

MIS596A: Fundamentals of Cloud Computing and its Design Strategies

Management Information Systems Department

Instructor: Dr. Muhammad Taqi Raza

Schedule: T&R from 14:00-15:15

Class Lectures URL: <https://arizona.zoom.us/j/97924266173>

Office Hours: T&R from 11:00-13:00

Office Hours URL: <https://arizona.zoom.us/j/95859783381>

Semester: Fall 2020

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TA Office Hours: M: 15:30-17:30 & F: 14:30-16:30

TA Office Hours URL: <https://arizona.zoom.us/j/2318012284>

1. Course Description: This course gives students a deep exposure to Cloud Computing, its enabling technologies, main building blocks, design strategies, and an in-depth understanding through homeworks, projects, and exams. Cloud computing has shaped our lives in many ways. Every one of us knowingly or unknowingly is using a number of cloud computing services in our daily life. These include shopping (e.g. Amazon), education (e.g. Coursera), health (e.g. UnitedHealth), social media (e.g. Facebook), entertainment (e.g. Youtube) and many more. The success of cloud computing is attributed to its ability to deliver computing as a service over the network, whereby distributed resources are rented, rather than owned, by an end user as a utility.

We will take a top-down approach in this course. We will start from cloud computing applications and working them down to the cloud infrastructures, virtualization, storage, computing, programming models, security, and the design strategies. The top-down approach has many advantages where we learn the high level concepts by answering intuitive questions. Such as, how cloud applications can handle millions of users? how these applications ensure quality of service? how reliability is achieved during failures? what sort of security measures are taken to protect subscribers data? and such others. In particular, we will consider four key cloud aspects: (i) cloud strategies and its infrastructure, (ii) importance of cloud migration, (iii) cloud applications, and (iv) cloud security.

As an introduction, we will discuss the motivating factors, benefits and challenges of the cloud, as well as service models, service level agreements (SLAs), security, examples of cloud service providers and use cases. We will then learn about data centers that drive the cloud paradigm. In this, we will

discuss key concepts behind data center design and management and software deployment. Thereafter, we will focus on how resource efficiency is achieved while reducing cost, increasing flexibility and easing network and service management. These will be discussed under virtualization techniques in cloud computing. After learning the virtualization techniques, we will study how business decisions influence the cloud choices. These choices can be private cloud, public cloud, or multi-cloud with hybrid infrastructure. Thereafter, we will understand how CPU, memory and I/O resources are virtualized, and how the scalability of these resources help application developers to achieve their application deployment goals. Subsequently, students will learn about different cloud storage concepts including data distribution, durability, consistency and redundancy. Finally, students will understand the details of the MapReduce programming model and gain a broad overview of the Hadoop as well as message queues and stream processing.

We will discuss the strategies behind the cloud computing architectures and its design considerations. We will understand the tradeoffs between security and performance, security and reliability, cloud availability and resource over-provisioning, and others. We will discuss different strategies utilizing novel analysis approaches in order to develop effective and secure cloud design architecture.

In summary, in this course, students will learn key principles in cloud computing research, understand the state-of-art and recent trends, learn basic and necessary research skills (such as, identifying flaws through critical thinking and critique, problem solving approach, technical writing, and team work). They will be prepared to carry-out original research through class homeworks and projects. The focus of the class will remain on the business aspects of the cloud computing where we will share the stories of cloud managers regarding their organizations' journey to the cloud.

2. Pre-Requisites: The pre-requisite for this class is Fundamentals of computer networks. Also an introductory course that familiarizes software tools and environments, particularly open-source tools to be used in upper-division information systems courses is a pre-requisite. The students must be comfortable with either C++ or Java programming language. The hands-on programming with Python is a plus but not required.

4. Textbooks and Course Materials: We will study the state of the art work in cloud computing (starting from basics to the advanced topics) by consulting the research papers. The course materials are mainly from the lecture slides and research papers that we will discuss in the class. We assume that students do not have any prior knowledge about the cloud computing, distributed computing, and the file system. Students may find following text books helpful to revise the basic concepts of networking and systems. In particular, the book they have used in MIS 543 is handy to refresh their networking concepts.

1. Luiz André Barroso and Urs Hölzle, The Datacenter as a Computer (Uploaded on D2L)
2. SK. Jerome H. Saltzer and M. Frans Kaashoek, Principles of Computer System Design: An Introduction, Morgan Kaufmann (2009). ISBN 978-01-2374957-4 (printed). ScienceDirect (free e-book available).
3. James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach (4th/5th/6th Edition). ISBN-13: 978-0132856201; Free PDF version is also available

4. Jerry FitzGerald, Alan Dennis, and Alexandra Durcikova, Business Data Communications and Networking. ISBN 978-1-119-36883-0

5. Assessment: Students performance will be assessed based on the following four criteria.

1. Final project (design + programming) and report (40%)
2. Class presentations on research papers (10%)
3. Two open-book quizzes (15% & 15%)
4. Two programming homeworks (10% & 10%)

6. Course Organization: Tentative schedule of the course and the topics is listed below.

Week	Topics	Deliverables/Assignments
1	Introduction to cloud computing and its applications	Projects assigned, HW1 assigned
2	Data center networks and their topologies	Project discussion
3	Scalable and fault tolerant topologies	
4	Transport layer	Project proposal due
5	File systems	
6	Handling big data	
7	Google and Amazon data store	HW1 due (Oct 11)
8	Facebook strategies for efficient storage of billions of photos	Quiz 1 (Oct 15)
9	Google spanner	
10	Consistent data store in Google and Microsoft	
11	High availability in Amazon Dynamo and Microsoft Azure	
12	Facebook caching strategies	Student presentations
13	Security and privacy in the cloud	Quiz 2 (Nov 24)
14	Untrusted cloud and Intel's SGX	HW2 due (Nov 29)
15	Softwareization trends in cloud computing (SDN & NFV)	Project demo
16	Project demo	Report due

7. Project Instructions: This course requires students to submit a project report in Week 16. The idea of project report is to prepare students to experience technical writing. The writing efforts will help them prepare the technical material in concise and coherent way, and let them describe their findings and thoughts in scientific writing. Following instructions must be taken care:

- Students must form a project group of 4 students by the end of Week 1.
- Students must submit 1-page project proposal by the end of Week 2. It is required to submit proposal in ACM template, please see the guidelines below.
- Students must meet the instructor on a regularly basis to discuss their project progress. Their bi-weekly progress will count towards their final grade and play a key part.

- The submission must use a 10pt font and be correctly formatted for printing on Letter-sized (8.5" × 11") paper. Paper text blocks must follow ACM guidelines: double-column, with each column (9.25" × 3.33"), 0.33" space between columns and single-spaced. If correctly formatted, this means that no page column will have more than 55 lines of text. Students can use either MS word or the LaTeX (preferred) template of the ACM.
- Figures and Tables must be professionally drawn. Students should benchmark the papers that we will study in the class.
- The submission (both project proposal and project final report) must be in PDF. No other format will be accepted.
- Submissions must be eight to ten (8 to 10) pages + unlimited number of pages for bibliography references.
- All reports must follow research paper style (similar to the ones that we will study in the class). For example, a final report can have following sections: Abstract, Introduction, Background, Related Work, Proposed Approach, Benefits of Proposed Approach, Evaluation and Results, Conclusion and References.
- Students will present their projects' findings through in-class presentations or posters. It will be announced later.

8. Policies:

8.1 Course Modality: This class is scheduled to be taught in the IN-PERSON modality, however all lectures be synchronous-online supported.

- *Meeting times for remote teaching:* We will be meeting remotely following the on-ramp approach for the first two weeks, and until the University notifies us that in-person meetings may commence. If you have any health concerns about in-person meeting, you CAN take the class fully remotely for the whole semester. Your grades will NOT be affected by the mode of your participation.
- *Meeting times and patterns for in-person teaching:* When the COVID-19 situation permits teaching on campus, we will have in-person lectures by enforcing social distancing. The D2L Announcements will contain a note prior to the first in-person class.
- *Remote / online only after Thanksgiving:* After the Thanksgiving holiday, we are scheduled to move to remote teaching. That means that we will meet live online through Zoom.
- *Class Recordings:* For lecture recordings, which are used at the discretion of the instructor, students will access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. Students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension. All recordings are the property of the faculty member.

8.2 Face coverings are required in our classroom: Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories and studios). Any student who violates this directive will be asked to immediately leave the learning space, and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved.

The Disability Resource Center is available to explore face coverings and accessibility considerations if you believe that your disability or medical condition precludes you from utilizing any face covering or mask option. DRC will explore the range of potential options as well as remote course offerings. Should DRC determine an accommodation to this directive is reasonable, DRC will communicate this accommodation with your instructor.

8.3 Physical distancing is required in our classroom: During our in-person class meetings, we will respect CDC guidelines, including restricted seating to increase physical distancing. Any student who does not maintain physical distance from others may be asked to immediately leave the learning space. Noncompliance may result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied.

8.4 Classroom attendance: If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel. Notify your instructors if you will be missing an in person or online course. Campus Health is testing for COVID-19. Please call (520) 621-9202 before you visit in person. Visit the UArizona COVID-19 page for regular updates.

8.5 Academic advising: If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

8.6 Life challenges: If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or email: DOS-deanofstudents@email.arizona.edu.

8.7 Physical and mental-health challenges: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling and Psych Services (CAPS) 24/7 hotline, call (520) 621-3334

8.8 Electronic communication: The course materials (such as class lectures, reading materials) and announcements will be posted online. I will not provide any handouts to the class. Students are welcome to email me and ask any question/concern they have without waiting for my office hours and the class. Students are also required to submit their homeworks and projects online using D2L.

8.9 Academic integrity: The University of Arizona upholds the highest standards of integrity both inside and outside the classroom. As a student and member of the UoA community, students are expected to demonstrate integrity in all of their academic endeavors for this course. In case of any accusations of academic dishonesty, the student case will be forwarded to the Office of the Dean of Students. The

office will investigate and adjudicate the suspected violations. Note that academic dishonesty, includes, but is not limited to, cheating, fabrication, plagiarism, multiple submissions or facilitating academic misconduct.

Every student needs to sign the Academic Integrity form and must submit to D2L by Week 2.

8.10 Understanding sexual harassment: The University of Arizona is committed to creating and maintaining a community free of sexual violence and sexual harassment. Sexual violence and sexual harassment violate both law and University policy. The student must immediately report conduct that may constitute sexual violence, sexual harassment, retaliation, and other prohibited behavior. If you believe that you are experiencing sexual harassment or gender discrimination, you should immediately contact the UA Title IX Coordinator for consultation.

8.11 Nondiscrimination in the classroom: The University of Arizona is committed to creating and maintaining a community free of all forms of discrimination and harassment, including gender discrimination. Gender discrimination includes sexual harassment and sexual violence, which are prohibited by law and University policy. Any such nondiscrimination cases must immediately reported to the UoA Office of Institutional Equity (OIE). The OIE is responsible of investigating reports of discrimination or harassment involving conduct that negatively impacts the campus climate related to equity, diversity and inclusion.

8.12 Accommodations for disabilities: The University of Arizona is committed to ensuring equal educational opportunities for students with disabilities. An integral part of that commitment is the coordination of specialized academic support services through the Disability Resource Center (DRC). The DRC facilitates academic accommodations for regularly enrolled, matriculating students with documented permanent and temporary disabilities. A student seeking academic accommodations should first register with DRC and then meet me to make particular arrangements.

8.13 Fire and other emergency situation: In the event of a fire emergency (fire alarm sound), students must exit the building (through the nearest exit) immediately. In case, the fire alarm triggers during the exam, students are required to deposit their exam to me before leaving the class room. We shall resume the exam when it is safe to return to the building.

Note: unless otherwise advised, all alarms should be treated as an emergency.