CS15-319 / 15-619
Cloud Computing

Recitation 1
Course Overview and Introduction
January 13 & 15 2015

http://www.cs.cmu.edu/~msakr/15619-s15/
Outline

• What is the course about?
• What is an online course?
• Administrivia
• A couple of demos
So What is Cloud Computing?
Data and Decision Making

• Analyzing data reflects reality

• Walmart: hurricane warning
  – Stock beer and strawberry pop-tarts
  – 7x increase in sales during large storms

• Government: resource allocation decisions
  – Data mining in Maryland → crime hotspots
  – Shuffle resource allocation, more to hotspots
    • violent crime down by 25%
    • $20 million saved in the city of Baltimore
Data Science

- Extraction of knowledge from data
- Employs statistical, machine learning and data mining techniques
  - Look for trends, patterns or anomalies in the data
- Affects research in many domains
  - Business, Economics and Finance
  - Biological Sciences and Bioinformatics
  - Social Sciences and Humanities
  - ...
An Increase in Data Capture

• Physical Sensors and Sensor Networks
  – Environmental, safety, transportation

• Social Media Interactions
  – Facebook, Twitter, Instagram

• Public Video and Image Capture
  – Surveillance, mobile phones, ...

• Customer Spending Habits
  – Loyalty programs and purchase data
What Happens in an Internet Minute?

- 639,800 GB of global IP data transferred
- 20 new victims of identity theft
- 204 million emails sent
- 47,000 app downloads
- 1,300 new mobile users
- $83,000 in sales
- 61,141 hours of music
- 20 million photo views
- 3,000 photo uploads
- 320+ new Twitter accounts
- 100,000 new tweets
- 277,000 logins
- 6 million Facebook views
- 2+ million search queries
- 1.3 million video views
- 30 hours of video uploaded

And Future Growth is Staggering

Today, the number of networked devices = the global population

By 2015, the number of networked devices = 2x the global population

In 2015, it would take you 5 years to view all video crossing IP networks each second

Source: IntelFreePress
What is Big Data?

• Big Data
  – Volume, Velocity, Variety, Veracity
  – Data of next year >> data of this year

• Many Challenges
  – Store, share, analyze, search, transfer, visualize, and secure
  – Traditional IT systems are insufficient

we need...

Large Scale Systems
Large Scale System Challenges

- Lengthy procurement cycles
- Lengthy deployment effort
- Costly power and cooling
- Costly systems administration
- Low utilization
- Costly disaster recovery
Evolution of Computing

“Cloud Computing is the transformation of IT from a product to a service”
Evolution of Electricity

Innovation
New Disruptive Technology

Product
Buy and Maintain the Technology

Service
Electric Grid, pay for what you use
A Cloud is ...

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

The “Cloud”
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.
Enabled by Maturing Technologies
So… how would you transform information technology into a Service?
How to Transform IT to a Service?

• Connectivity
  – For moving data around

• Interactivity
  – Seamless interfaces

• Reliability
  – Failure will affect many

• Performance
  – Should not be slower

• Pay-as-you-Go
  – No upfront fee

• Ease of Programmability
  – Ease of development of complex services

• Manage Big Data

• Efficiency
  – Cost
  – Power

• Scalability & Elasticity
  – Flexible and rapid response to changing user needs
How to Transform IT to a Service?

- **Connectivity**
  - For moving data around

- **Interactivity**
  - Seamless interfaces

- **Reliability**
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- **Performance**
  - Should not be slower

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- **Ease of Programmability**
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- **Manage Big Data**

- **Efficiency**
  - Cost
  - Power

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

- **Virtualization and Resource Sharing Technologies**

- **Internet**
  - Web 2.0

- **Fault-Tolerance**
  - Should not be slower

- **Utility Computing**

- **Programming Model**
  - Storage Technologies

- **Parallel / Distributed Systems**
Cloud Building Blocks

Cloud services are available in various forms, corresponding to the layer of abstraction desired by the user:

- **Software as a Service (SaaS)**
- **Platform as a Service (PaaS)**
- **Infrastructure as a Service (IaaS)**
Software as a Service (SaaS)

- Software is delivered through the internet over a browser or mobile application
- Replace desktop software with cloud-based versions
- Webmail, Productivity Software, ERP, CRM etc.
- Centrally managed, globally available, automatically updated
Platform as a Service (PaaS)

- Tools and APIs to develop and deploy cloud-based applications
- Create customized SaaS in the form of Web or mobile applications
Infrastructure as a Service (IaaS)

- Compute, storage and network resources bundled in the form of virtual machines
- Fully flexible in terms of software and environment

Logos for Amazon EC2, Windows Azure, Rackspace, Google Compute Engine, and Google Cloud Platform.
Infrastructure as a Service

Amazon EC2

Client 1

Provisioning Request

Amazon EC2

Client 2
Benefits of Cloud Computing

- Pay-as-You-Go economic model
- Simplified IT management
- Elasticity Scale quickly & effortlessly
- Customization Flexible options
- Carbon Footprint decreased
Risks and Challenges

- Migration
- Security & Privacy
- Vendor Lock-In
- Legal
- Internet Dependence
Service Level Agreements and Objectives (SLA/SLO)

- **SLA:** Contract between cloud providers and users to define expected service
  - Service availability and delivery
  - Payment terms, bonuses and penalties for service
- **SLO:** Individual performance/service metrics regarding service delivery defined in the SLA
- **Auditing:** monitor resources to enforce SLOs and SLAs
Cloud Use Cases: Start-ups

- Infrastructure on demand
- Save money on data center real estate, servers, power and cooling
- Saving in capital expenditure which could be used to drive other areas of business growth
- Scale infrastructure as the business grows
- Levels the infrastructure playing field with established companies
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.
<table>
<thead>
<tr>
<th>Unit #</th>
<th>Title</th>
<th>Modules and Description</th>
</tr>
</thead>
</table>
| 1     | Introduction           | Introduction to Cloud Computing  
|       |                        | Building Blocks and Service Models in Cloud Computing  
|       |                        | Topics in Cloud Security  
|       |                        | Popular Cloud Stacks and Use Cases                                                                                                                     |
| 2     | Data centers           | Historical Perspective  
|       |                        | Datacenter Components  
|       |                        | Design Considerations  
|       |                        | Power Calculations  
|       |                        | Software Defined Networks and Storage (SDN & SDS)                                                                                                     |
| 3     | Virtualization         | Resource Abstraction  
|       |                        | Resource Sharing (CPU, Memory, I/O)  
|       |                        | Sandboxing  
|       |                        | Case Study: Amazon EC2                                                                                                                                    |
| 4     | Cloud Storage          | Introduction to Storage Systems  
|       |                        | Cloud Storage Concepts  
|       |                        | Distributed File Systems  
|       |                        | Cloud Databases  
|       |                        | Case Study: Amazon Object Storage                                                                                                                       |
| 6     | Programming Models     | Introduction to Programming Models  
|       |                        | Variety of Programming Models  
|       |                        | Case Studies: MapReduce, Spark, GraphLab                                                                                                                      |
Projects

• Four Projects (all students):
  0. Primer (Complete by Sunday, January 18, 2015)
  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
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
## Carnegie Mellon Global Course

<table>
<thead>
<tr>
<th>Location</th>
<th>Students</th>
<th>Teaching Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMU Pittsburgh</td>
<td>182</td>
<td>20</td>
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<tr>
<td>CMU Silicon Valley</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>CMU Rwanda</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>CMU Adelaide</td>
<td>18</td>
<td>1</td>
</tr>
</tbody>
</table>
Online Course Engagement Model

Cloud platform to implement all projects

Open Learning Initiative
Access learning content, quizzes and checkpoints

Weekly, in-class recitations
- **Tuesdays**: Videotaped
- **Thursdays**: Video conf. to SV

Video Conf.

Feedback & questions

Piazza

Piazza

THEPROJECTZONE
Expectations

• Real world practical experience
  – Learn on your own
    • Languages, API, debugging
  – Overcome challenges
  – Deal with uncertainty

• Self paced learning

• Using experimental tools
  – Bleeding edge comes with risks
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

• TAs in Adelaide, Rwanda, Pittsburgh & Silicon Valley

• Piazza
  – Email does not scale
  – Discussion forum to support each other

• Recitations
  – Tuesdays (recorded)
    • At 8AM in GHC 4307
  – 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

• Anshima Gupta
Pittsburgh: Teaching Assistants

- Chao Zhang
Pittsburgh: Teaching Assistants

• Debjani Biswas
Pittsburgh: Teaching Assistants

• Eryue Chen
Pittsburgh: Teaching Assistants

• Gongxun Liu
Pittsburgh: Teaching Assistants

• Haoliang Quan
Pittsburgh: Teaching Assistants

• Jiaduo He
Pittsburgh: Teaching Assistants

• Lei Wang
Pittsburgh: Teaching Assistants

- Lu Zeng
Pittsburgh: Teaching Assistants

- Mayank Singh Shishodia
Pittsburgh: Teaching Assistants

- Mengyu Yang (Rainy)
Pittsburgh: Teaching Assistants

• Mrigesh Kalvani
Pittsburgh: Teaching Assistants

- Prajwal Yadapadithaya
Pittsburgh: Teaching Assistants

• Pan Sun
Pittsburgh: Teaching Assistants

• Ravi Chandra Bandlamudi Venkata
Pittsburgh: Teaching Assistants

• Rohit Upadhyaya
Pittsburgh: Teaching Assistants

• Ru Jia
Pittsburgh: Teaching Assistants

• Satya Venkata Kamuju (Durga)
Pittsburgh: Teaching Assistants

• Siyuan Zhou
Pittsburgh: Teaching Assistants

• Suhail Rehman
Pittsburgh: Teaching Assistants

• Tianqi Wen
Pittsburgh: Teaching Assistants

• Zichang Feng
SV: Teaching Assistants

- Vinay Kumar Vavili
Rwanda: Teaching Assistant

- Cathy Bishop
Adelaide: Teaching Assistant

• Enrique Arango Lyons
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>
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<tbody>
<tr>
<td>12-Jan-15</td>
<td>Unit 1 – Introduction</td>
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<td>Primer</td>
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<td>19-Jan-15</td>
<td>Unit 1 Checkpoint Quiz</td>
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<td>Project 1</td>
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<tr>
<td>26-Jan-15</td>
<td>Unit 2 –</td>
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<td>Project 2</td>
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<td>2-Feb-15</td>
<td>Datacenters</td>
<td>Unit 2 Checkpoint Quiz</td>
<td>Project 3</td>
<td></td>
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<td>9-Feb-15</td>
<td>Unit 3 – Virtualization</td>
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<td>Project 3</td>
<td></td>
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<tr>
<td>16-Feb-15</td>
<td>Unit 3 Checkpoint Quiz</td>
<td></td>
<td>Project 4</td>
<td>15-619 Extra Project</td>
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<td>23-Feb-15</td>
<td>Unit 4 – Cloud Storage</td>
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<td>Project 4</td>
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<td>2-Mar-15</td>
<td>Unit 4 Checkpoint Quiz</td>
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<td>Project 4</td>
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<td>16-Mar-15</td>
<td>Unit 5 – Programing Models</td>
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<td>Project 4</td>
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<td>23-Mar-15</td>
<td>Unit 5 Checkpoint Quiz</td>
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<td>Project 4</td>
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<td>30-Mar-15</td>
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<td>6-Mar-15</td>
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<td>Project 4</td>
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<td>13-Apr-15</td>
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<td>Project 4</td>
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<td>20-Apr-15</td>
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<td>Project 4</td>
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<tr>
<td>27-Apr-15</td>
<td></td>
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<td>Project 4</td>
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</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 3 - Virtualization
- Week 1
- Week 2
- Week 3
- Quiz (5%)

Unit 4 - Cloud Storage
- 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, Scaling in Databases
Project 3.2: Replication & Sharding
Project 3.3: Consistency
Project 3.4: DBaaS (RDS, DynamoDB)
Project 3.5: DB Warehousing

Project 4.1: Input Text Predictor: Language Model and User Interface
Project 4.2: Iterative Computation
Project 4.3: Graph Computation

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>
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</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.
The Penalties are Severe

• Cheating leads to several students being dismissed from the university every semester

LET IT NOT BE YOU!
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
  – Content quizzes are due on Thursdays
• Schedule of weekly projects is on TheProject.Zone
  • Weekly project modules are due on Sundays
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
  – Resources need to be tagged, otherwise ➔ penalties
This Week

• Become familiar with OLI
  – Content (Outline of Units 1-5)
• Projects (Primer)
• Check that you were enrolled on Piazza
• Create an account on AWS (Deadline, Jan 18)
  – Submit your AWS account number using the link provided
• Complete Project Primer by Sunday
• Start reading Unit 1, Module 1 on OLI
Questions?