are always available

1-year to 3-year terms.

Scheduled Instances

Purchase instances that are always available on the specified **recurring schedule**, for a one-year term.

Spot Instances

Bid on unused instances, which can run as long as they are available and your bid is above the Spot price.

Dedicated Instances

Pay, by the hour, for instances that run on single-tenant hardware.

Dedicated Hosts

Pay for a physical host that is fully dedicated to running your instances.



Storage: EBS vs S3

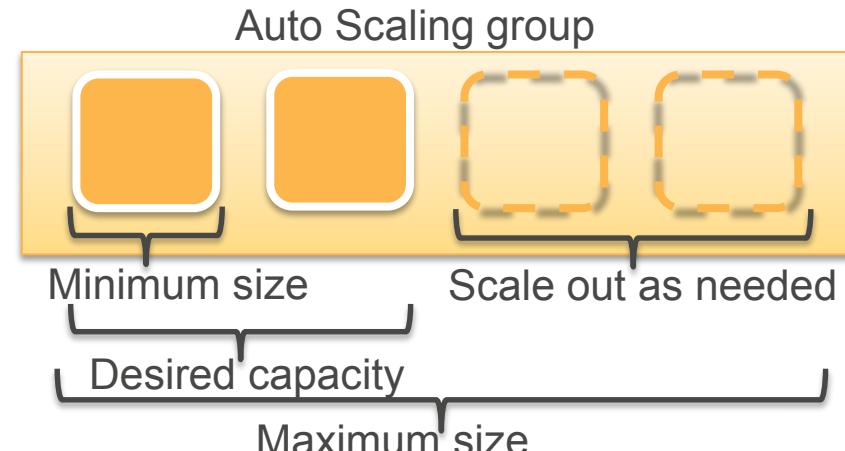
	Amazon EBS	Amazon S3
Paradigm	Block storage with file system	Object store
Performance	Very fast	Fast
Redundancy	Across multiple servers in an Availability Zone	Across multiple facilities in a Region
Security	EBS Encryption – Data volumes and Snapshots	Encryption
Access from the Internet?	No (1)	Yes (2)
Typical use case	It is a disk drive	Online storage



Launching Options

- ◎ Load Balancing
 - Creates a group of instances
 - A monitor dispatches requests according to a metric (health checking)

- ◎ Autoscaling
 - Automatically scales the EC2 capacity (horizontally)
 - Interesting for applications that experience variability in usage



GCP basics

Datacenters



Computing core services

- ◎ App Engine
 - Allow to publish applications as services
 - ◎ Ex: a python Flask web server for a page
- ◎ Computer Engine
 - Like AWS EC2
 - Instances, groups, load balancers, autoscaling, ...

~~Container~~ Kubernetes Engine

- Service that allows running containers using the Kubernetes orchestrator



Computer Engine processors

- ◎ Basically 3 families of processors
 - N1 – main group of processors, instances can run on top of Intel Sandy Bridge, Ivy Bridge, Haswell, Broadwell or Skylake
 - Ex: n1-standard-2
 - 2 vCPUs, 7.5 GB RAM
 - Also variants "highmem" and "highcpu"
 - N2 – Second generation
 - relies on Intel Cascade Lake processors
 - Incompatible with GPUs
 - E2 – economy instances that can run on Intel ou AMD EPYC, have limited capabilities but are less expensive
- ◎ What about the GPUs?

They are simply an option when choosing the N1 family

Examples of supported GPUs

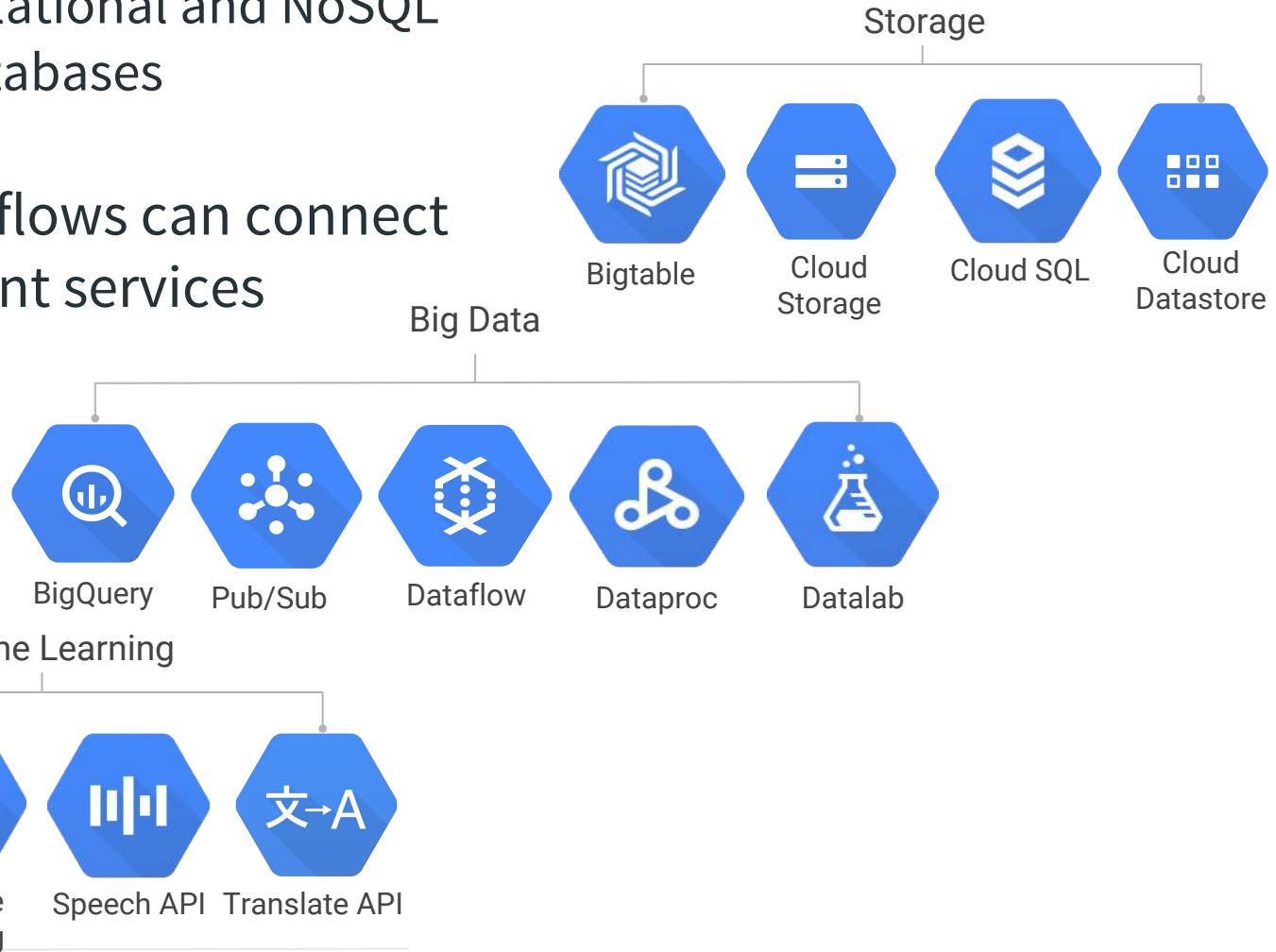
- ◎ Any N1 instance can be equipped with up to 8 GPUs
 - NVIDIA Tesla K80
 - NVIDIA Tesla P4
 - NVIDIA Tesla T4
 - NVIDIA Tesla V100
- Besides NVIDIA GPUs, we can also create TPUs
 - Tensorflow processor units
 - Designed and still kept proprietary by Google
 - TPUs act as a second instance



Need to ask
a quota extension

Storage and Big Data/ML Services

- ◎ Storage services planned for the use with Big Data tools
 - Relational and NoSQL databases
- ◎ Workflows can connect different services



Summing up

- ◎ Today we saw basic elements from cloud computing
- ◎ Rapid overview on both AWS and Google clouds
- ◎ The program for tomorrow:
 - Kubernetes Engine
 - AI Platform
 - AutoML tools
- ◎ And for the practice session:
 - Deploy instances on AWS and GCP
 - Deploy containers on GCP with Kubernetes
 - Experiment some Machine Learning tools on GCP

Contact

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