CS15-319 / 15-619
Cloud Computing

Recitation 1
Course Overview and Introduction
August 26 & 28 2014

http://www.cs.cmu.edu/~msakr/15619-f14/
Outline

• What is the course about?
• What is an online course?
• Administrivia
So What is Cloud Computing?
“Cloud Computing is the transformation of IT from a product to a service”
Cloud Computing

• Transformation of IT from a Product to a Service

Innovation of IT

New Disruptive Technology

IT Products

Buy and Maintain the Technology

Cloud Computing

On-Demand IT services on a Pay-as You-Go basis
How About Electricity?

• Transformation from a Product to a Service

Innovation
New Disruptive Technology

Product
Buy and Maintain the Technology

Service
Electric Grid, pay only for the electricity you use
A Cloud is ...

- Datacenter hardware and software that the vendors use to offer the computing resources and services
Cloud Computing

“Cloud Computing is the transformation of IT from a product to a service”
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.
So... how would you transform information technology into a Service?
Requirements to Transform IT to a Service

- **Connectivity**
  - For moving data around

- **Interactivity**
  - Seamless interfaces

- **Reliability**
  - Failure will affect many people, not just one

- **Performance**
  - It should not be slower or less efficient than what people already have

- **Pay-as-you-Go**
  - Should not pay an upfront fee for the service

- **Ease of Programmability**
  - Ease of development of complex services to users

- **Manage Large Amounts of Data**
  - Big Data

- **Efficiency**
  - Cost
  - Power

- **Scalability & Elasticity**
  - Flexible and rapid response to changing user needs
Requirements to Transform IT to a Service

- **Ease of Programmability**
  - Ease of development of complex services to users

- **Manage Large Amounts of Data**
  - Big Data

- **Efficiency**
  - Cost
  - Power

- **Scalability & Elasticity**
  - Flexible and rapid response to changing user needs

**Virtualization Technologies**

- **Programming Model**
  - Internet
  - Programming Model

- **Storage Technologies**
  - Web 2.0

- **Efficiency**
  - Parallel/Distributed Programming

- **Reliability**
  - Fault-Tolerance
  - Failure will affect many people, not just one

- **Performance**
  - Internet
  - For moving data around

- **Interactivity**
  - Web 2.0
  - Seamless interfaces

- **Pay-as-you-Go**
  - Utility Computing
  - Should not pay an upfront fee for the service

- **Pay-as-you-Go**
  - Utility Computing

- **Connectivity**
  - Internet

- **Interactivity**
  - Web 2.0

- **Reliability**
  - Fault-Tolerance

- **Performance**
  - Parallel/Distributed Programming

- **Pay-as-you-Go**
  - Utility Computing

- **Connectivity**
  - Internet
  - For moving data around

- **Interactivity**
  - Web 2.0
  - Seamless interfaces

- **Reliability**
  - Fault-Tolerance
  - Failure will affect many people, not just one

- **Performance**
  - Parallel/Distributed Programming

- **Pay-as-you-Go**
  - Utility Computing
  - Should not pay an upfront fee for the service
Combine the Enabling Technologies...
The delivery of application software, as a service to the end user, typically over a web browser.

Software development and computing platforms as a service, which can be used to develop applications that run on a cloud.

Computing resources made available to users to deploy their own platform and applications.

Service Models

Software as a Service (SaaS)

Platform as a Service (PaaS)

Infrastructure as a Service (IaaS)
Infrastructure as a Service

Amazon EC2

Client 1

 Provisioning Request

Client 2

Application
OS
Instance 1
Hypervisor
Hardware
Application
OS
Instance 2

Amazon EC2
Cloud Computing

• Applications
• Development Platforms
• Elasticity
  – APIs to enable automation, Alarms, protocols, triggers, etc...
• Sharing mechanisms
  – Virtualization, SDX, ...
• Distributed systems
  – Programming models
  – Storage
• Data centers
What is this course about?

• Applied aspects of cloud computing
  – Between systems and services

Online content on OLI

1.0 Introduction to Cloud Computing
  Service and deployment models, economics and use cases

2.0 Data Centers
  Components, design considerations and power

3.0 Resource Sharing
  CPU, memory and I/O Virtualization

4.0 Cloud Storage
  Distributed File Systems and Distributed Databases

5.0 Programming Models
  MapReduce, GraphLab and Pregel

Projects on AWS

Big Data

Cloud Service

Scaling & Elasticity

Cloud Storage

Programming Models
Course Objectives

Students will learn:

• the fundamental ideas behind Cloud Computing;
• the basic ideas and principles in data center design and management;
• the resource sharing and virtualization techniques that serve in offering software, computation and storage services on the cloud;
• about cloud storage technologies and relevant distributed file systems;
• the variety of programming models and develop working experience in one of them.
# Units

<table>
<thead>
<tr>
<th>Unit #</th>
<th>Title</th>
<th>Modules and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Introduction to Cloud Computing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building Blocks and Service Models in Cloud Computing</td>
</tr>
<tr>
<td>2</td>
<td>Data centers</td>
<td>Historical Perspective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Datacenter Components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design Considerations</td>
</tr>
<tr>
<td>3</td>
<td>Virtualization</td>
<td>Resource Abstraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resource Sharing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sandboxing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case Study: Amazon EC2</td>
</tr>
<tr>
<td>4</td>
<td>Cloud Storage</td>
<td>Introduction to Storage Systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cloud Storage Concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributed File Systems (HDFS, PVFS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cloud Databases (HBase, Cassandra)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case Studies: S3 Object Storage</td>
</tr>
<tr>
<td>5</td>
<td>Programming Models</td>
<td>Introduction to Programming Models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variety of Programming Models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case Study: MapReduce, Pregel, GraphLab</td>
</tr>
</tbody>
</table>
Ref: OLI Content Units and Modules

UNIT 1: Introduction to Cloud Computing
   Module 1: Introduction to Cloud Computing
   Module 2: Building Blocks and Service Models

UNIT 2: Data Centers
   Module 3: Data Center Trends
   Module 4: Data Center Components
   Module 5: Design Considerations

UNIT 3: Virtualizing Resources for the Cloud
   Module 6: Introduction and Motivation
   Module 7: Virtualization
   Module 8: Resource Virtualization - CPU
   Module 9: Resource Virtualization - Memory
   Module 10: Resource Virtualization – I/O
   Module 11: Case Study

UNIT 4: Cloud Storage
   Module 12: Cloud Storage
   Module 13: Case Studies: Distributed File Systems
   Module 14: Case Studies: NoSQL Databases
   Module 15: Case Studies: Cloud Object Storage

UNIT 5: Distributed Programming and Analytics Engines for the Cloud
   Module 16: Introduction to Distributed Programming for the Cloud
   Module 17: Distributed Analytics Engines for the Cloud: MapReduce
   Module 18: Distributed Analytics Engines for the Cloud: Pregel
   Module 19: Distributed Analytics Engines for the Cloud: GraphLab
Projects

• Four Projects (all students):
  0. Primer (Complete by Sunday, August 31, 2014)
  1. Big Data
  2. Scalability and Elasticity
  3. Cloud Storage
  4. Programming Models

• 15-619 Project (extra 3-units)
  – One multi-week team project to build a complete web service.
Ref: Project Modules on OLI

• Project Primer
  Essential Skills in Linux
  Amazon Web Services
  Project Guidelines

• Project 1
  Introduction to Big Data Analysis
  Sequential Analysis
  Elastic MapReduce

• Project 2
  Introduction and APIs
  Single Instance Benchmarks
  Elastic Load Balancing
  Static Load Benchmarking
  AutoScaling on Amazon

• Project 3
  Files vs. Databases
  Vertical Scaling in Databases
  Horizontal Scaling in Databases
  Working with NoSQL: DynamoDB / HBase

• Project 4
  MapReduce
  Hadoop MapReduce
  Input Text Predictor: NGram Generation
  NGram Generation
  Input Text Predictor: Language Model, UI
  Language Model Generation
What this course is not about

• Building Cloud Stack Modules
  – OpenStack
• Cloud Software Development
  – SaaS software engineering
• Distributed Systems
  – Synchronization, Consistency, ...
• Operating Systems
  – Developing a hypervisor
• Networks
  – Routing and switching protocols
Outline

• What is the course about?
• **What is an online course?**
• Administrivia
## Global Course

<table>
<thead>
<tr>
<th>Location</th>
<th>Students</th>
<th>Teaching Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMU Pittsburgh</td>
<td>300</td>
<td>19</td>
</tr>
<tr>
<td>CMU Silicon Valley</td>
<td>83</td>
<td>3</td>
</tr>
<tr>
<td>CMU Adelaide</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>
Online Course Engagement Model

Amazon Web Services
- Cloud platform to implement projects

Piazza
- Feedback and Questions

Weekly Recitations

Video Conference
- Tuesdays: Videotaped
- Thursdays: Video conf. to SV

Online Learning Initiative
- Access Learning Content
- Quizzes and Checkpoints
Outline

• What is the course about?
• What is an online course?
• Administrivia
Target Audience

• Technical Majors
• Undergraduate Juniors / Seniors
  – Pre-requisites:
    • 15213 – Introduction to Computer Systems
• Graduate Students
  – Experience:
    • Unix, scripting, python, & java
Course Organization

- Course Units
- Course Projects
- Weekly Recitations
- Office Hours
- Discussions on Piazza
Getting Help

• Piazza
  – Email does not scale
  – TAs in Adelaide, Pittsburgh, & Silicon Valley

• Recitations
  – Tuesdays (recorded)
    • At 8AM in GHC 4307 (Rashid GHC 4401?)
  – Thursdays (video conferenced to SV)
    • At 4:30PM in GHC 4307 (SV 212)

• Office Hours
  – Check Piazza for Office Hour schedule
Teaching Staff

Majd F. Sakr

msakr@cs.cmu.edu
GHC 7006
Office Hours:
Tuesdays, 3-4pm
Pittsburgh: Teaching Assistants

Andi Ni
Bin Feng
Felipe Faraco
Jialiang Lin
Jiang Xue
Jiten Mehta
Junqi Wang
Kasipan Kanniah
Lina Li
Lu Zeng
Mrigesh Kalvani
Preston Lin
Ravi Chandra
Suhail Rehman
Vivek Munagala
Yiqi Wu
Yishuang Pang
Yu Wu
SV: Teaching Assistants

Lu Qu  
Luning Pan  
Xiaokang Zhang
Adelaide: Teaching Assistant

Guillermo Garcia
Online Course Content - OLI

Course content is on the Open Learning Initiative:

- Students are automatically registered
- Access to OLI is through Blackboard
- Demo if time permits
Syllabus

• Updated on webpage
• Provides details on:
  – Course Objectives
  – Learning Outcomes
  – Policies
  – Grading
  – Tentative Schedule
<table>
<thead>
<tr>
<th>Date</th>
<th>OLI Content</th>
<th>Quiz</th>
<th>Project</th>
<th>Extra Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-Aug-14</td>
<td>Unit 1 – Introduction</td>
<td>Unit 1 Checkpoint Quiz</td>
<td>Primer</td>
<td></td>
</tr>
<tr>
<td>1-Sep-14</td>
<td></td>
<td></td>
<td>Project 1</td>
<td></td>
</tr>
<tr>
<td>8-Sep-14</td>
<td>Unit 2 –</td>
<td></td>
<td>Project 2</td>
<td></td>
</tr>
<tr>
<td>15-Sep-14</td>
<td>Datacenters</td>
<td>Unit 2 Checkpoint Quiz</td>
<td>Project 3</td>
<td></td>
</tr>
<tr>
<td>22-Sep-14</td>
<td>Unit 3 – Virtualization</td>
<td></td>
<td>Project 4</td>
<td>15-619 Extra Project</td>
</tr>
<tr>
<td>29-Sep-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Oct-14</td>
<td></td>
<td>Unit 3 Checkpoint Quiz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-Oct-14</td>
<td>Unit 4 – Cloud Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-Mar-14</td>
<td></td>
<td>Unit 4 Checkpoint Quiz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27-Oct-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Nov-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-Nov-14</td>
<td>Unit 5 – Programing Models</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-Nov-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-Nov-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-Dec-14</td>
<td></td>
<td>Unit 5 Checkpoint Quiz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Content: Timeline and Dependencies

Unit 1 - Introduction
- Week 1
- Week 2
- Quiz (5%)

Unit 2 - Datacenters
- Week 1
- Week 2
- Quiz (5%)

Unit 4 - Cloud Storage
- Week 1
- Week 2
- Week 3
- Quiz (5%)

Unit 3 - Virtualization
- Week 1
- Week 2
- Week 3
- Quiz (5%)

Unit 5 - Prog. Models
- Week 1
- Week 2
- Week 3
- Week 4
- Week 5
- Quiz (5%)
Projects: Timeline and Dependencies

Project 1.1: Introduction to Big Data Analysis, Sequential Analysis
Project 1.2: Introduction to Big Data Analysis, Elastic MapReduce

Project 2.1: Introduction and APIs
Project 2.2 & 2.3: Elastic Load Balancer and Static Load Benchmarking
Project 2.4: AutoScaling on Amazon

Project 3.1: Files vs. Databases
Project 3.2: Vertical Scaling in Databases
Project 3.3: Horizontal Scaling in Databases
Project 3.4: DynamoDB
Project 3.5: DynamoDB/HBase

Project 4.1: MapReduce
Project 4.2: Input Text Predictor: NGram Generation
Project 4.3: Input Text Predictor: Language Model and User Interface

15619 Project: Phase 1
15619 Project: Phase 2
15619 Project: Phase 3
Grading

<table>
<thead>
<tr>
<th>Course Elements</th>
<th>#</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects</td>
<td>4 or 5</td>
<td>75%</td>
</tr>
<tr>
<td>OLI Unit Checkpoint Quizzes</td>
<td>5</td>
<td>25%</td>
</tr>
</tbody>
</table>

- All projects are equal weight
  - 18.75% for 15-319
  - 15% for 15-619
- All quizzes are equal weight
  - 5% for each quiz
Academic Integrity

It is the responsibility of each student to produce her/his own original academic work.

• Individual work:
  – Weekly Project Modules
  – Unit Checkpoint Quizzes

• Team work:
  – 15-619 Project

Read the university policy on Academic Integrity.
What is Cheating

• Sharing code or other electronic files either by copying, retyping, looking at, or supplying a copy of any file.
• Copying answers to any checkpoint quiz from another individual, published or unpublished written sources, and electronic sources.
• Collaborating with another student or another individual on Unit Checkpoint Quizzes or Project Module Checkpoint Quizzes.
• Sharing written work, looking at, copying, or supplying work from another individual, published or unpublished written sources, and electronic sources.
• Collaboration in team projects is strictly limited to the members of the team.
• ...
Course Administration

• Students are automatically registered on OLI through blackboard.andrew.cmu.edu

• A *single* Piazza course page is created
  – We manually register students to Piazza

• Schedule of units and quizzes is on OLI
  – Weekly project modules are due on Sundays
  – Content quizzes are due on Thursdays
Special Note on Amazon EC2

• Paid Cloud Service – billed by the hour
• Start a resource only when you need it
• To explore, use a micro instance
  – You can keep one micro instance running 24x7
• Terminate all other resources as soon as you are done with them
• Students will be penalized for over usage
  – We have a fixed budget, do not abuse the resources!
  – Intentional or unintentional abuse -> grade penalties
This Week

• Become familiar with OLI
  – Content (Outline of Units 1-5)
  – Projects (Primer, Outlines of Projects 1-4)
• Check that you were enrolled on Piazza
• Create an account on AWS (Deadline, Aug 31)
  – Submit your AWS account number using the link provided within the Project Primer on OLI
• Complete Project Primer by Sunday
• Start reading Unit 1, Module 1 on OLI
Questions?