Principles of Computer Science II

Cloud Computing

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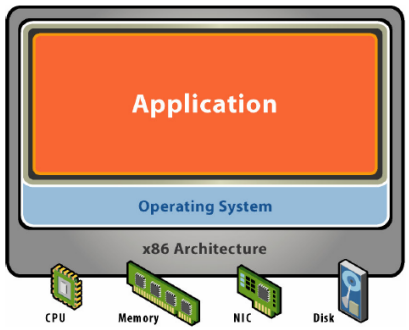
Lecture 9

Virtualization

- Virtualization deals with "extending or replacing an existing interface so as to mimic the behavior of another system"
- Virtual system examples:
  - virtual private network,
  - virtual memory,
  - virtual machine,
  - ...

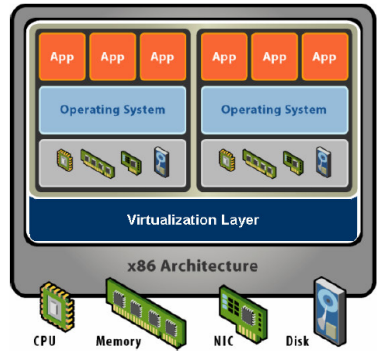
Starting Point: Physical System

- Physical Hardware
  - Processors, Memory, I/O devices, ...
  - Physical resources often underutilized
  - Periods that are over-utilized
- Software:
  - Tightly coupled to Hardware,
  - Single active OS,
  - OS controls Hardware



What is a Virtual Machine?

- Hardware-level Abstraction
  - Virtual Hardware: Processors, Memory, I/O devices, ...
  - Encapsulates all OS and application state.
- Virtualization Software:
  - Extra level of indirection decouples hardware and OS,
  - Multiplexes physical hardware across multiple "guest" VMs,
  - Strong isolation between VMs,
  - Manages physical resources, improves utilization.

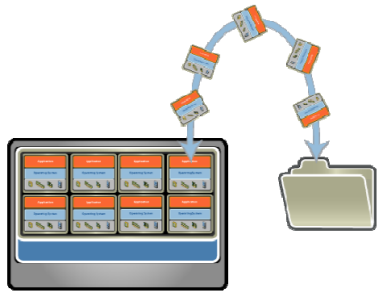


Virtual Machine Isolation

- Secure Multiplexing:
  - Run multiple VMs on single physical host,
  - Processor hardware isolates VMs.
- Strong Guarantees:
  - Software bugs, crashes, viruses within one VM cannot affect other VMs
- Performance Isolation:
  - Partition system resources,
  - Example: VirtualBox controls for reservation, limit, shares.

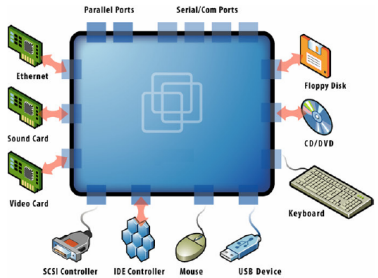
Virtual Machine Encapsulation

- Entire VM in a file:
  - OS, applications, data;
  - Memory and device state.
- Snapshots and Clones:
  - Capture VM state on the fly and restore to point-in-time,
  - Rapid system provisioning, backup, remote mirroring.
- Easy Content Distribution:
  - Pre-configured apps, demos.
  - Virtual Appliances.



Virtual Machine Compatibility

- Hardware Independent:
  - Physical hardware hidden by virtualization layer,
  - Standard virtual hardware exposed to VM.
- Create Once, Run Anywhere:
  - No configuration issues,
  - Migrate VMs between hosts.
- Legacy Virtual Machines:
  - Run legacy OS on new platform.



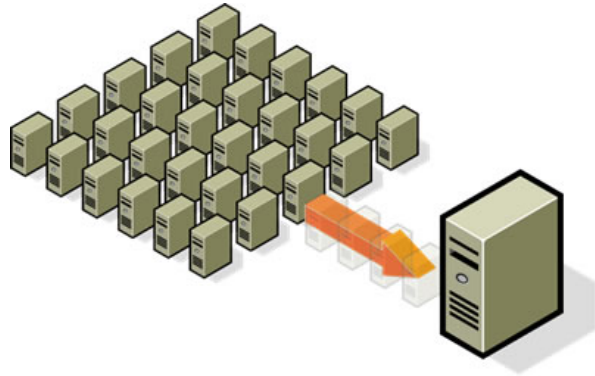
Common Uses

- Test and Development
  - Rapidly provision test and development servers.
  - Store libraries of pre-configured test machines.
- Business Contunuity
  - Reduce cost and complexity by encapsulating entire systems into single files
  - Replicated and restored on demand into any target system.
- Enterprise Desktop
  - Secure unmanaged PCs without compromising end-user autonomy by layering a security policy in software around desktop virtual machines.

Common Uses

- Run legacy software on non-legacy hardware
- Run multiple operating systems on the same hardware
- Create a manageable upgrade path
- Manage outages (expected and unexpected) dynamically

Virtualized Data Centers



Reduce costs by consolidating services onto the fewest number of physical machines

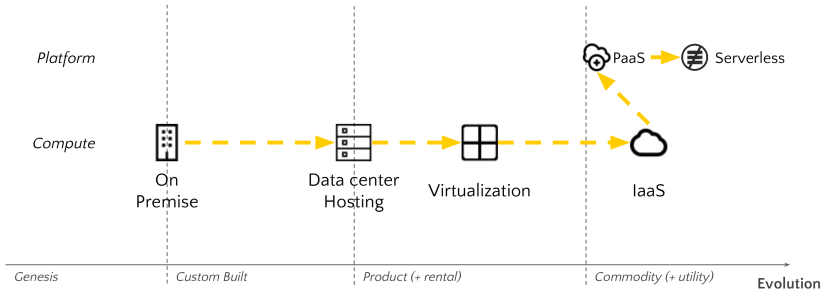
Non-virtualized Data Centers

- Too many servers for too little work
- High costs and infrastructure needs
  - Maintenance
  - Networking
  - Floor space
  - Cooling
  - Power
  - Disaster Recovery

Dynamic Data Centers

- Virtualization helps us break the "one service per server" model
- Consolidate many services into a fewer number of machines when workload is low, reducing costs
- Conversely, as demand for a particular service increases, we can shift more virtual machines to run that service
- We can build a data center with fewer total resources, since resources are used as needed instead of being dedicated to single services

Towards Serverless Computing



Function as a Service

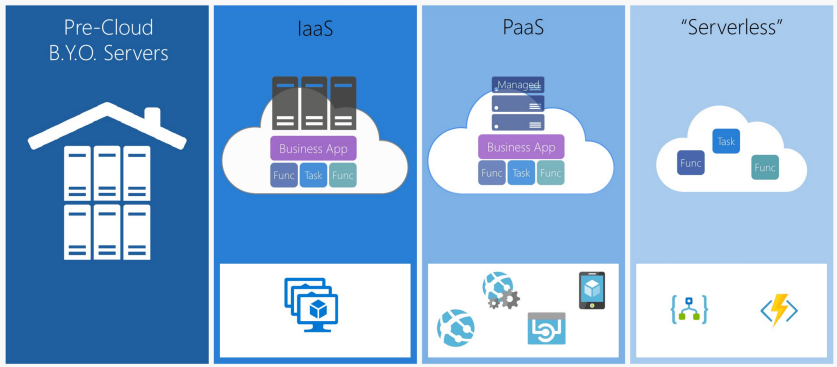
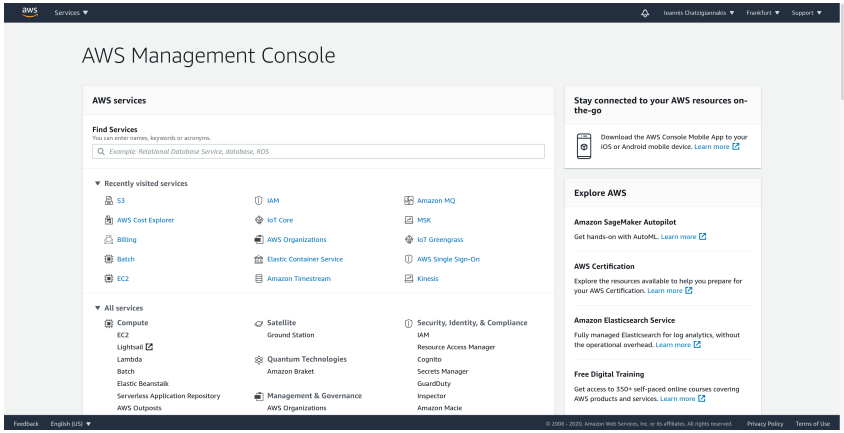
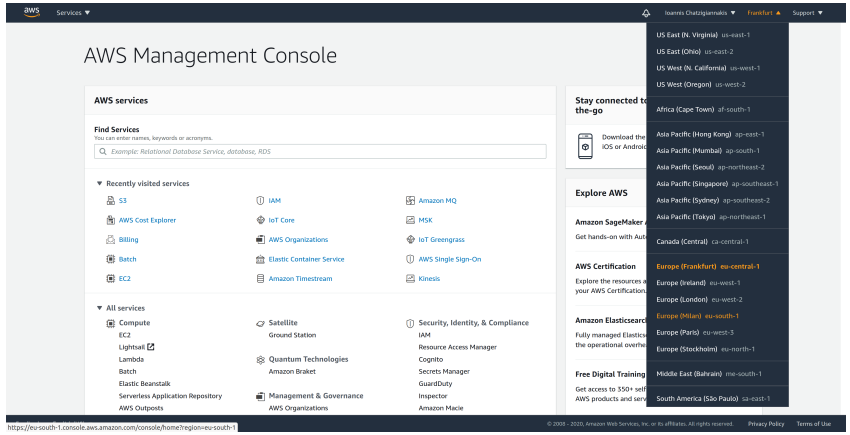
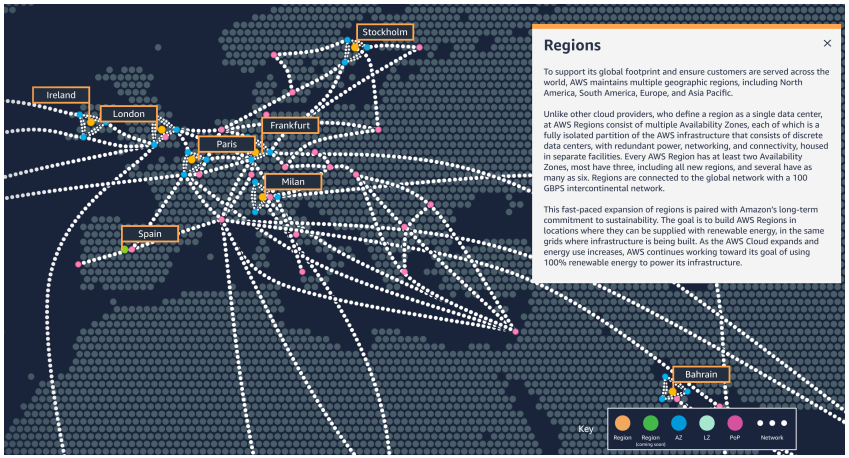


Figure 1. Magic Quadrant for Cloud Infrastructure and Platform Services





AWS Infrastructure



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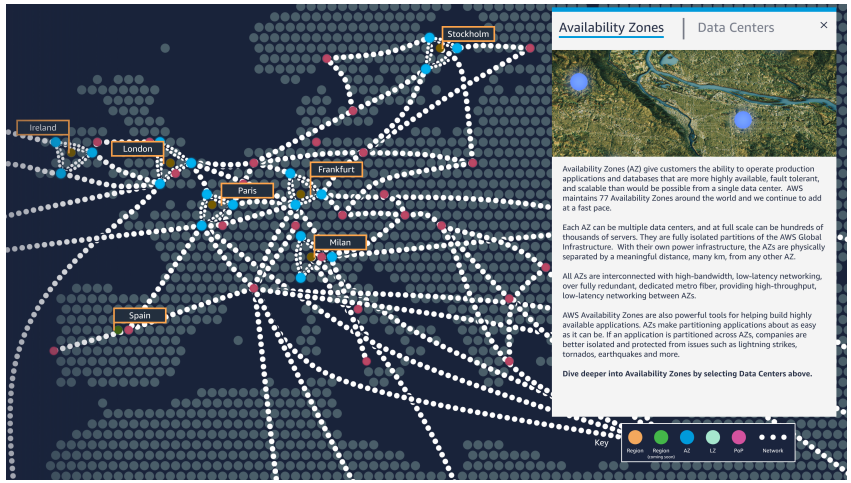

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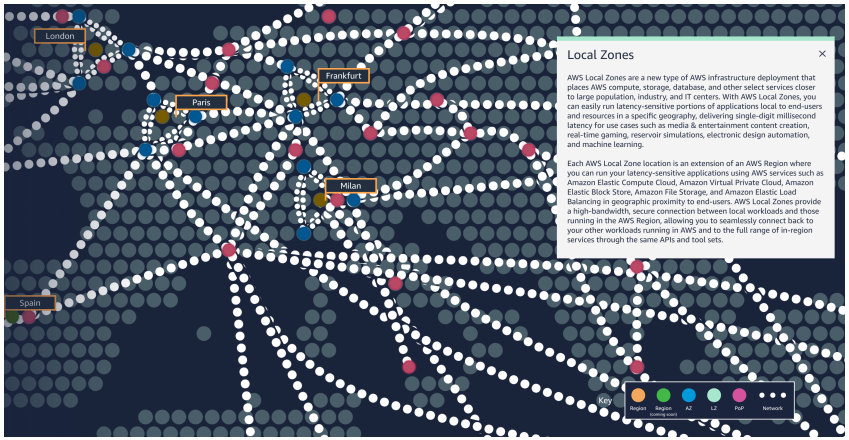

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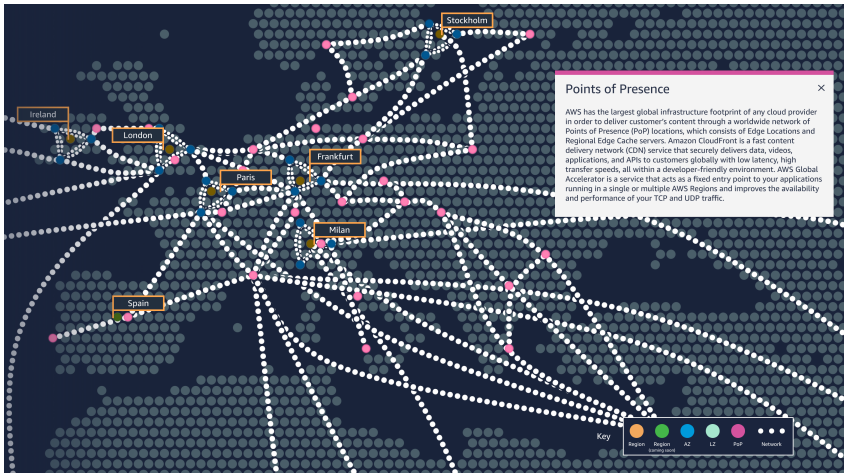

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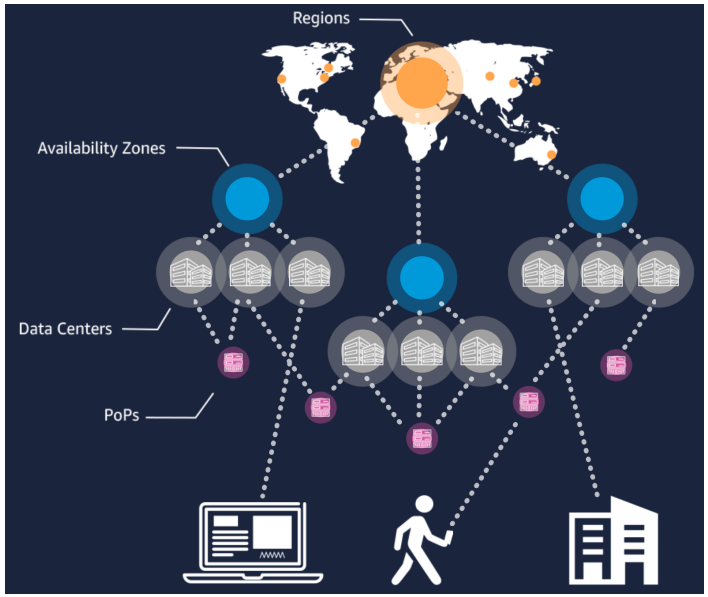

Introduction to AWS S3

- S3 = Simple Storage Service
  - From 0 bytes to 5 Tbytes.
- Provides a secure, durable, highly-scalable storage space.
  - AWS secures content with encryption, ACL and bucket policies.
  - AWS guarantees 99.999999999% durability (11 $\times$ 9s).
  - AWS guarantees 99.99% availability.
- We can access items stored:
  - Using the web.
  - Using the Web Console.
  - Using the Smartphone App.
  - From the Command line AWS tool.
  - Programmatically through the AWS S3 API.

S3 Basics

- Object-based storage.
  - Files = Objects.
  - Not suitable to install an operating system or host a database.
- Files/Objects are organized in Buckets.
- Bucket names must be unique – S3 is a universal namespace.
  - `http://sapienza2020adm.s3.amazonaws.com/`
  - When you create a new S3 bucket, AWS creates a new web address.
- Objects (Files) have the following properties:
  - Key: the name of the object.
  - Value: the actual contents.
  - Version ID: used by the versioning system.
  - Metadata: tags that we can attach to objects.
  - ACL: who can access the object.

S3 Storage Classes

- Free Tier – new AWS accounts
  - 5GB of S3 storage.
  - 20,000 GET – 2,000 PUT/COPY/POST/LIST
  - 15GB of Data Transfer Out each month for one year
- S3 Standard
  - $0.0245 per GB
  - $0.0054 per 1000 PUT/COPY/POST/LIST
  - $0.00043 per 1000 GET/SELECT/all other requests.
- S3-IA Infrequent Access
  - $0.0135 per GB – a minimum storage duration of 30 days.
  - $0.01 per 1000 PUT/COPY/POST/LIST
  - $0.001 per 1000 GET/SELECT/all other requests.
- S3 Glacier
  - $0.0045 per GB – a minimum storage duration of 90 days.
  - $0.06 per 1000 PUT/COPY/POST/LIST
  - $0.00043 per 1000 GET/SELECT/all other requests.

3^{th} Assignment

- https://www.rosalind.info/
  - Complete the following challenges:
    fibo, ins, maj, mer, 2sum, bins, ms, par, 3sum, inv, par3, med
  - http://rosalind.info/problems/{challenge}
- Create a GitHub repository and upload the code for each exercise.
- Email `ichatz@diag.uniroma1.it`
  Subject: [PCS2] Homework 3
  Your GitHub repository with your solutions, for all challenges.
  Also send your account user account link:
  http://rosalind.info/users/{username}
- **Deadline: 13/November/2020, 23:59**