SFWE 409/509: Cloud Computing Principles
Course Syllabus

Course Description

Units: 3

Cloud has become a de facto computing infrastructure in many business and research organizations to deliver various user-facing, business, and scientific applications to end users. In this course, you will learn the underlying technologies and concepts that create the current cloud computing infrastructure, and obtain hands-on experience in designing and implementing modern cloud applications.

This is an introductory cloud computing course designed for both senior-level undergraduate students and graduate students. This class will cover the following concepts and topics:

- Concept and Definition of Cloud Computing
- Virtualization and Data Centers
- Cloud Service Models: IaaS, PaaS, SaaS, FaaS
- Public Clouds, Private Clouds, and Hybrid Clouds
- Cloud Resource Management, and Basic Linux Commands
- Cloud Infrastructure Management Systems
- Cloud Storage, NoSQL, and Distributed Key/Value Store
- Containers and Microservices
- Container Orchestration Systems like Kubernetes and Docker Swarm
- Cloud Function and Serverless Computing
- Cloud Security
- Cloud IoT, Mobile Clouds
- Edge/Fog Computing, AI at the edge
- Big Data Processing Frameworks – Hadoop, Spark, Storm.

Instructor and Contact Information

Instructor Name: Sen He
Email: senhe@arizona.edu
Cell Phone: (520)621-6548
Office: Engineering Room 260A
Office Hours:

- **Online via Zoom**: By Request (AZ time zone)
- **In-Office**: Tuesday and Thursday from 2:00 PM – 3:30 PM (AZ time zone) or by appointment

You are encouraged to reach out to your instructor frequently throughout the semester via email, phone, text, office hours, or a scheduled synchronous meeting (in-person or Zoom). Every attempt will be made to respond to questions and concerns that you may have within 24 hours.

Course Pre-/Co-requisites

- Completion of ECE 369A or CSC 252 is *required*.

- Data structures, operating systems, distributed systems, and computer networks are not required, but prior knowledge of those courses is *recommended.*

Course Format and Teaching Methods

This course is structured around weekly progress. It will include a combination of lectures, and team activities focused on experiential learning, in-class discussions, and web-based assessments. The expected weekly progress is outlined in the course schedule. At a minimum it is recommended that students keep up with coursework by following the outlined course schedule on D2L. Note the DUE DATES on course deliverables are all posted on D2L.

This course also uses Amazon AWS, Google Cloud, Azure for practices, assignments, and the projects.

Course Objectives

During this course, you will:

1. Learn the core concepts of cloud computing including cloud computing fundamentals, virtualization, and the architecture of data centers.
2. Learn the difference in cloud services models including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and Function as a Service (FaaS).
3. Learn and practice cloud resource management skills on public clouds (AWS, Google Cloud, Azure).
4. Learn and practice basic Linux commands to interact and manage cloud instances.
5. Learn cloud storage solutions and their application in cloud environments, and explore NoSQL databases and distributed key/value stores.
6. Learn the basics of containers and microservices in cloud architecture.
7. Learn concepts of cloud security, IoT, mobile clouds, and edge computing.
8. Learn and practice big data processing frameworks.

Expected Learning Outcomes

Upon completion of this course, you should be able to:

1. Develop a solid understanding of fundamental cloud computing concepts. [ABET Student Outcome 7]
2. Choose and differentiate appropriate cloud service models and deployment options for different usage scenarios. [ABET Student Outcomes 1 and 6]
3. Create, take snapshots, manage, and delete IaaS cloud instances using both graphic interfaces and command line Interfaces. [ABET Student Outcome 7]
4. Develop simple python code, and use Linux commands to run the code on the cloud and retrieve the results to local machine. [ABET Student Outcomes 6 and 7]
5. Create, manage, and delete serverless cloud instances (container based serverless cloud) using both graphic interfaces and command line interfaces. Execute sample code on serverless clouds. [ABET Student Outcomes 1 and 6]
6. Create, manage, and delete FaaS cloud using both graphic interfaces and command line interfaces. Execute sample code on FaaS clouds, and explore different triggers. [ABET Student Outcomes 1 and 6]

7. **[Graduate Students]** Configure a Hadoop and Spark based big data processing framework to handle big data task.

Textbooks & Software

Required Textbooks

All required textbooks are available electronically through the UArizona library for *FREE*.

Cloud Computing: Theory and Practice (2nd ed.)
Dan Marinescu
ISBN: 0-323-91047-5

Cloud Computing for Machine Learning and Cognitive Applications
Kai Hwang
ISBN: 978026203641

The lecture will be based on the slides provided by the instructor. Also, the students will be required to read research papers and technical documents about cloud computing.

Required Software

All software required for this course is available for *FREE* through the Digital Engineering Factory. Applications used in this course include:

- An IDE of the student's choosing
- Register Amazon AWS using CatMail
- Register Google Cloud using CatMail
- Register Microsoft Azure using CatMail

Course Schedule

Because this course relies heavily on hands-on experiments on state-of-the-art commercial cloud platforms, the specific course schedule will be posted on D2L for any given semester. However, the table below provides an outline of topics and platforms that will also be covered/used in the class:

Module	Topic	Learning Outcomes
Module 1	**Concept and Definition of Cloud Computing**	• Define cloud computing with clarity and accuracy. • Explain the key benefits and limitations of using cloud computing. • Compare and contrast traditional computing with cloud computing. • Differentiate between various cloud computing deployment models (private, public, hybrid).
Module 2	**Virtualization and Data Centers**	• Explain the concept of virtualization and its role in cloud computing. • Describe the components and functionalities of a modern data center.

		• Analyze the impact of virtualization on resource utilization and efficiency. • Identify different types of virtual machines and their applications.
Module 3	**Cloud Service Models: IaaS, PaaS, SaaS, FaaS**	• Define and distinguish between IaaS, PaaS, SaaS, and FaaS cloud service models. • Identify the key characteristics, benefits, and use cases of each service model. • Choose the appropriate service model based on specific needs and requirements. • Compare and contrast the level of control and responsibility offered by each model.
Module 4	**Public Clouds, Private Clouds, and Hybrid Clouds**	• Explain the advantages and disadvantages of public, private, and hybrid cloud models. • Identify factors to consider when choosing between different cloud deployment models. • Describe security considerations for each cloud deployment model. • Explain the benefits and challenges of implementing hybrid cloud solutions.
Module 5	**Cloud Resource Management, and Basic Linux Commands**	• Manage cloud resources effectively using essential Linux commands (navigation, file management, basic scripting). • Utilize cloud-based management tools for resource provisioning, monitoring, and optimization. • Implement cost-effective strategies for cloud resource utilization. • Troubleshoot basic issues related to cloud resources using Linux commands.
Module 6	**Cloud Infrastructure Management Systems**	• Explain the purpose and functionalities of cloud infrastructure management systems. • Monitor and manage cloud infrastructure performance with

		dedicated tools.
Module 7	**Cloud Storage, NoSQL, and Distributed Key/Value Store**	• Compare and contrast traditional relational databases with NoSQL databases. • Explain the key features and benefits of distributed key/value stores. • Choose the appropriate cloud storage solution based on data type and access patterns. • Manage and manipulate data in NoSQL databases and distributed key/value stores.
Module 8	**Containers and Microservices**	• Explain the concept of containerization and its advantages for cloud applications.
Module 9	**Container Orchestration Systems: Kubernetes and Docker Swarm**	• Explain the purpose and functionalities of container orchestration systems. • Using Kubernetes or Docker to manage containerized applications at scale. • Monitor and troubleshoot containerized applications deployed on orchestration platforms.
Module 10	**Cloud Function and Serverless Computing**	• Explain the concept of serverless computing and its benefits for cloud applications. • Develop and deploy serverless functions using cloud function platforms (e.g., AWS Lambda, Azure Functions). • Trigger and integrate serverless functions with other cloud services. • Design and build event-driven and microservices-based architectures using serverless functions.
Module 11	**Cloud Security**	• Identify key security threats and vulnerabilities in cloud environments. • Implement best practices for securing cloud resources and applications. • Utilize cloud security services and tools for access control, encryption, and threat detection. • Comply with relevant data privacy regulations when using cloud services.
Module 12	**Cloud IoT, Mobile Clouds**	• Explain the role of cloud computing in the

		Internet of Things (IoT). • Describe the specific requirements and challenges of mobile cloud computing. • Design and optimize mobile applications for performance and scalability in the cloud.
Module 13	**Edge/Fog Computing, AI at the edge**	• Explain the concepts of edge/fog computing and its applications in cloud environments. • Understand the benefits and challenges of deploying AI at the edge. • Identify potential use cases for edge/fog computing in various industries. • Explore tools and platforms for developing and deploying edge-based applications.
Module 14	**Big Data Processing Frameworks – Hadoop, Spark, Storm**	• Explain the challenges of big data processing and the role of distributed frameworks. • Describe the functionalities and applications of big data processing frameworks like Hadoop,

Assignments and Examinations

Individual Programming Assignments (x5)

There will be regular programming assignments on the topics covered in class, with approximately a total of 5 programming assignments. These assignments are to be completed on an individual basis (not a team basis).

[Graduate Students] Graduate Students will complete an additional group programming assignment. The graduate students in the class will form a group of 3 students, and will be required to work on an additional group programming assignment in the area of cloud computing and big data.

[Graduate Students] Graduate Students will complete an additional research paper presentation individually. The paper topic should be related to cloud computing.

Grade Distribution, Scale & Policies

The grading distribution for course assignments is as follows:

	Undergraduate	**Graduate**
Individual Assignments	50%	35%
Group Assignments	-	10%
Midterm Exam	20%	20%
Final Exam	20%	20%
In-class Participation/Exercise	10%	10%

Paper Presentation	-	5%
Total	100%	100%

Total **100%**

Late Work Policy

All assignments are due at the time that is specified in the course schedule and/or D2L content pages. Late assignments *will not* be accepted without prior approval by the instructor and will receive zero points.

Make-up exams may only be given under extraordinary circumstances. The student requesting a make-up exam should contact the instructor well in advance and provide *written* documentation for the reason that they will not be able to attend the regularly scheduled exam. It is up to the discretion of the instructor to accept the justification provided by the student.

Use of AI

Students are encouraged to use generative AI (e.g., ChatGPT, Bard) on homework assignments and projects, However, generative AIs are strictly forbidden to use during the exam.

Instructor Grading & Student Appeals Policy

All assignments will be graded by the instructor within one week of the submission deadline. Feedback will be posted to D2L in the form of (1) detailed rubrics and (2) individualized written remarks. This feedback is designed to help you improve your craft; questions regarding your assignment feedback is welcomed during Office Hours or via email.

To appeal a grade on any assignment, submit an email identifying the assignment, question, and justification for the appeal within two weeks of the grade being posted to D2L.

Grading Scale

The following scale will be used to award final grades:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
E	less than 60%

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal respectively.

Course Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview.

Also watch the video available at https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy0000000000003560.

University Policies

Links to the following UA policies are available at, https://catalog.arizona.edu/syllabus-policies:

- Absence and Class Participation Policies
- Threatening Behavior Policy
- Accessibility and Accommodations Policy
- Code of Academic Integrity
- Nondiscrimination and Anti-Harassment Policy
- Subject to Change Statement

Final Examination

The final exam of this course will be given in accordance with the Final Exam Regulations and Final Exam Schedule, https://registrar.arizona.edu/finals.