



Cloud Computing

Class 1: Introduction



Stelios Sotiriadis

Welcome to Cloud Computing 2022!

- ✔ This is a module for:

- ▶ Cloud Computing Concepts (BUCI028H6)
- ▶ Cloud Computing (BUCI029H7)

- ✔ Are you up for the challenge?

- ▶ “Look at a day when you are supremely satisfied at the end. It’s not a day when you lounge around doing nothing; it’s a day you’ve had everything to do and you’ve done it.” [Margaret Thatcher]

Plan for today

✓ Lecture session part 1:

- ▶ Module administration
 - Is this module for me?
 - Assessment plan
 - Syllabus

✓ Lecture session part 2:

- ▶ What is Cloud Computing?
- ▶ What are the advantages?
- ▶ What are the cloud deployment models?
- ▶ What is virtualization?

✓ Lab session:

- ▶ Connect to the Google Cloud Platform
- ▶ Run Linux commands
- ▶ Install Apache2 server and create a simple cloud service



Module administration

Are you registered?

- ✔ Cloud computing is not open for audit
 - ▶ If you are not registered please exit Teams now!



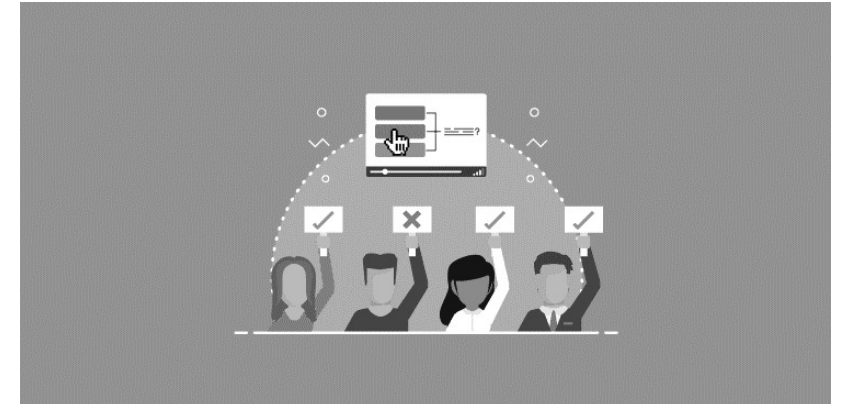
Class starts at 6pm sharp!

✔ Please join **5** minutes earlier



Let's have an interactive class!

- ✓ Please turn on your camera, microphone and interrupt me any time you like
- ✓ **Participate in class, making mistakes is good!**
- ✓ If you don't get it, ask!
- ✓ Be gentle with MS Teams...



Cloud computing 2022

✓ To cover:

- ▶ State-of-the-art systems for Cloud application development and deployment
- ▶ Programming Cloud services using **NodeJS** and **Python**
- ▶ Di
- ▶ The module assumes that you have an **excellent** knowledge of programming (Python or Java etc.)
 - Or you are eager to learn!

What is this module about?

- ✔ Is about:

- ▶ The theory of **distributed systems**, focusing on Cloud Computing
- ▶ The use of **distributed computing technologies** to develop distributed Cloud applications using NodeJS and Python

- ✔ This is a module for Computer Scientists:

- ▶ Software developers, computer and data scientist aiming to the direction of software solutions for scalable application development and big data systems!

About Stelios

- ✔ PhD on scheduling in distributed systems
 - ▶ How large-scale systems can run faster and efficient
 - ▶ Heavily involved with data analytics and algorithms
- ✔ Worked as a researcher and developer to solve modern industry-based problems to improve systems performance
 - ▶ I developed projects for University of Toronto, Huawei, Autodesk, IBM and other companies and various startups in US, Canada, UK and EU
 - Looking to bring my experiences in class

How to contact?

- ✓ MS Teams (preferred way)
 - ▶ Feel free to send any time
- ✓ My office:
 - ▶ Room 151A (unlikely to find me there...)
- ✓ Me email:
 - ▶ s.sotiriadis@bbk.ac.uk

Cloud Computing on Social Media and Git

✓ YouTube channel:

▶ [CloudTV](#)

✓ LinkedIn channel:

▶ [cloud@Birkbeck](#)

✓ GitHub repository

▶ [Link to cc repo](#)

Classes will be online

- ✔ Classes will be delivered on MS Teams and will be recorded
 - ▶ Recordings will be available on Moodle
- ✔ To run the labs:
 - ▶ You will need patience!
 - ▶ Make sure you follow the instructions
- ✔ Labs are highly complex and require dedication

Material and timetable

- ✓ Material is on Moodle
 - ▶ Update of content: Material will be available every week 15' before the start of a class
- ✓ Times and place are unlikely to change (if so, I will let you know)
- ✓ Virtual Office hours:
 - ▶ Friday 4-6pm, send in Teams or contact to plan a meeting another day
- ✓ The teaching assistants are:
 - ▶ Spyros Chouliaras
 - ▶ Simona Stavarache
 - ▶ Jitesh Vora
 - ▶ Feel free to contact them for help in Teams (not for debugging..)
- ✓ Support sessions will be organised soon

Material is updated yearly

- ✔ I always try to improve the material
 - ▶ Material will be updated, make sure you download the updated slides
 - Check latest version on Moodle (usually slides will be online 5:30 pm)
 - ▶ Classes are linked, if you miss a class:
 - Make sure you watch the recordings and complete the labs
 - ▶ Lecture slides require extra study...
 - ▶ Labs are huge! You need to commit!



Prerequisites

- ✓ **Excellent** knowledge of **Python** programming
 - ▶ BSc: SP2; MSc: POP1 etc.
- ✓ Willingness to work with Unix environments
- ✓ No prior knowledge of parallel and distributed systems is required, **only enthusiasm!**
- ✓ No need to know NodeJS, but willingness to learn fast
- ✓ **But you need to have an excellent background in programming (Python)**
 - ▶ Object oriented programming, Functional programming, exception handling etc.

This is a heavily involved programming class!

The module is not for you if...

- ✓ You are not genuinely interested in the topic of **DISTRIBUTED SYSTEMS**
- ✓ You cannot put in the time
 - ▶ 1 hour in class requires 2-5 hours study outside the class
- ✓ You are not ready to do **a lot of programming** work
 - ▶ Coding, configuration and use of command line interfaces
- ✓ This module is designed for the BSc Computing/MSc Advanced Computing Technologies
- ✓ We will learn **hands on Cloud application and service development and deployment** using the NodeJS framework
- ✓ Coursework is challenging!

Assessment

✓ Programming coursework (30%)

- ▶ BSc: One programming coursework with a report.
- ▶ MSc: One programming coursework with a report.
- ▶ Coursework will be published in Week 1
 - Time to complete the coursework: 14 weeks
 - You can start working on it after week 4
 - A new coursework every year!

✓ Written examination (70%)

- ▶ Based on lecture and lab sessions
 - Exam will include writing coding tasks
 - Plus: Theory of distributed systems and understanding of algorithms

How the class is planned

✓ Lectures

- ▶ Theory
 - Usually half of the session time
- ▶ Each class starts with a short quiz on last class material
 - Time to complete: 5 minutes (18.00-18.05), so join on time!

✓ Labs

- ▶ In-class exercises aligned with the coursework
- ▶ Each student will have access to a virtual machine
 - This year we will use Google Cloud and MS Azure

✓ Tutorials

- ▶ Demonstrations on how to access, use and deploy systems
- ▶ On-screen demos, will be recorded for further study

Resources and virtual environments

- ✔ Each student has access to the Google Cloud Platform (GCP) and Microsoft Azure.
 - ▶ Each student will redeem:
 - \$50 coupon (GCP)
 - \$100 in MS Azure
 - ▶ For GCP: You will need to have a Gmail account
 - ▶ For MS Azure: You will need to use your University account
 - No credit card or any other information is required
 - Tutorial will be released soon...
 - ▶ We will learn how to use and deploy software in GCP and MS Azure

Syllabus

✓ Class 1 – Week1

- 🖥️ Cloud computing Introduction
- 🔧 Setting up a work environment + basic Linux commands

✓ Class 2 – Week2

- 🖥️ Cloud services
- 🔧 Developing cloud applications with NodeJS and MongoDB

✓ Class 3 – Week3

- 🖥️ Microservices, REST and introduction to Distributed systems
- 🔧 Developing RESTful APIs with NodeJS, MongoDB and OAuth

✓ Class 4 – Week4

- 🖥️ Distributed systems theory
- 🔧 Distributed applications with Python

✓ Class 5 – Week5

- 🖥️ Advanced distributed systems algorithms
- 🔧 Introduction to containerised systems with Docker

✓ Bonus class – Week6 (reading week)

- 🖥️ Let's decide together!
- 🔧 Blockchain, or MongoDB workshop or Graph DBs (Neo4J), Kubernetes or ..?
- * Material of bonus class will not be assessed!

✓ Class 6 – Week7

- 🖥️ Transactional and Messaging systems
- 🔧 Using Kafka/ZeroMQ for developing messaging applications

✓ Class 7 – Week8

- 🖥️ Practical DevOps
- 🔧 Infrastructure as a code with Terraform

✓ Class 8 – Week9

- 🖥️ Distributed databases (NoSQL)
- 🔧 Developing applications using Apache Cassandra NoSQL system

✓ Class 9 – Week10

- 🖥️ Introduction to Big Data using Hadoop MapReduce
- 🔧 Deploying Hadoop MapReduce and running big data applications

✓ Class 10 – Week11

- 🖥️ Big Data using Apache Spark
- 🔧 Deploying and running Apache Spark analytics

On course completion

- ✔ Understand Cloud computing architecture and models
 - ▶ Cloud scalability and elasticity
- ✔ Use Linux systems for application deployment
- ✔ Develop and deploy Cloud applications and secure RESTful web services
- ✔ Use of Linux to configure complex systems
- ✔ Understand complex distributed systems algorithms and systems
- ✔ Understand containerized environments
 - ▶ Use of Docker for deployment
- ✔ Understand how Big Data systems work (Hadoop Map Reduce and Apache Spark)

Questions?

- ✔ Thank you!



Lecture 1: Cloud, a gentle intro

We make sacred pact...

I promise teach karate to you, you promise learn.

I say, you do, no questions...

*not in our case!

[Mr. Miyagi]



Material to cover today

✓ Cloud Computing lecture session

- What is cloud computing?
- What is a virtual machine?

✓ Lab session:

- ▶ Connect to virtual machine in Google Cloud Platform (GCP)
- ▶ Using the Linux command line interface
 - Basic commands
 - Deploy a web server
 - Run a simple application
 - Develop a service

Some facts!

- ✓ How much data is generated every minute?
 - ▶ YouTube users search 5M videos per day
 - ▶ Netflix users spent a combined **164 million** hours per day watching content
 - ▶ Amazon ships 306 items per second
 - ▶ In the fourth quarter of 2020, Uber's ridership worldwide reached 1.4 billion trip, it was 1.9 in 2019...
 - ▶ Instagram users post 49.380 photos
 - ▶ Google conducts 5.9M searches per day, it was 3.9 two years ago...
 - ▶ Everyday, we create roughly **2.5 quintillion bytes** of data.

640K ought to be enough for anybody!
(B. Gates – a rumor)



Essential questions?

- ✓ Where is such humongous data stored?
- ✓ How is data managed?
- ✓ Do we have enough resources to accommodate data, if data size is growing every day?
 - ▶ That is called data scaling
- ✓ How fast a software can analyze such data?
 - ▶ Computational intensive applications:
 - Need a lot of CPU and memory
 - ▶ Data intensive applications
 - Big data software solutions
 - Need CPU, memory and access to huge storage

Cloud computing aims to answer such questions!

Where data is stored?

✓ In a Cloud datacenter...

- ▶ A building, dedicated space within a building, or a group of buildings used to house computer systems and associated components, such as telecommunications and storage systems. [[Source](#)]

Apple (Maiden, N.C.)



NSA (Utah)



Switch SUPERNAP Campus (Las Vegas)
Size: 7 football fields...



SUPERNAP at a glance

- ✓ SUPERNAP

- ▶ A big building with a lot of electricity and air conditioning.
- ✓ It uses renewable power sources, the Nevada desert is an ideal place for solar panels
- ✓ From the street, though, all you see is a high concrete wall – to innocent bystanders, it could be a prison or military base back there
- ✓ SUPERNAP clients include eBay, AWS, Marvel, Cisco, PS4, MGM, Verizon, Salesforce, HP, Deutsche Bank...
 - ▶ [\[Source\]](#)





Quiz 1!



✓ Is it true or false?

- a. A cloud data service is located somewhere away from your company's physical premises and lets you access your data through the internet.
- b. In a cloud datacentre, the actual hardware is managed and run by a client that hires system administrators to support IT operations.
- c. Netflix is an example of a computational expensive application



Quiz 1!

True or False?

- a. A cloud data service is located somewhere away from your company's physical premises and lets you access your data through the internet.
- b. In a cloud datacentre, the actual hardware is managed and run by a client that hires system administrators to support IT operations.
- c. Netflix is an example of a computationally expensive application

That's true 😊

That's false, the hardware is managed by the cloud provider)

According to Netflix, you use about **1GB of data per hour for streaming a TV** show or movie in standard definition and up to 3GB of data per hour when streaming HD video, so it could be considered as a data intensive application.

The Cloud need...

- ✔ Companies need computational power (CPU, Memory, Disks, Networks, Storage systems) to run their workloads.

- ▶ What is a workload?

A Cloud workload is the amount of computational work required from an application or service that can be run on a Cloud server.

- ▶ For example, serving up a Web site or watching a movie in Netflix is a Cloud workload.
 - Storing data in your iCloud is also a workload

What do we need as Cloud users?

- ✓ Remote access to a reliable infrastructure
- ✓ Cheap hardware in a pay per use model
 - ▶ No IT costs
- ✓ Scalable (if we need more resources we just ask)
- ✓ Offsite data storage
 - ▶ Not in our computer...
- ✓ Security and reliability
 - ▶ Cloud providers promise 99.9% service uptime
 - ▶ This is called Service Level Agreement (SLA)
 - An SLA outlines what a Cloud provider intends to provide, and the client expects to receive

What is Cloud computing?



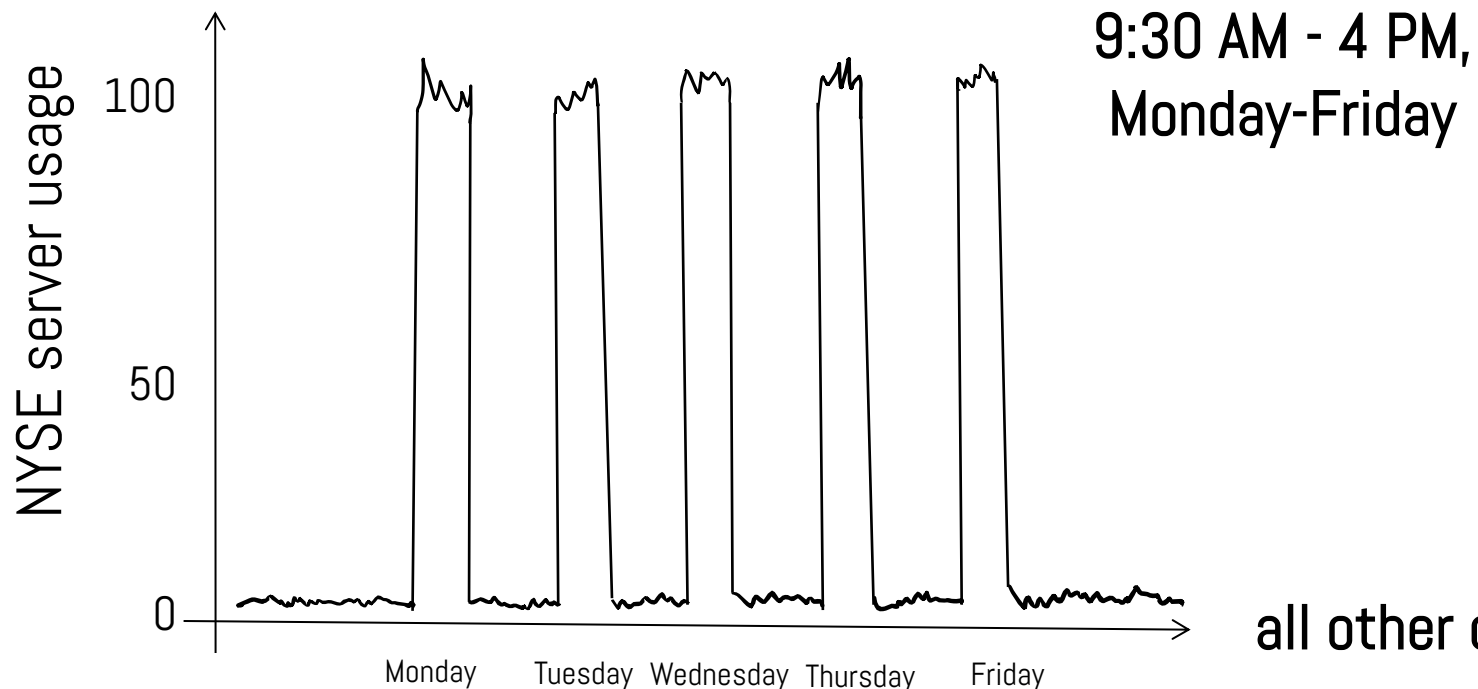
- ✔ Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user.
[[Wikipedia](#)]
- ✔ Cloud computing includes a variety of technologies including virtualization, storage services, networks and other.

What is Cloud Computing?

- ✓ Example of New York stock exchange market
 - ▶ www.nyse.com
- ✓ NYSE is the largest equities-based exchange in the world, according to the total market capitalization of its listed securities
 - ▶ Data is generated on huge volumes
- ✓ Core Trading Session: 9:30 a.m. TO 4:00 p.m. ET
 - ▶ NYSE calendar

NYSE system

- ✓ On-line real time stock market data system resource utilization
 - ▶ Example of NYSE workload



- Why to pay for resources and capacity for evening-early morning and weekends?
- Why to run the servers if there aren't any workloads?

Use of a Cloud provider!

- ✓ Use of a Cloud provider to deploy NYSE system such as Google Cloud, Amazon EC2 etc.
- ✓ Provision new servers every morning before 9:30 and deprovision after 4:30pm!
- ✓ Payments of \$0.10* per server per hour
- ✓ The Cloud provider will manage and administer the infrastructure
 - ▶ NYSE will access it remotely
 - ▶ 24/7 support with high availability
- ✓ Contract between service provider and client
 - ▶ Service level agreement (SLA)
 - ▶ Service will be up and running 99.99% of the time

What is provision?

✓ Provision of resources:

- ▶ Create a virtualized environment with resources
 - Resources: CPU, memory, hard disk, virtual networks etc.
- ▶ Cloud environments are virtualized, this means it is easy to scale up in size
 - Scale up means:
 - From 2 cores, 4GB RAM, 100GB disk to move to
 - 4 cores, 64GB RAM, 250GB disk

What is deprovision?

- ✔ Deprovision of resources:
 - ▶ Freeing up resources
 - ▶ In some case refer to changing the configuration of a virtualized environment
 - ▶ Deprovision also refers: turning off a virtual server
 - More cheap!

SLA vs SLO

- ✓ A **service level agreement**, or SLA, is a formal set of service commitments made to a customer by a service provider.
 - ▶ Google Cloud SLA:
 - Cloud Functions uptime $\geq 99.95\%$
- ✓ A **service level objective**, or SLO, is a specific target for a service metric that is included in an SLA.
 - ▶ Google Cloud SLO:
 - "Service responses shall be faster than 400 milliseconds (ms) for 95% of all valid requests measured over 14 days."



SLA vs SLO vs SLI

✔ A service level indicator:

- ▶ An SLI should be measured as a percentage such that 0% constitutes horrible (non-existent) performance and **100% represents a perfect performance**.
- ▶ SLA specifies that your systems will be available 99.95% of the time, your SLO is likely 99.95% uptime and your SLI is the actual measurement of your uptime. Maybe it's 99.96%.

Quiz 2!



✔ It is an advantage or a disadvantage?

What do you think?:

Security

Reliability

Zero downtime

Bandwidth

Cost savings

Trust of a Vendor

Fully Control

Quiz 2 Solutions...

✔ Cloud advantage or disadvantage?

- ▶ Security → Advantage / Disadvantage (always online)
- ▶ Reliability → Advantage
- ▶ Zero downtime → Advantage (almost zero)
- ▶ Bandwidth → Disadvantage (requires high bandwidth)
- ▶ Cost savings → Advantage (definitely cheaper)
- ▶ Trust a Vendor → Advantage (optimized services) / Disadvantage (vendor lock-in)
- ▶ Fully Control → Advantage (you don't have to worry) / Disadvantage (no control)

Zero downtime deployment is a deployment method where your website or application is never down or in an unstable state during the deployment process.

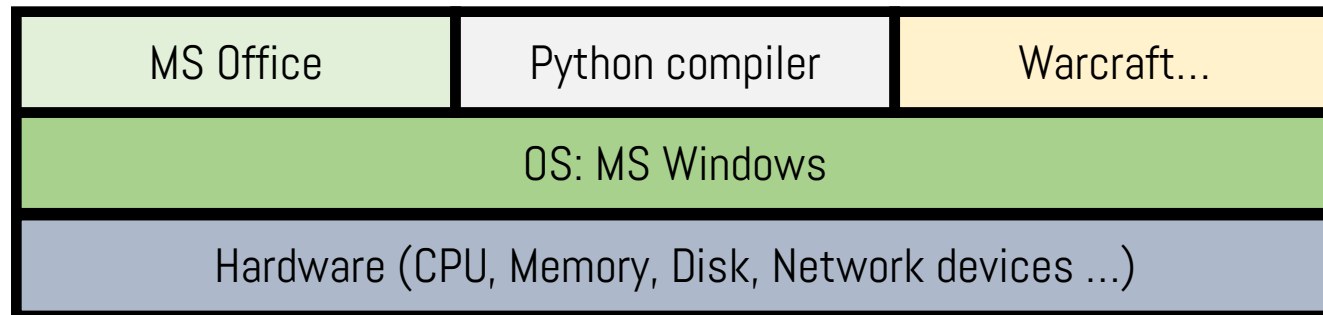
Cloud uses Hardware and Software

✓ What is a stack?

- ▶ It's a data structure,
- ▶ But also a way to demonstrate how hardware (HW) and software (SW) are stacked on top of each other

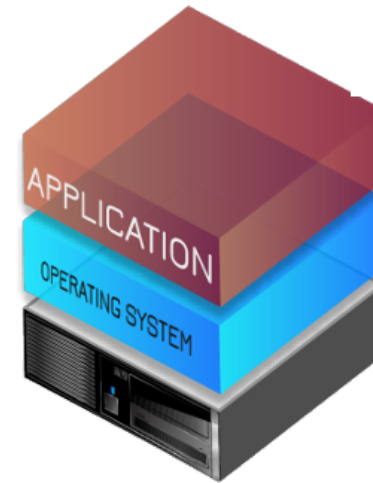
✓ Example?

- ▶ My desktop HW and SW stack looks like this:

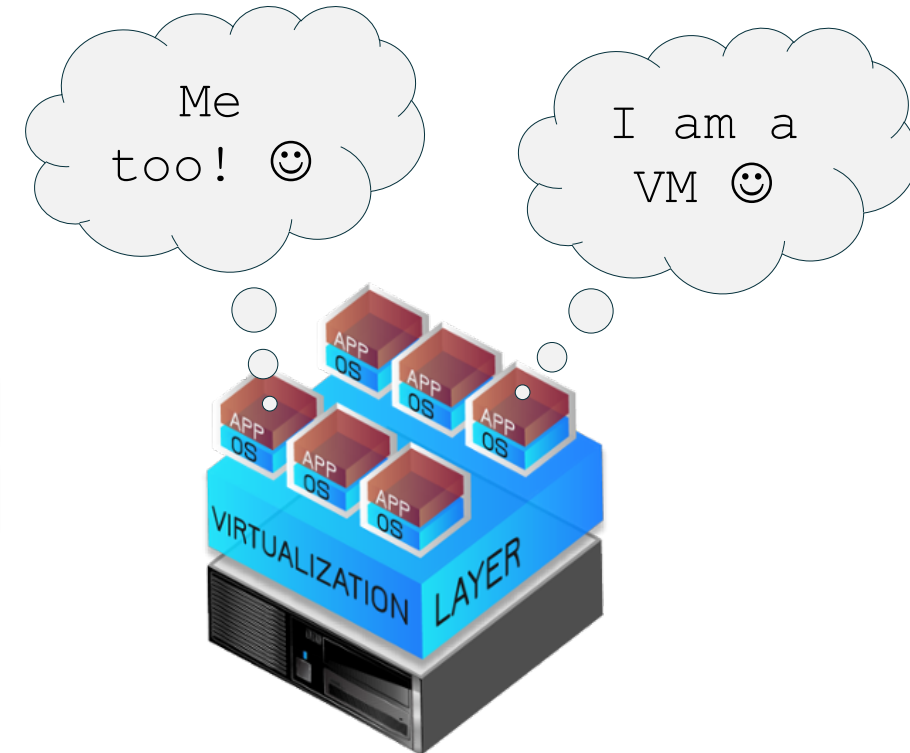


Virtualization

- ✓ Act of creating a virtual (rather than actual) version of something
 - ▶ Something: HW + SW
- ✓ It includes virtual computer hardware platforms, storage devices, and computer network resources. [Wikipedia]



Traditional Server Architecture



Virtualized Server Architecture

Virtual machine (VM)

- ✓ Preferred definition:

- ▶ A virtual machine is a computer file, typically called an image, that behaves like an actual computer

- ✓ Each virtual machine provides its own virtual hardware, including CPU, memory, hard drive, network interface, and other devices.

- ✓ Multiple virtual machines can run simultaneously on the same physical computer.

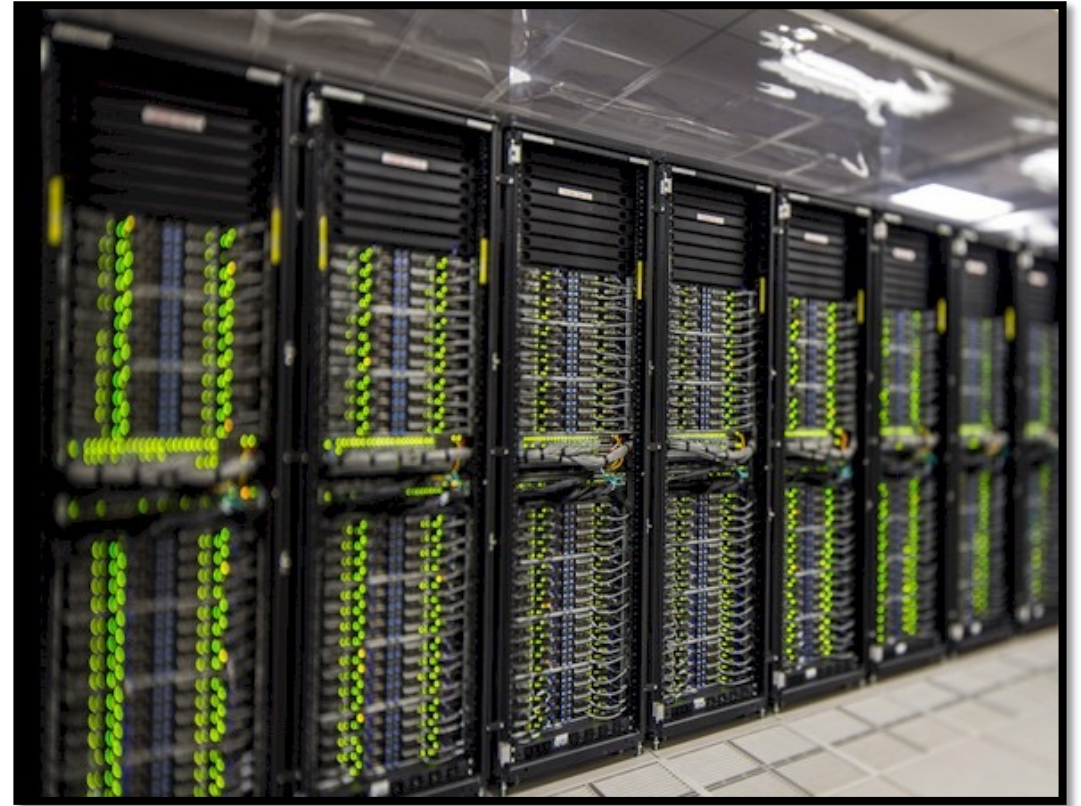
- ✓ The virtual machine is sandboxed from the rest of the system.

- ▶ A VM provides isolation from the rest of the environment

[Source: [MS Azure](#)]

Characteristics of virtualization

- ✓ Multi tenancy in one bare metal server
 - ▶ Bare metal?
 - A 'Single-tenant physical server'
 - Cloud administrators creates several virtual machines (multi-tenancy).
 - ▶ Run multiple VMs of same or different operating systems in same hardware
- ✓ Isolation:
 - ▶ Each VMs is isolated from each other
 - This means that users have access to only their own data and applications



Let us summarize what we just learned

✔ Cloud Computing:

- ▶ A fancy name for a very cool technology
- ▶ Pay as you go for online services (HW and SW)
- ▶ On demand hardware resources over the network

✔ Virtualization

- ▶ Process of creating a virtual version of a computer
- ▶ Virtual machines (VMs) are “seating” on top of a bare metal
 - Easy to manage!
 - Hard to alter (e.g. scale up and down)

Quiz 3!



- ✓ True or False?
- ✓ Cloud computing is the delivery of different software services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, and software.
- ✓ Virtualization is a process that allows for more efficient utilization of physical computer hardware and is the foundation of cloud computing.
- ✓ Virtualisation is mainly dependent on processing power and memory. So you'll need to factor in both much more memory and processing power into your Virtualisation strategy.

Quiz 3 Solutions...

- True or False?
- Cloud computing is the delivery of different software services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, and software.
 - ▶ False, not only software
- Virtualization is a process that allows for more efficient utilization of physical computer hardware and is the foundation of cloud computing.
 - ▶ True
- Virtualisation is mainly dependent on processing power and memory. So you'll need to factor in both much more memory and processing power into your Virtualisation strategy.
 - ▶ True

Cloud Computing systems

✓ Public Cloud

- ▶ Available over the Internet to access, pay and deploy.
- ▶ Amazon EC2, Google Cloud etc.

✓ Private Cloud

- ▶ Under a secure network, usually government or organisation systems

✓ Hybrid Cloud

- ▶ Mix of private and private services

What is Cloud deployment?

- ✔ **Cloud deployment** refers to the enablement of:
 - ▶ SaaS (software as a service)
 - ▶ PaaS (platform as a service)
 - ▶ IaaS (infrastructure as a service)
- ✔ Models are delivered to end users over the Internet
- ✔ **A key technical skill** for a modern computer engineer, application developer and data engineer
 - ▶ Understanding the complexity of a deployment will give you intuitions to develop a better software

Types of Cloud deployment models

- ✓ SaaS – Software as a Service
 - ▶ Software delivered over the Internet
- ✓ PaaS – Platform as a Service
 - ▶ Tools delivered over the Internet
- ✓ IaaS – Infrastructure as a Service
 - ▶ Hardware resources delivered over the Internet

SaaS – Software as a Service

- ✔ Software delivery over the Internet, usually as a Web service
- ✔ SaaS applications are also known as Web-based software, on-demand software and hosted software.
- ✔ SaaS apps are typically accessed by users using a **thin client**, e.g. via a web browser.
- ✔ SaaS providers generally price applications using a subscription fee, most commonly a monthly fee or an annual fee [[Source](#)]

Useful terminology

- ✔ A **thin client** is software that is primarily designed to communicate with a server
 - ▶ Its features are produced by servers such as a cloud platform
 - Web applications e.g. www.google.com
- ✔ A **thick client** is software that implements its own features
 - ▶ E.g. including a local data storage
 - Microsoft Outlook etc.

SaaS – Software as a Service

✓ Example of SaaS products:

- ▶ Google Docs
- ▶ Facebook
- ▶ Email
- ▶ Dropbox
- ▶ Slack
- ▶ Microsoft Office 365
- ▶ ...

PaaS – Platform as a Service

- ✓ A platform allows customers to **develop, run, and manage** applications without the complexity of building and maintaining the infrastructure
- ✓ Its typically associated with developing and launching an app
- ✓ Example of SaaS products:
 - ▶ AWS EC2
 - ▶ Windows Azure
 - ▶ Force.com
 - ▶ Google App Engine
 - ▶ ...

IaaS – Infrastructure as a Service

- ✓ Delivers fundamental compute, network, and storage resources to consumers on-demand, over the internet, and on a pay-as-you-go basis
- ✓ IaaS delivers **virtualized** hardware over the Internet
- ✓ Typically IaaS involves the use of a cloud orchestration technology to manage and create virtualized environments such as Virtual Machines or containers.

IaaS – Infrastructure as a Service

- ✓ Google Compute Engine
- ✓ Amazon AWS
- ✓ Microsoft Azure
- ✓ Rackspace Open Cloud
- ✓ HP Enterprise Converged Infrastructure
- ✓ IBM SmartCloud Enterprise

...

Quiz 4!



✓ True or False?

An online accounting tool (e.g. Xero) is an example of SaaS

Netflix is an example of an application

Gmail is an example of PaaS

A VM is an example of IaaS

Salesforce is an example of SaaS

Quiz 4 Solutions...

✓ True or False?

- ▶ An online accounting tool (e.g. Xero) is an example of SaaS **TRUE**
- ▶ Netflix is an example of an application **TRUE**
- ▶ Gmail is an example of PaaS **FALSE** (it's a SaaS)
- ▶ A VM is an example of IaaS **TRUE**
- ▶ Salesforce is an example of SaaS (it's PaaS and PaaS)

Let us summarize what we just learned

☑ SaaS

- IaaS + PaaS + Application and Data

☑ PaaS

- IaaS + Runtime environment

☑ IaaS

- Virtualized Hardware

Thank you!

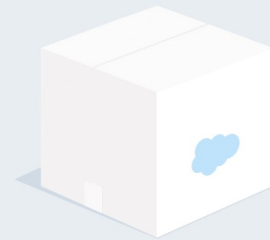
- ✔ Quote:

“Patience you must have, my young padawan”

~ Yoda

- ✔ Time for break...

- ✔ Lab sessions starts in 15'!





Lab 1: Connecting to a VM

Lab preparations

- ✓ Connecting to the GCP
 - ▶ Follow the video tutorials:
 - How to connect to the GCP platform and redeem coupon
 - Setup Visual Studio Code
- ✓ Connecting to the VMs using an editor
 - ▶ Terminal based editors are hard to use, and not recommended when coding...
 - ▶ The use of a good editor is a key to a smooth development-deployment
 - We will use Visual Studio Code

stackoverflow Products Customers Use cases Search...

Home PUBLIC Stack Overflow Tags Users Jobs TEAMS What's this? Free 30 Day Trial

How do I exit the Vim editor?

Asked 7 years, 5 months ago Active 6 days ago Viewed 2.0m times

I'm stuck and cannot escape. It says:

3592 "type :quit<Enter> to quit VIM"

But when I type that it simply appears in the object body.

880 vim vi

share improve this question edited May 14 '19 at 22:49 Peter Mortensen 24.6k • 19 • 89 • 118 asked

123 Are you just trying to quit VIM ? If this is the case, press "escape" and then at 12:28 ✓

Blog Podcast

ONE DOES NOT SIMPLY EXIT VIM

```
:quit
:exit
exit()
:q
:wq
:x
x
quit
leave
omg get me out of here
```

-- INSERT --recording

Just memorize these fourteen contextually dependant instructions

Exiting Vim

Eventually

O RLY? @ThePracticalDev

To do

1. Watch the Video:
 - ▶ Connect to GCP and redeem your coupon
2. Watch the Video:
 - ▶ Setup VSC
3. Follow the tutorials
 - ▶ [Lab 1: Linux Intro](#)
 - ▶ [Lab 2: Linux user management](#)
 - ▶ [Lab 3: Homework](#)

Labs are in CC
GitHub repo



If you don't complete the first class labs you will NOT BE ABLE to complete most of the remaining lab sessions!

End of Class 1



✓ Take home:

- ▶ What is Cloud? What is Virtualization? What is a VM?
- ▶ What are the Cloud deployment models, and what are their differences?
- ▶ Connect to the VM and run commands
- ▶ Play around with the data generator and collector homework