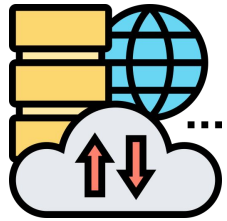
COEN 241
Introduction to Cloud Computing

Lecture 1 - Introduction & Course Overview



Agenda for Today

- Welcome!
- Cloud Computing Primer
- Course Overview
  - Course Objectives
  - Course Structure
  - TODOs
  - Logistics
  - Instructor Information
- Readings
  - Recommended: CCSA 1.1 - 1.3
  - Optional: CCSA 1.5 - 1.15

Welcome to COEN 241!

- About the instructor

- Let's introduce ourselves!
  - Name
  - Department
  - Degree of study
  - Full/Part-Time
  - What do you expect to learn from this class?

What is Cloud Computing?

What is Cloud Computing?

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

* NIST(The National Institute of Standards and Technology)

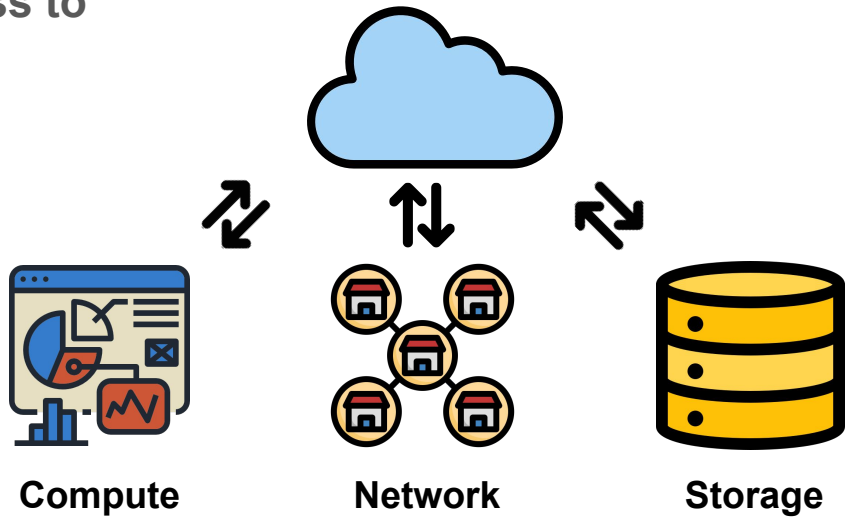
What is Cloud Computing?

- Cloud computing is when you access computing services—like servers, storage, networking, software—over the internet (“the cloud”) from a cloud provider. - Microsoft

- Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centers and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider. - AWS

What is Cloud Computing?

On demand access to

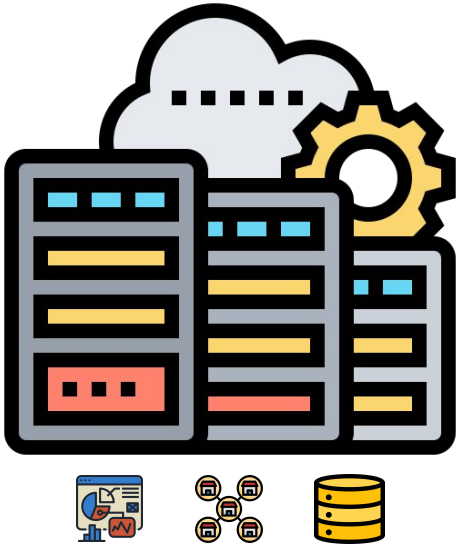


over the internet

What is Cloud Computing?

Clients

Internet



Data Centers

Where did “Cloud Computing” come from?

- Cloud symbol used in diagrams to symbolize the Internet since 1960s.

- The first reported public use of the phrase was in August of 2006 by Eric Schmidt (Ex-Google CEO)

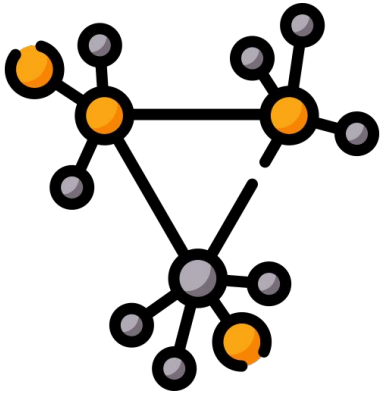
Cloud Computing Enables:

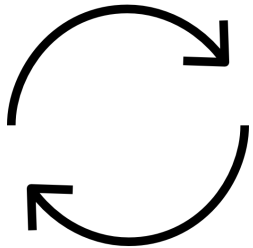
- The illusion of “Ubiquitous” & infinite “Shared Pool” of computing resources available “On-Demand”.
  - Eliminates the need to plan far ahead for provisioning.
- Rapidly and automatically provisioned computing resources.
- Minimal hardware / infrastructure management with increased reliability.

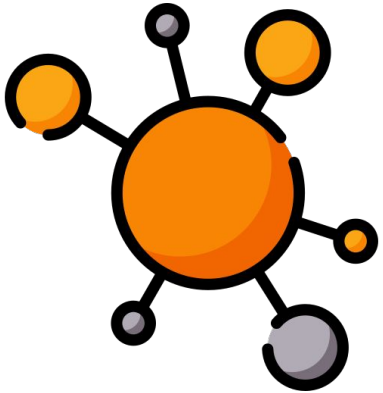
Cloud Computing Enables:

- Access to need-based performance.
- The elimination of an up-front commitment by Cloud users.
  - Allows companies to start small and expand only when needed.
- The ability to pay for use of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day)
  - Rewards freeing resources when they are no longer useful.

Why Cloud Computing?







Decentralized

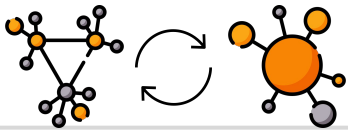
Centralized

*https://www.geeksforgeeks.org/comparison-centralized-decentralized-and-distributed-systems/

Why Cloud Computing Now?

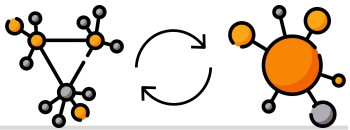
- 1950 ~ 1970s (Centralized)
  - Huge computers, shared by multiple users
  - Hard for people to own a computer own their own

- 1980s ~ 2000s (Decentralized)
  - People started owning their personal machines (Personal Computers)
  - PC speed was doubling every two years (Moore's Law)
  - Less need to share a large computer unless it is for specific purposes

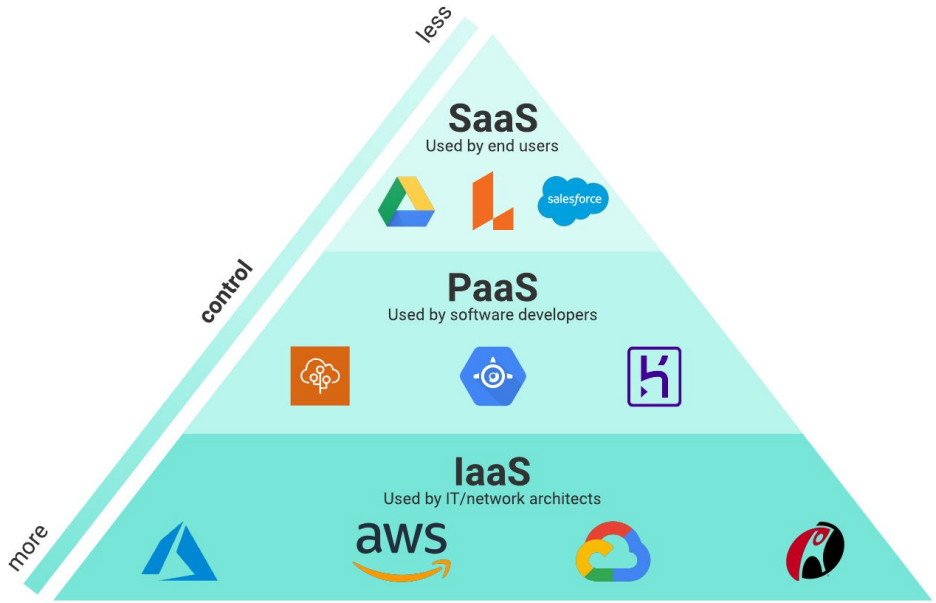


Why Cloud Computing Now?

- 2000s ~ Now (Centralized Cloud)
  - Moore's Law is ending: End of Scale-up, Start of Scale-out
  - People are more mobile than ever
  - Applications need global availability
  - Hard to scale fast when maintaining infrastructure

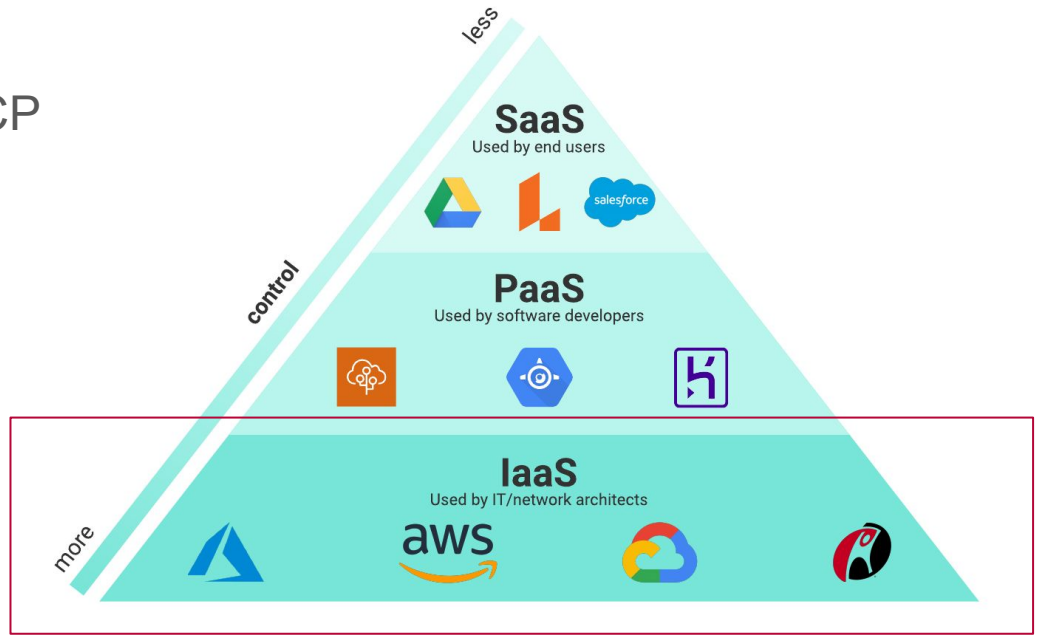


Cloud Service Models



IaaS : Infrastructure as a Service

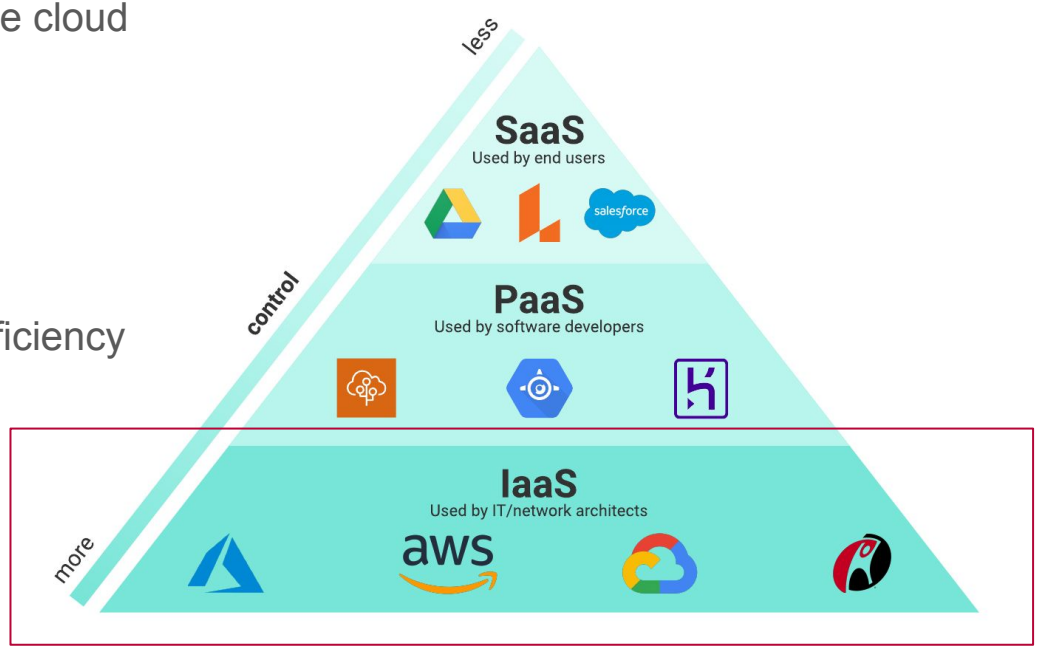
- Provides capabilities to provision computing resources
- Examples: AWS, Azure, GCP
- Users:
  - Network Architect
  - ITs
  - Enterprises



IaaS : Infrastructure as a Service

- Pros:
  - Flexible cost
  - Less maintenance vs private cloud
  - Guaranteed performance
  - Scalable

- Cons:
  - Higher learning curve
  - Hard to optimize for cost efficiency
  - Cloud Lock-in

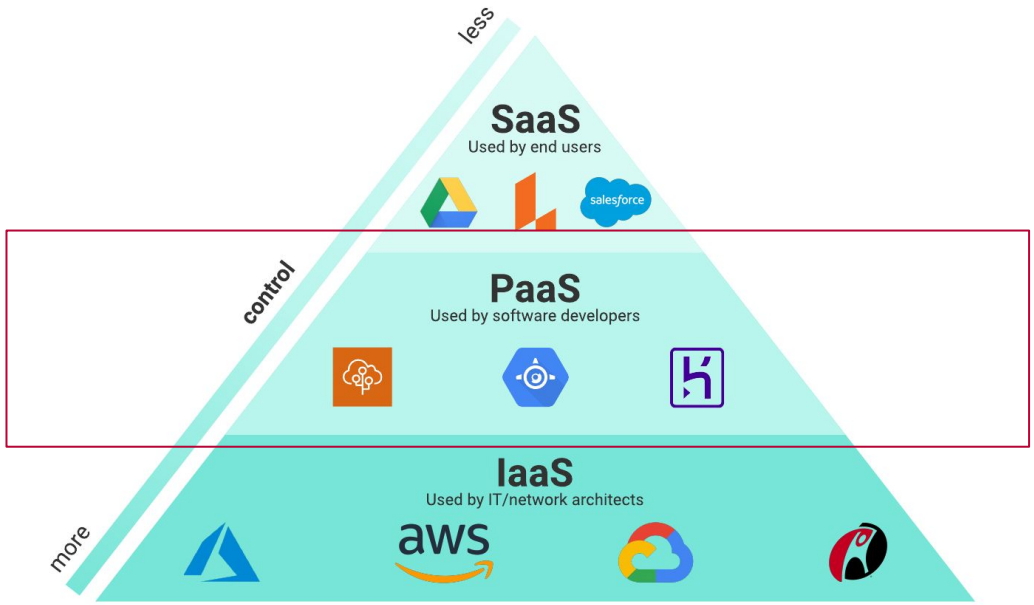


PaaS : Platform as a Service

- Provides ability to develop and deploy applications on the cloud

- Examples
  - Google App Engine
  - Heroku
  - Github

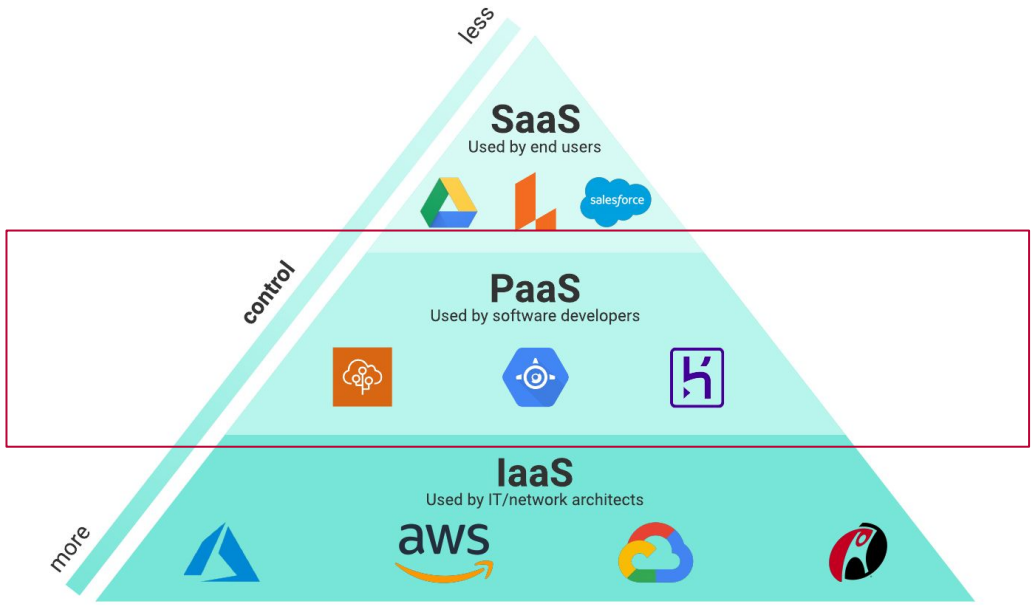
- Users:
  - Software Developers
  - Large Enterprises



PaaS : Platform as a Service

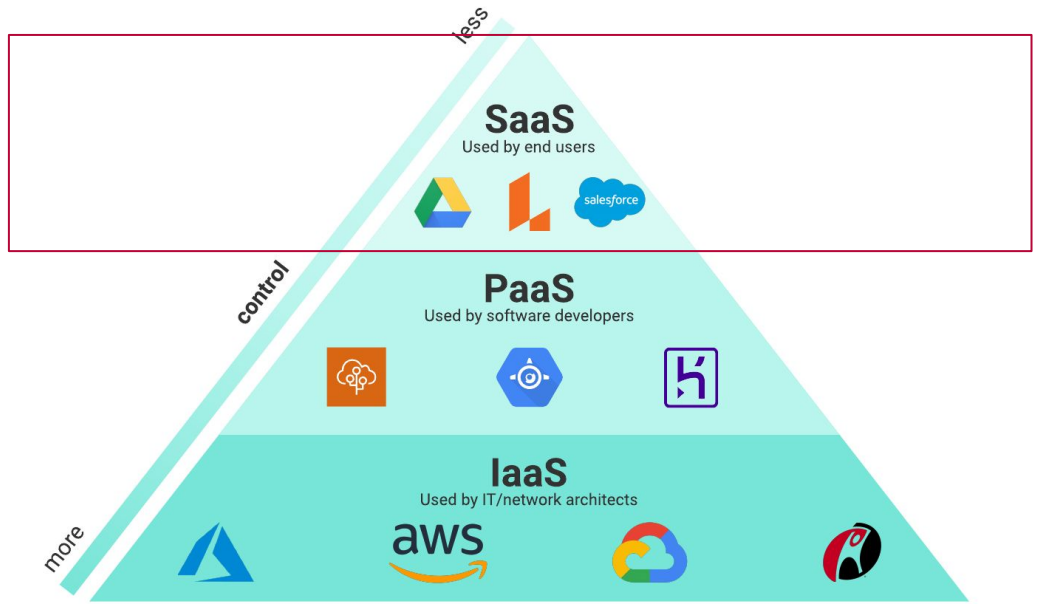
- Pros:
  - Lower learning curve
  - Less operational cost
  - Improved scalability

- Cons:
  - Costs more than IaaS
  - Platform Lock-In



SaaS : Software as a Service

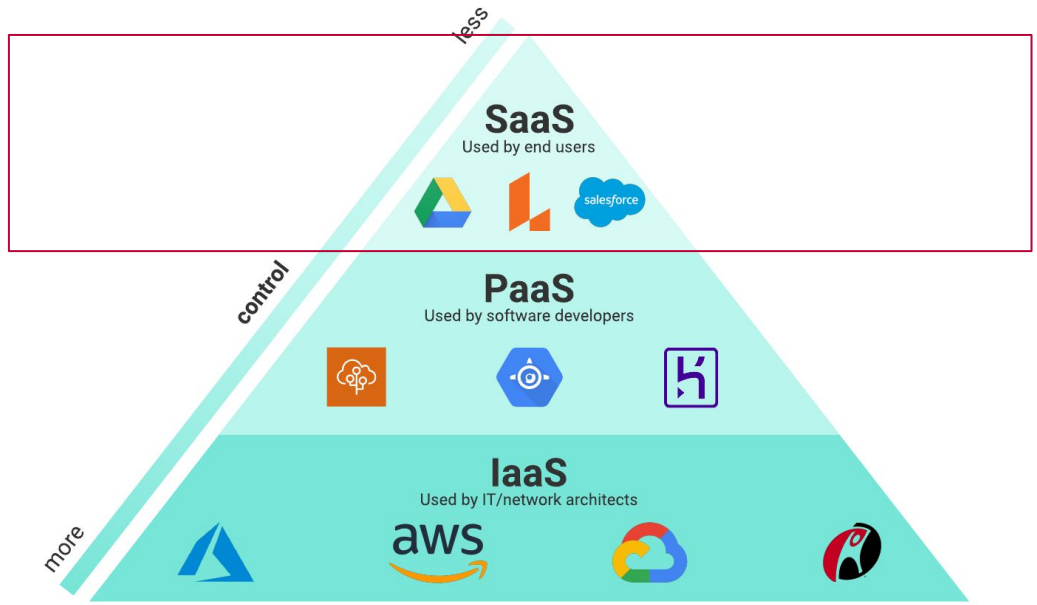
- Provides a complete application environment
- Examples
  - Google Apps
  - Salesforce
  - Dropbox
- Users:
  - End users



SaaS : Software as a Service

- Pros:
  - Lowest learning curve
  - Easy upgrade
  - Secure
  - Fast and High adoption

- Cons:
  - Costs the most
  - Lack of transparency



Cloud Deployment Models

Cloud Deployment Models

- Public
  - Infrastructure built operated by cloud providers
  - Anyone can provision and use
- Private
  - Infrastructure provisioned for a single consumer
- Community
  - Cloud shared by organizations that have similar policy and compliance needs
- Hybrid
  - Two or more cloud models combined

Cloud Use Cases #1 : Netflix on AWS

Netflix operates “many tens of thousands of servers and many tens of petabytes of storage” in the Amazon cloud*

*https://aws.amazon.com/solutions/case-studies/netflix/

Cloud Use Case #1 : Netflix on AWS

- Runs **Everything** on AWS, Netflix shuts down its own data centers
  - Netflix only focuses on its business logic
- ~100k virtual machine instances running at peak time
  - Dynamic environment
  - Cost saving (pay-as-you-go)
- ~500 microservices running on Containers
  - Allows for agile development

*https://aws.amazon.com/solutions/case-studies/netflix/

Cloud Use Case #1 : Netflix on AWS

- Many companies are moving to the public cloud
- Enables rapid development with less management overhead
  - Availability
  - Reliability
  - Scalability
- Not necessarily cost saving or the most performant

*https://aws.amazon.com/solutions/case-studies/netflix/

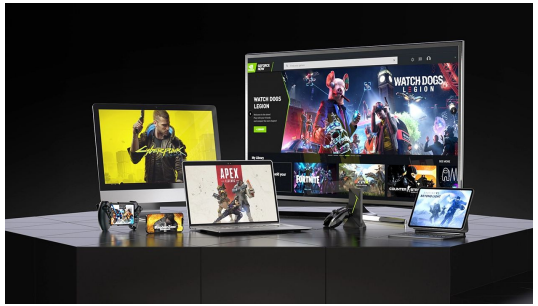
Cloud Use Case #2 : Dropbox ‘off’ AWS

- Some companies are moving away from the ‘public’ cloud as well
- Started off with Hybrid Cloud, but needed more performance and cost efficiency
- Now running their own private cloud

https://blogs.dropbox.com/tech/2016/03/magic-pocket-infrastructure/

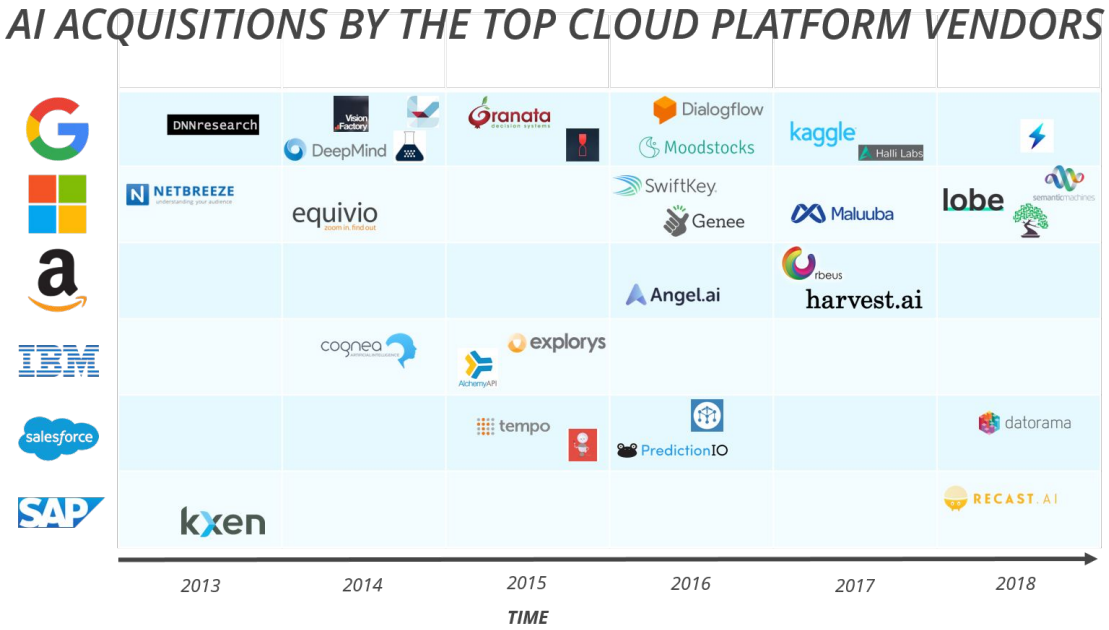
Cloud Use Case #3 : Cloud Gaming

- Stream games from powerful servers in the cloud
- Clients no longer need powerful machines
- Just need a fast and quick network connection
- VR, Self-Driving

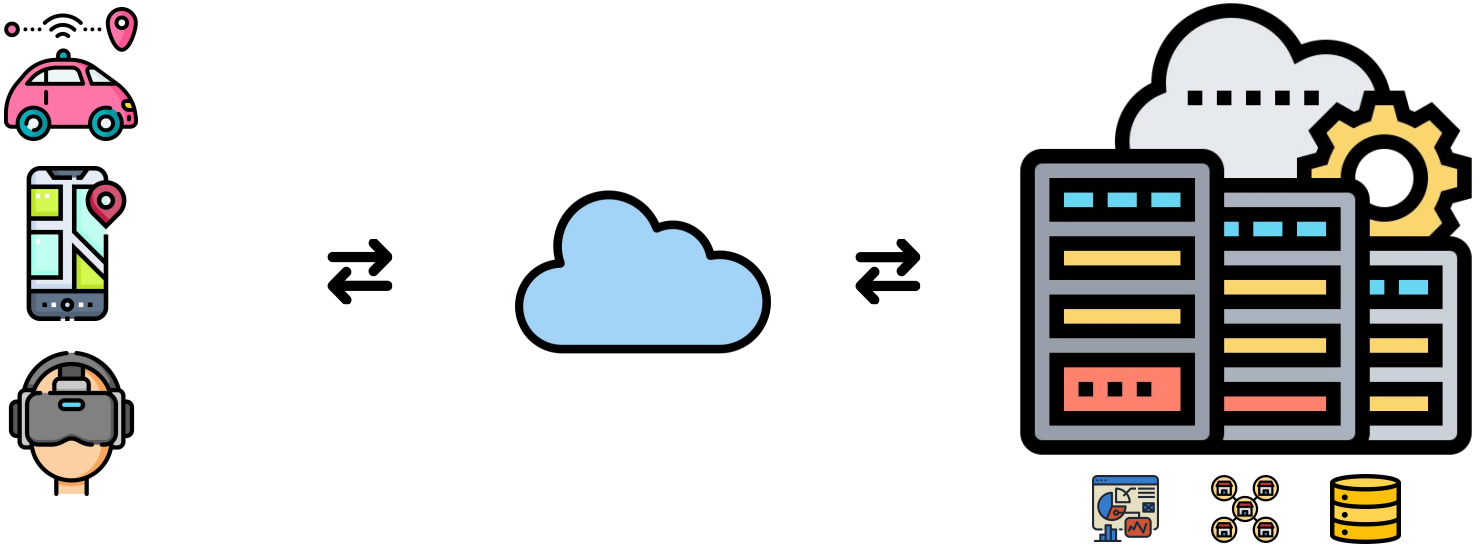


https://blogs.nvidia.com/blog/2021/02/26/what-is-cloud-gaming/

Cloud Use Case #4 : Data Analytics



What does it mean to “Learn” cloud computing?



Clients

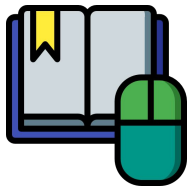
Internet

Data Centers

Course Objectives

- Introduce the following concepts:
  - Cloud architecture and service models
  - **Technologies that enable cloud computing**
  - Technologies that use cloud computing (e.g., MapReduce, Databases)

- Provide hands-on experience on building / using cloud resources
  - Building an (open-ended) application using cloud framework
  - Be creative!



What does it mean to “Learn” cloud computing?

- What technologies in the “data centers” enable cloud computing?
  - Virtualization, Containers, Serverless
  - Software-Defined Networking
  - Databases
  - More…
- How to optimize data centers for
  - Colocation
  - Various Applications
- How does cloud-specific applications work?
  - Mapreduce
  - Many many More...

What This Course Will NOT Teach

- Programming & Languages
  - No preference on languages and IDEs
- How to use different type of OS or shells
  - Prefer to use Linux (e.g., Ubuntu) for assignments
- Algorithms & Data Structures
- How to use commands from a specific cloud provider
  - We won't cover AWS, GCP, or Azure specific contents

Word of Caution!

- Cloud computing is not about just spinning VMs and containers up & down in AWS or GCP or Azure
- First part of the course will be very system & OS heavy!
  - **Check if you have enough OS knowledge!**
- Second part of the course will have lot of networking material
  - **Check if you have enough Networking knowledge!**

Course Topics

1. Cloud Computing Introduction
2. Virtualization Overview: Virtual Machines and Hypervisors
3. Containerization: Docker and Kubernetes
4. Serverless Computing
5. Microservices and Orchestration
6. Availability, Reliability and Scalability

Course Topics

6. Computer Networks 101
7. Software Defined Networks & Network Virtualization
8. Storage Virtualization
9. Distributed Databases / NoSQL
10. MapReduce and Spark/Hadoop
11. Consistency (Zookeeper, Raft)
12. Sustainable Cloud

Course Structure & Grading Breakdown

- 2 Lectures per week (10% participation)
  - In-person (and maybe hybrid)
- 1 Midterm Exam (15%)
  - Will be on Zoom, remotely
- 3 Assignments (**not including HW 0**) (15%)
  - 7 late days to use
- 6 Quizzes (10%)
- Final Team Project (50%)
  - We will talk more about this next class

Course Logistics

- Course Schedule
  - Mon, Wed 5:10~7:00PM
  - Hybrid Fashion (~30% remote)
- Course Website
  - On Camino
  - Syllabus!
- All class related contacts via Piazza
  - https://piazza.com/scu/fall2022/coen241mw0510pm
  - Access code: ***coen241fall2022scu***
  - Also available on Camino as well
- Instructor: Prof. Sean Choi
  - Office Hours: Mon 3-5PM
- Grader: Lakshmi Naarayanan Vaigai Shrinivasan

Late & Absence Policy

- Assignments
  - 7 late days to use at a daily increment (no hour or minute usage)
  - 20% deduction per day late after the 7 late days have been spent
- Final Project
  - No late submission for **any** parts of the project or presentations
- Lectures
  - Up to 2 lectures can be missed
  - 5% deduction of the participation grade after the first two absence

About the Final Project

- A team project of 3~4 people with two possible directions
- Build an application on the cloud using the techniques we will learn
- Study, analyze, and report an existing cloud computing technique/system
- Students are strongly encouraged to explore problems of existing techniques, and possible solutions during this project
- More details will come as the course progress

Course Textbook

- Cloud Computing Solutions Architect (CCSA) by Bahga and Madisetti
- Textbook has substantial AWS information (Unlike this course)
  - We will not cover any tools/commands for a specific cloud provider
- Recommended for additional high-level information
- Optional Readings
  - OS Three easy pieces: https://pages.cs.wisc.edu/~remzi/OSTEP/
  - Each lecture will have relevant optional reading materials

TODOs

- Please participate in the survey in the following link https://forms.gle/RP8HPdgQ8WyvDGXv6

- Watch the following videos
  - Above the Clouds: A Berkeley View of Cloud Computing
    - https://www.youtube.com/watch?v=IJCxqoh5ep4
  - Migrating to Cloud — Lessons from Netflix, Brought Up to Date
    - https://www.youtube.com/watch?v=XrWII4ewrXA
  - Large-scale Data Centers
    - https://www.youtube.com/watch?v=_r97qdyQtIk

- (Optional): Apply for cloud credits

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Questions?