Carnegie Mellon University

14-848 Cloud Infrastructure: Design, Analysis and Implementation

Meeting Dates/Times: Tue/Thu 3:30 - 4:50 PM ET (12:30 – 1:50 PM PT)
Location: CIC 1201 for PIT Students & B23 109 for SV Students
Course Webpage: https://canvas.cmu.edu/courses/51286

Semester: Spring**, Year:** 2026

Units: 12**, Sections:** A (Pittsburgh), SV (Silicon Valley)

Instructor

Name	Mohamed Farag (he/his/him) – Addressed as "Mohamed" or "Dr. Farag"
Contact Info	farag@cmu.edu
Office Hours Location	CMU Remote
Office Hours	Monday, Thursday 11:30am – 12:30pm ET (8:30 – 9:30am PT). Conducted remotely via Zoom (link is available on the course Canvas page).

Course Description

- Cloud computing has emerged as a new paradigm for efficient and highly elastic delivery of computing services over the Internet to achieve economies of scale. It focuses on the delivery of services via on-demand and fluidly scalable shared resources. This course focuses on the design and implementation of networked systems and software necessary to implement the infrastructure for elastic, global-scale computing, and storage clouds. Upon successful completion of the course, students will be able to design, implement, and analyze the underlying infrastructure of cloud and edge-based services. Topics covered in this course include data center networking, cloud-scale storage, virtualization, computing programming models, large-scale distributed computing, edge computing, resource utilization and sharing, and cloud service frameworks. The course material will focus on recent landmark research papers and existing tools and software systems. Students will have substantial programming project work in which they design, implement, and analyze aspects of cloud infrastructure and services. Students are expected to be proficient in Python, Linux system programming, and command-line tools.

- The premise of this course is to build a broad and solid foundation in cloud computing that will pay significant dividends throughout a student's research and work career across cloud computing and DevOps related fields. In this class, we will focus on five main themes:

  - Cloud computing concepts and programming paradigms
  - Cloud Deployment and Orchestration
  - Big data processing frameworks.
  - Miscellaneous topics related to cloud computing.

- **Prerequisites**: project course in software systems (e.g., networking, OS, etc.) and python programming experience should be sufficient.

- **Class Structure:** Lectures will be synchronous, and attendance is required. There will be an in-class quiz offered via Canvas to assess students' understanding of the material covered in the previous lecture. For this reason, students are expected to bring a laptop or mobile device to class.

- **Recitations:** Virtual recitations are offered to provide additional practice on the concepts, topics, and examples presented during the lecture. Recitations will be conducted over Zoom, and attendance is not required.

Learning Objectives

In taking and successfully completing this course, students will achieve the following objectives:

- Understand the current cloud computing technology and critical technology trends that are enabling cloud computing, including cloud Computing architecture along with the services and the applications that cloud computing offers.
- Gain hands-on experience in building and analyzing cloud infrastructure components and developing and testing services that operate within them.
- Develop big-data processing applications to handle large loads of data.
- Simplify the deployment and portability of large complex applications to promote continuous integration and continuous delivery concepts using Docker.

    The work that you will carry out in this course maps to some of the learning outcomes that INI has defined as vital to the full CMU graduate-level experience. Specifically:
    - self-directed learning
    - critical thinking; and
    - complex problem solving.

Learning Resources

There is no primary textbook, as most reading material will come from research papers and other technical documentation. Additional background reading material can be suggested upon request.

Important Dates

- January 19th, 2026: MLK Jr. Day (no office hours)
- March 2nd – March 6th, 2026: Spring break (no classes/office hours).
- April 9th – April 11th, 2026: Spring Carnival (no classes/office hours).
- April 23rd, 2026: Final exam (during lecture time).

Assessments

Students are encouraged to attend class regularly, read the assigned reading material and participate in class discussions. The final grade will be based upon 1 exam, 1 project, 7 homework assignments, and in-class quizzes.

Final Exam	Project	Assignments	Quizzes
20%	20%	40%	20%

- **Quizzes** are offered during each lecture via Canvas. Each quiz will be accessible via a unique access code that will be provided to the students. Students will have 5 minutes to answer two multiple choice questions covering materials from the previous lecture.
  - Please note that students are not allowed to share Quiz Access Code with their peers who didn't attend the class in person without pre-approval from the instructor. Sharing the quiz access code, without instructor's approval, is considered an academic integrity violation.
- **Assignments** are designed to provide opportunities to practice the concepts taught during lectures. Students may need to spend a good amount of time on their own to learn implementation details that are not covered in class. Students will receive 7 assignments throughout the course. Assignment schedule is shown on the last section of this syllabus. Most assignments will utilize Google Cloud Platform (GCP) as the main cloud provider
- **Project** details are released in week 3. Each student will have the option to work with their peer(s) on one of three project options. For the final project submission, students are expected to record a video including a code-walkthrough of their work and functionality demo showing the running version of their application. Project submission deadline is **April 2nd, 2026, 11:59PM ET /8:59pm PT.** The course project will require a significant amount of self-learning and the course instructor may provide project-related hints, high-level guidance, and clarifications during lectures. However, students should not expect any additional project support during office hours or via email. There will be a checkpoint to ensure that students are making good continuous progress (refer to the proposed course schedule in the last section of this syllabus). Project grading rubric and evaluation will be released along with project details.
- **Final Exam** is an open note test to validate student knowledge with the taught materials and the verbal notes mentioned during the lectures.
  - Students will have access to all the **PDFs for lectures, readings and HW solutions**. Students can **bring any hard-copied materials with them**.
  - Students are required to follow the schedule of their registered section. **On the scheduled final lecture of each section, final exam will be released only to the registered students of the corresponding section**. Each section will have its final exam version(s).
  - Exam will be offered via **Lockdown Browser and no knowledge exchange is allowed among students during the exam.**
  - Students are expected to install and test Lockdown browser on their machines ahead of the exam. If students face an issue with Lockdown browser installation, students must reach out to the instructors **no later than 2 weeks** before the final exam date.
  - **You can get four bonus points on the final exam if you obtain TWO of the following certifications two weeks before the final exam:**
    - Google Cloud: Associate Cloud Engineer
    - AWS Certified Solutions Architect – Associate
    - Microsoft Certified: Azure Developer Associate
    - GCP Professional Data Engineer
    - AWS Certified Data Engineer - Associate
    - Microsoft Azure Data Engineer Associate
    - Certified Kubernetes Application Developer
    - NVIDIA's Fundamentals of Accelerated Data Science
  - Late acquisition of these certificates beyond the deadline won't be accepted. Students who would like to boost their final exam score must upload proof of obtaining up to two certificates two weeks prior to the exam.
  - Obtaining 1 certificate will gain you two bonus points on the final exam.

Students will be assigned the following final letter grades, based on rubric provided in the above table. +/- are assigned in equal intervals to provide further granularity.

Grade	Percentage Interval
A/A-	[85-100%], A starts from 93
B	[70-85%)
C	[55-70%)
D	[40-55%)
R (F)	Below 40%

Homework, Course Project, Late Submission & Grading Policies

- Students are expected to check the course webpage on Canvas regularly for announcements, class schedules, lecture notes, homework assignments, reading assignments, and other course-related information.
- Homework assignments and the course project must be submitted via **Gradescope** as a **GitHub Classroom repository URL**. To prepare, create a free GitHub account (if you don't already have one) and use the provided GitHub Classroom assignment invitation link. This will automatically generate your repository within our course's GitHub Organization, which you will then submit on Gradescope.
- **Students must push their code to GitHub and submit their GitHub Classroom repository URL on Gradescope before the submission deadline.**
- GitHub Classroom repositories are the official source of record for code submissions. Submissions made outside of your GitHub Classroom repository will not be accepted.
- Students are expected to use Google Cloud Platform for homework and project assignments. If students run out of credit (or mis-redeem a coupon), students are requested to email the course instructor.
  - Students should expect a 24-48-hour delay to receive a new coupon.
- Students are strongly encouraged to complete the assignments and the project as early as possible. No extensions for homework will be offered, even in the case of technical difficulties.
- **Students will have 3 days to submit an assignment after the due date,** and a late penalty will be applied. Late penalties are applied based on the timestamp of the last code commit on GitHub and it will follow this equation:
  - 5 points for up to 24 hours delay
  - 15 points for the next 24 hours delay
  - 25 points for the next 24 hours delay
  - 100 points penalty (no grade) after this time.
- **Late submissions for the course project will receive no grade (0 points).**
- After homework and project grades are released, **Regrade requests can be made for 48 hours via Gradescope**. Regrade requests **cannot be submitted via email**. Also, regrade requests **cannot be submitted after the 48 hours window is closed**.
- Students are encouraged to read their privacy rights in Family Educational Rights and Privacy Act (FERPA).

Guidelines for Office Hours and Out-of-class Questions

- Students are encouraged to leverage office hours to get the support they need. Some office hours will be held in-person while others will be held via Zoom. Refer to the course page for details.

- Students are required to reserve their location in the queue by signing up using OH Queue.
- During Piazza OH, questions posted before the session will be addressed.
- For example, if Piazza OH is scheduled from 10–11am, then all questions submitted before 10am will be answered during that 10–11am window.
- If you have materials-related questions, you can post them on **Piazza** or ask them during office hours. You should plan to receive the question responses on **Piazza** during office hours allocated time.
- You may email personal inquiries and severe emergencies to the instructor(s). The email subject line should begin with **"14-848"**. Emails sent to the instructor should be 2-3 lines maximum and the instructor's response will not be more than few words. Generally, the course instructor is available to respond to personal inquiries during M-F 9am-8pm ET. Please don't expect responses over the weekend or late at night.

Expectations for Class Attendance and Class Absence

- Class attendance and participation are important components of learning in this course. To account for this, a portion of the final grade is based on quizzes that are offered during the lectures (see assessment section). That said, I also recognize that students may need to miss class for a variety of reasons (religious observance, job interview, university-sanctioned event, or illness). **For that reason, all students are permitted two class absences (including their quizzes) without any impact on the final grade.** If you encounter extenuating circumstances and must miss more than two classes, please email the course instructor and follow the student affairs guidance below:
    "Based on the Student Affairs recommendation for guiding students who may be absent for more than a few classes due to a personal issue (injury/illness or other), the student affairs recommend that students either contact the office of disability resources (particularly if it may be an extended issue) or fill out a CMU cares referral form for the student to get them in touch with a student affairs liaison. The student can also be advised to fill out the form on their own behalf if they are seeking guidance on an issue they are dealing with. Here is the form: https://www.cmu.edu/wellbeing/resources/student-support-resources.html"
    - When filling in the form, add my information in the description box. Upon approval of your request from the university, I'll be able to provide necessary accommodations.
- When attending the class in-person, I expect that you will abide by all behaviors indicated in A Tartan's Responsibility, including any timely updates based on the current conditions.

Recording of Class Sessions

- Class recordings will be available after each lecture. Please note it may take a few hours for the recording to become available. The Class recording catalog will be published on Canvas.

Academic Integrity

- We take academic integrity seriously. Students are encouraged to ask questions if they are unclear about any aspect of academic integrity. The standard penalty for an academic integrity violation in this course is failure of the course. However, the instructor may assess a lesser penalty at his discretion.
- Discussing assignments with your classmates is allowed and encouraged, but it is important that every student gets practice working on these problems. This means that **all** the work you turn in must be your own. You must devise and write your own solutions and carry out your own tests. The general policy on homework collaboration is:
    - You may use all the materials and readings that we explicitly provide you with in the assignment document. In this case, attribution is not required.
    - You may use other course material, including lectures, Piazza posts by the instructors, and material from Canvas. For any such use, you must provide a proper attribution.
    - Beyond this, you may not obtain code or other solution information, either by copying, retyping, or looking at files or documents from any of the above-listed courses for this semester, or a previous

semester.
- o You may not obtain code or other solution information from an unauthorized external source, including web pages, code repositories, blog posts, etc.
- o You may not look at someone else's code (or other documents.) This includes one person looking at code and describing it to another. There is no notion of looking "too much," since no looking is allowed at all.
- o You may not make use of any information about the assignments posted online, except for the authorized sources provided with the assignment document.
- o You may get assistance on an assignment from the instructors, course staff, and university tutors.
- o You may only get high-level, strategic advice from others, including current and former students, and people external to the university. Forbidden forms of advice include anything more detailed than a brief verbal description or block diagram, any kind of code or pseudo-code, explicit directions on how to assemble allowed blocks of code, and code-level debugging assistance.
- o You may not provide detailed help with an assignment to students this semester or in future semesters for any of the above-listed courses (unless you are serving as a teaching assistant or instructor for the course.
- o You may not supply a copy of a file or document to an individual student or via a public channel, such as a blog post.
- o You may not have any of your solution files in unprotected directories or in unprotected code repositories, either by putting files in an unprotected location or by allowing protections to lapse. Be sure to store your work in protected directories, and log off when you leave an open cluster, to prevent others from copying your work. If you make use of a code repository, such as GitHub, make sure your work is kept private, even after you have left CMU.
- o You may not provide electronic, verbal, or written descriptions of code or other solution information.
- o You may clarify ambiguities or vague points in class handouts or textbooks.

- Students may use Generative AI platforms (e.g., ChatGPT) to assist them with understanding the homework concepts. However, students can't use the direct homework question in their prompt to the AI tool. In addition, students are expected to cite the text (or code) that was generated from ChatGPT carefully. This includes scenarios where generative-AI was used to generate base-code/scenario and minor (or significant) changes have been made to it.

- Please talk to the instructor if you have any questions about this policy. Any form of plagiarism or cheating will result in sanctions to be determined by the instructors, including grade penalties (such as negative points for the assignment or reductions in letter grade) or course failure. Students taking the course pass/fail may have this status revoked. We are also obliged to report violations to your academic program and the appropriate University authorities. Please refer to the University Policy on Academic Integrity.

Student Wellness

- The last few years have been challenging. We are all under a lot of stress and uncertainty at this time. I encourage you to find ways to move regularly, eat well, and reach out to your support system or me (farag@cmu.edu) if you need to. We can all benefit from support in times of stress, and this semester is no exception.

Diversity Statement

- **We must treat every individual with respect**. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our

students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.

- Each of us is responsible for creating a safer, more inclusive environment.
- Unfortunately, incidents of bias or discrimination do occur, whether intentional or unintentional. They contribute to creating an unwelcoming environment for individuals and groups at the university. Therefore, the university encourages anyone who experiences or observes unfair or hostile treatment on the basis of identity to speak out for justice and support, within the moment of the incident or after the incident has passed. Anyone can share these experiences using the following resources:
  - o **Center for Student Diversity and Inclusion**: csdi@andrew.cmu.edu, (412) 268-2150
  - o Report-It **online anonymous reporting platform**: reportit.net username: tartans password: plaid
- All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.

Food Insecurity

- If you are worried about affording food or feeling insecure about food, there are resources on campus that can help. Any undergraduate or graduate student can visit the CMU Pantry and receive food for free. Follow the directions on the CMU Pantry website to schedule your visit.

Disability Resources

- If you have a disability and have an accommodations letter from the Disability Resources office, we encourage you to discuss your accommodations and needs with us as early in the semester as possible. We will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, we encourage you to contact them at access@andrew.cmu.edu.

Religious Observances

- Students who anticipate conflicts between religious observances and scheduled class activities should notify the instructor by email within the first two weeks of the semester.

Student Academic Success Center

SASC programs to support student learning include the following (program titles link to webpages):
- Academic Coaching: This program provides holistic, one-on-one peer support and group workshops to help undergraduate and graduate students implement habits for success. Academic Coaching assists students with time management, productive learning and study habits, organization, stress management, and other skills.
- Peer Tutoring: Peer Tutoring is offered in two formats for students seeking support related to their coursework. Drop-In tutoring targets our highest demand courses through regularly scheduled open tutoring sessions during the fall and spring semesters. Tutoring by appointment consists of ongoing individualized and small group sessions. You can utilize tutoring to discuss course related content, clarify and ask questions, and work through practice problems.
- Communication Support: Communication Support offers free one-on-one communication consulting as well as group workshops to support strong written, oral, and visual communication in texts including IMRaD and thesis-driven essays, data-driven reports, oral presentations, posters and visual design, advanced research, application materials, grant proposals, business and public policy documents, data visualisation, and team

projects. Appointments are available to undergraduate and graduate students from any discipline at CMU. Schedule an appointment (in-person or video), attend a workshop, or consult handouts or videos to strengthen communication skills.

- **Language and Cross-Cultural Support:** This program supports students seeking help with language and cross-cultural skills for academic and professional success through individual and group sessions. Students can get assistance with writing academic emails, learning expectations and strategies for clear academic writing, pronunciation, grammar, fluency, and more. Make an appointment with a Language Development Specialist to get individualized coaching.
- **Supplemental Instruction (SI):** This program offers a non-remedial approach to learning in historically difficult courses at CMU. It utilizes a peer-led group study approach to help students succeed and is facilitated by an SI leader, a CMU student who has successfully completed the course. SI offers a way to connect with other students studying the same course, a guaranteed weekly study time that reinforces learning and retention of information, as well as a place to learn and integrate study tools and exam techniques specific to a course.

Mental Health Resources

- **CaPS has partnered with TimelyCare** for provision of virtual well-being services, including immediate emotional support 24/7 as frequently as needed, scheduled appointments with therapists that can be chosen by identity group and other features, health coaching (e.g., sleep issues, weight management, etc.), and group sessions for things like yoga, meditation, etc.

Preliminary Course Schedule (Subject to Change)

Date	Topic	Notes
Week-1 (Jan. 12th)	- Introduction & Syllabus - Computing Service Models.	- System Setup homework released
Week-2 (Jan. 19th)	- Virtualization Basics - Containerization	- System Setup homework deadline. - Docker homework released - Recitation-1: Introduction to Google Cloud
Week-3 (Jan. 26th)	- Lab: Containerization - Deployment Orchestration - Pokémon Go Case Study	- Course Project released. - Recitation-2: Docker Scripting and Debugging + Docker Compose Basics.
Week-4 (Feb. 2nd)	- Lab: Deployment Orchestration - Kafka	- Docker homework deadline - Kubernetes homework released. - Recitation-3: YAML Scripting for Kubernetes.
Week-5 (Feb. 9th)	- Lab: Confluent Kafka - Infrastructure-as-a-Code	- Recitation-4: More Kafka Examples.
Week-6 (Feb. 16th)	- Infrastructure-as-a-Code (Cont'd) Terraform - Lab: Terraform	- Kubernetes homework deadline - Kafka Homework released - Recitation-5: HCL Basics and Terraform Practice Set.
Week-7 (Feb. 23rd)	- Cloud Data Storage Models - Lab: NoSQL Database: Google BigTable	- Course Project Checkpoint
Spring Break (Mar. 2nd - Mar. 6th)		

Week-8 (Mar. 9th)	- Cloud Infrastructure Concepts - Introduction to Hadoop	- Kafka Homework deadline - Terraform Homework released
Week-9 (Mar. 16th)	- Hadoop HDFS - Hadoop MapReduce	- Terraform Homework deadline
Week-10 (Mar. 23rd)	- Big Data Algorithms - Introduction to Spark	- Hadoop MapReduce homework released - Recitation-6: Hadoop MapReduce Practice Set.
Week-11 (Mar. 30th)	- Spark (Cont'd) - Lab: Spark Programming	- Course project submission deadline
Week-12 (Apr. 6th)	- Metaverse, Edge Computing and Fog Computing	- Hadoop MapReduce homework deadline - Apache Spark homework released - Recitation-7: Spark Practice Set.
Week-13 (Apr. 13th)	- Cloud Security & Privacy Concepts - DevSecOps	- Apache Spark homework deadline
Week-14 (Apr. 20th)	- Student Vote Lecture. - Final Exam	