ECE 1779
Introduction to Cloud Computing

Eyal de Lara

delara@cs.toronto.edu
www.cs.toronto.edu/~delara/courses/ece1779
Where in the World is Carmen Sandiego?
Where in the World is Carmen Sandiego?
Course Overview

Introduction
Python
Web Development
Databases
Amazon Web Services
Cluster Computing
Function as a Service
No SQL Databases
Virtualization
Batch Processing
Stream Processing
## Marking

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participation</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>A1 (Web Development)</td>
<td>20%</td>
<td>Feb 22</td>
</tr>
<tr>
<td>A2 (Amazon EC2)</td>
<td>35%</td>
<td>Mar 22</td>
</tr>
<tr>
<td>A3 (Amazon Lambda)</td>
<td>35%</td>
<td>Apr 21-23</td>
</tr>
</tbody>
</table>
Class Mechanics

- Prepare
  Tasks listed on web site, under “Calendar and Lecture Notes”
  Papers, book chapters, videos

- Lecture
  Zoom based presentation
  Hands-on group exercises
Week 2: Python Overview

• Prepare
  
  *Option 1:*
  An Introduction to Computer Science Using Python 3
  By Paul Gries, Jennifer Campberll, Jason Montojo
  Read chapters 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14

  *Option 2:*
  PCRS
  View videos in *prepare* sections for weeks 2

• Lecture Friday 10am-12pm
Recommended Reading

The Cloud at Your Service
Jothy Rosenberg and Art Mateos

Cloud Computing Bible
Barrie Sosinsky

Programming Amazon Web Services
James Murty

AWS Lambda in Action
Danilo Poccia

Practical Programming (2nd edition)
An Introduction to Computer Science Using Python 3
by Paul Gries, Jennifer Campbell, Jason Montojo
Wolf, goat, and a cabbage river crossing puzzle

• Once upon a time a farmer went to a market and purchased a wolf, a goat, and a cabbage. On his way home, the farmer came to the bank of a river and rented a boat. But crossing the river by boat, the farmer could carry only himself and a single one of his purchases: the wolf, the goat, or the cabbage.

• If left unattended together, the wolf would eat the goat, or the goat would eat the cabbage.

• The farmer's challenge was to carry himself and his purchases to the far bank of the river, leaving each purchase intact.

• **Question**: What is the minimum number of times that the farmer needs to row the boat between river banks to accomplish the task?

Source: https://en.wikipedia.org/wiki/Wolf,_goat_and_cabbage_problem
Instructions

- Working on the problem:
  - Introduce yourself to the other students in your breakout room
  - On zoom, start a shared whiteboard by having one person in your breakout room click on "Share Content" and then "Whiteboard"
  - The rest of the group can also draw on the whiteboard using the screen annotation tool
- Once the problem is solved each member should submit their answer on PCRS:
  - https://pcrs.teach.cs.toronto.edu/ECE1779-2021-01
  - Navigate to Week 1: Perform, River Crossing Puzzle
  - Answer the multiple-choice question
  - You can attempt answering multiple times without penalty
  - Exit the breakout room when done.
What is Cloud Computing?

SIMPLY EXPLAINED - PART 17:
CLOUD COMPUTING
Definition

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a metered service over a network (typically the Internet).

Wikipedia
Why call it “Cloud” Computing?

Figure 1.4  A picture of a cloud is a ubiquitous representation of the internet and is used almost universally in discussions or drawings of computer architecture.
The Cloud will Solve **ALL** Problems
Haven’t I heard this story before?
What is New?

- No up-front commitment by Cloud users
  - Anyone with a credit card can rent resources
- Metered billing
  - Pay-as-you-go model
  - Can pay for use on a short-term basis (processors by hour, and storage by day)
- Elasticity
  - Infinite computing resources available on demand
  - Pooled resources
  - No need to plan far ahead on provisioning
- Virtualization
  - User gets controls application
  - Provider can still safely multiplex customers on same HW
- Automation
  - APIs to allocate and release resources
Why care about Cloud Computing?
Main Players

Top four providers account for 63% of cloud spend

**Worldwide cloud infrastructure services spend**

- **Q2 2019**
  - US$26.3 billion
  - Growth: 37.8%
  - 41% Others
  - 18% Alibaba Cloud
  - 31% Google Cloud
  - 4% Microsoft Azure
  - 5% AWS

- **Q1 2020**
  - US$31.0 billion
  - Growth: 34.5%
  - 38% Others
  - 17% Alibaba Cloud
  - 32% Google Cloud
  - 6% Microsoft Azure
  - 6% AWS

- **Q2 2020**
  - US$34.6 billion
  - Growth: 31.4%
  - 37% Others
  - 20% Alibaba Cloud
  - 31% Google Cloud
  - 5% Microsoft Azure
  - 6% AWS

Source: Canalys estimates, July 2020
Advantages

- Shift from CAPEX to OPEX
  - Lowers barrier for starting a new business/project
- Can be cheaper even in the long run
  - Economies of scale
  - Geography

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cost in Medium-sized DC</th>
<th>Cost in Very Large DC</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>$95 per Mbit/sec/month</td>
<td>$13 per Mbit/sec/month</td>
<td>7.1</td>
</tr>
<tr>
<td>Storage</td>
<td>$2.20 per GByte / month</td>
<td>$0.40 per GByte / month</td>
<td>5.7</td>
</tr>
<tr>
<td>Administration</td>
<td>≈140 Servers / Administrator</td>
<td>&gt;1000 Servers / Administrator</td>
<td>7.1</td>
</tr>
</tbody>
</table>
Advantages

• Instant agility
  • No need to procure, provision and configure new HW
  • No need to plan far ahead on provisioning
• Security
  • Cloud provider can afford better physical and logical security
  • Bank vs. company vault
Advantages

- Reliability
  - Redundancy, geographic replication

At last, the fossil evidence to prove our theory! The dinosaurs died off – not because of a meteor or climate change – but because their cloud computing platform collapsed!
Challenges

• Performance predictability (QoS)
  • Fair sharing of I/O resources among VMs
• Vendor lock-in
Challenges

• Security and privacy

• Data transfer bottleneck
  • Uploading 10 TB over 20 Mbps link takes 45 days!
Cloud-friendly Applications

- Existing apps that do not require specialized hardware resources
- Internet scale apps
  - Geographical proximity to user base.
  - Potentially large user base
- Apps with elastic demands
  - For most services peak demand exceeds average by factor of 2 to 10 apps
- Burst computing
  - Testing
  - Batch processing
Cloud Types

- Public
- Private
- Hybrid
Cloud Computing Taxonomy

- Infrastructure/hardware as a Service (IaaS)
- Platform as a Service (PaaS)
- Software/Framework as a Service (SaaS/FaaS)
Infrastructure as a service (IaaS)

- Also know as Utility Computing
- VM images of different OS flavors
- Can run any application natively on chosen OS
- User administers VMs
  - User in charge of elasticity and failover
- Almost like buying your how HW
- Billing:
  - CPU hour
  - Gigabyte of storage per month
  - Network traffic in and out of datacenter
- Examples:
  - Amazon Elastic Compute Cloud (EC2), Rackspace
Example: Amazon EC2 Instance Types

- **Small Instance**
  - 2 GB memory
  - 1 EC2 Compute Unit
  - I/O Performance: Moderate

- **XXLarge Instance**
  - 32 GB memory
  - 8 EC2 Compute Units
  - I/O Performance: High

- **GPU Compute**
  - 732 GiB of memory
  - 64 EC2 Compute Units
  - NVIDIA K80 GPUs
  - I/O Performance: Very High (10 Gigabit Ethernet)

- One EC2 Compute Unit provides the equivalent CPU capacity of a 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor.
Platform as a Service (PaaS)

- Application need to conform to provider’s API
- VM managed automatically by provider
  - Automatic scaling and failover
- Billing:
  - Per-request
  - Gigabyte of storage per month
  - Network traffic in and out of datacenter
- Examples:
  - Google App Engine
  - Microsoft Azure
  - AWS Lambda
**Software/Framework as a Service (SaaS/FaaS)**

- **SaaS**: services and applications available on an on-demand basis.
- **FaaS**: a configurable SaaS
- **Billing**:  
  - Application specific  
  - Per hour  
  - Per transaction
- **Examples**:  
  - Salesforce.com  
  - Google Docs
How do they stack up?

- **SaaS User**
  - Web applications

- **SaaS Provider / Cloud User**
  - Utility computing

- **Cloud Provider**

**Software as a Service (SaaS)**
- Packaged software application

**Framework as a Service (FaaS)**
- Environment for building a module for an ERP system

**Platform as a Service (PaaS)**
- Environment for building a managed application with an IDE with a rich class library that executes in a runtime container

**Infrastructure as a Service (IaaS)**
- Environment for building a native application
Choosing between IaaS and PaaS

- **IaaS**
  - Use third party sw or other programming languages
  - Have existing code
  - Care about lock in
    - Transfer web app to your own server or a different provider
  - Want complete control
  - Are OK with the extra work needed to manage the system

- **PaaS**
  - Provider’s API provider all needed functionality
  - Have no issues with lock-in
  - Don’t want to or cannot afford to manage the servers
How to disillusion your boss:

1. "This is our private cloud?"
2. "This is a cloud? Just computers?"
3. "The cloud?"
4. "A good consultant is always on duty."
5. "My daughter smokes, my son is in jail and my wife and my girlfriend have left me. Do you have any advice for me?"
6. "That's the solution to all our problems. The private cloud. Great idea!"
7. "I thought that was cotton candy. CEOs love the cloud."
Week 2: Python Overview

- Prepare
  
  *Option 1:*
  An Introduction to Computer Science Using Python 3  
  By Paul Gries, Jennifer Camberll, Jason Montojo  
  Read chapters 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14
  
  *Option 2:*
  PCRS  
  View videos in *prepare* sections for week 2