*CS 425 Distributed Systems, Fall 2024, University of Illinois at Urbana-Champaign*

# Course Information

## § Course Overview (or – What Will I Learn from this Course?)

This course will equip students with foundational basics needed to understand, work with, and build distributed systems such as cloud computing systems. Topics include, but are not limited to, MapReduce, peer-to-peer systems, failure detectors, synchronization, election, consensus, inter-process communication, gossiping, concurrency control, replication, key-value stores, NoSQL, security, probabilistic protocols, stream processing, measurements, etc. These topics are discussed in the context of real-life and deployed systems such as clouds and datacenters, databases, peer to peer systems, clusters, etc. This course assumes knowledge of fundamentals in both OS and networking.

## § Course Essentials

**Class Meets:** Tuesdays and Thursdays, 2:00 PM - 3:15 PM, 0027/1025 Campus Instructional Facility.

**Professors:**


| | | |
|---|---|---|
| Indranil Gupta | http://indy.cs.illinois.edu | indy at illinois dawt edu |
| Aishwarya Ganesan | https://aishwaryaganesan.github.io | aganesn2 at illinois dawt edu |


**Course Website:** `http://courses.engr.illinois.edu/cs425/`

All lectures and some announcements will be posted on this website, so please check periodically.

**Discussion Forum:** We will be using Piazza (link is on the website). Important announcements will be posted on this forum, so please check periodically. This is your go-to place to ask clarification questions for HWs (Homeworks) and MPs (Machine Programs, or Programming Assignments). Before you post, check if someone has already asked that question.

The course staff will attempt to ensure your questions are looked at within 24-48 hours of it being posted. We recommend you start Homeworks and MPs early; posting questions at the last minute, e.g., right before a deadline, has no guarantees of being answered in time (spare a thought for the TAs!).

**Prerequisites:**

- For all students: CS 240/241/340/341 (Systems Programming) or ECE 391, or equivalent course on Operating Systems or Networking (approval of instructor required if you've taken only a Networking course but not an OS course).
- For 4 cr On-campus: Prior experience with a major programming language (for the MPs), and basic sockets programming experience. In the past, students have used Java, C++, Go, C, Rust, etc. (one of these suffices - you will have a choice).

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- For MCS Online /DSO students (Online, via Coursera; includes MCS Chicago students): Prior experience with C++ (for the online Coursera MPs).

- This course assumes knowledge of fundamentals in both OS and networking. While CS240/241/340/341 are co-requisites, we assume students complete knowledge of OS (and socket programming for on-campus MPs).

- This course does not deal with details of computer networking and routing and wireless/mobile computing – other courses in the department (e.g., CS 438/439) cover those.

**Credits:** 3 hours or 4 hours.

- For On-campus 4 credit students do the MPs. If you want to do MPs, register/upgrade to 4 credits.

- We cannot grade MPs for students not in the 4 cr on-campus section.

- All MCS Online/DSO students do the online Coursera MPs.

**Main Textbook (Recommended, not Required):** Coulouris, G., Dollimore, J., Kindberg, T., and Blair, G., *Distributed Systems: Concepts and Design*, Addison-Wesley, *Fifth Edition, 2011, ISBN: 0132143011*. [Recommended purchase – copies available at Illini Book Store. On reserve at Grainger Library]. *We will refer to chapter, section, and problem numbers ONLY in the Fifth Edition. If you use an older edition, correct interpretation/translation of these numbers is solely the students' responsibility (no excuses).*

Supplementary materials are listed at the end of this handout.

**Course Staff Contact Information and Office Hours:** To get the fastest responses, please first post to:

1. Discussion Forum: All students (3 cr, 4 cr, MCS Online/DSO) must use Piazza. See website for link.

2. If your question is private or not answerable on the discussion forum, then email the staff mailing list. See website for address. Please DO NOT email individual TAs, as the mailing list will get you the fastest response.

3. Use office hours of the TA or professor. See website for dates and times.

4. For private matters, you can contact the professor.

For more details, please see course website.

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| | 3 cr (On-campus) | 4 cr (On-campus) | MCS Online (Coursera, and MCS Chicago) |
|---|---|---|---|
| HWs 1-4 On-campus | Y | Y | Y |
| MP On-campus | N | Y | N |
| Coursera Quizzes 5 + 5=10 Coursera Finals: Part 1 + Part 2 | N | N | Y |
| Coursera Programming Projects Part 1 + Part 2 | N | N | Y |
| On-campus Midterm Exam + On-campus Final Exam | Y | Y | Y |

Table 1: Assignments for Sections in CS425/ECE428. Y = Yes. N = No.

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## § Course Participation

**Sections and Assignments:**

There are 3 categories of students (i.e., sections) in this class. They are listed, and their assignments summarized in Table 1 below. More description is below.

The three categories (sections) of students and their assignments are:

1. On-campus Students 3 credits: Homeworks, Midterm Exam, Final Exam. Henceforth referred to as **"3 credit students"**.

2. On-campus Students 4 cr: Homeworks, Midterm Exam, Final Exam, On-campus Programming Assignments (MPs). Henceforth referred to as **"4 credit students"**. These include all 4 credit on-campus students *except* MCS Online/DSO students.

3. All **MCS Online/DSO Students Please read carefully.** Students (coming in via Coursera): All Quizzes (5+5=10) on Coursera, All Exams on Coursera (2 Finals), 2 Programming Assignments on Coursera, All homework sets (given to On-campus students), Midterm Exam and Final Exam (both given to On-campus students). MCS Online/DSO students *do not* do the 3-4 MPs given on campus. For each of the *5+5 Coursera quizzes* (but *not Coursera exams*), we will have a *Pass/Fail grade (cutoff is 70% of the quiz points for that quiz)*. Overall, the work for the MCS Online/DSO students is *equivalent to* (though not equal to) the 4 credit on-campus version of the course.

**Assignments - Detail:**

1. All HW and MP Assignments (except Coursera MPs) will be clearly marked Fall 2024 and have deadlines on them. The deadline time+date printed on the assignment is final – no extensions or late submissions (for whatever reason)! (Coursera MPs may say "Revised Fall 2020"' - that is just the date the MPs were last revised; they are current). If you see an older version (except Coursera MPs) please let staff know!

2. (For All Students) There will be four to five homework sets (HWs) , with about 1-2 weeks turnaround time per homework. **Your homework solution submissions are required to be**

**typed** (you may use any of your favorite word processors). We will not accept handwritten solutions. Figures and equations (if any) may be drawn by hand. With some exceptions, Homeworks are usually **due at the beginning of class on the day of the deadline (US Central time zone), so online students please be mindful of what this time translates to in your local timezone** (please watch for exceptions to this rule). More details will be available with each HW on how to submit your HW. There are **no exceptions to the submission deadline** (Medical exceptions will need a doctor's certificate at least 24 hours before the deadline, and are not approved until an instructor replies positively. Interviews, travel, and other deadlines are not acceptable reasons for seeking extension.).

3. (For all 4 credit Students, Except MCS Online/DSO Students) Four programming assignments (Machine Programs, or MPs) will be given throughout the semester, each requiring 2-4 weeks of effort. All MPs are evaluated via 1) a **report**, and 2) a live **demo** (must be done in-person in Fall 2024). All groups will receive access to a cluster (typically the CS VM Farm cluster). All groups can choose their programming language of choice (past groups have used C++, Java, Go, C, Python, Rust, etc.). There are **no exceptions to the submission deadline** (Medical exceptions will need a doctor's certificate at least 24 hours before the deadline, and are not approved until an instructor replies positively. Interviews, travel, and other deadlines are not acceptable reasons for seeking extension.).

4. (For Only MCS Online/DSO Students) 2 Programming Assignments Building Distributed Systems via a C++ Emulator. **Prior knowledge of C++ is required and essential.**. Please be mindful of the deadline times noted in Coursera, especially as there are many deadlines! There are **no exceptions to the submission deadlines on Coursera**, due to the automated nature of Coursera.

5. (For Only MCS Online/DSO Students) All Quizzes (5+5=10) on Coursera, All Exams on Coursera (2 Finals). The 5+5 quizzes will each be pass/fail (cutoff is 70% of points on that quiz). Coursera exams are not pass/fail. There are **no exceptions to the submission deadlines on Coursera**, due to the automated nature of Coursera.

6. (For All Students) In-class Midterm Exam and Final Exam. Both exams are in-class for all on-campus students. If MCS Online/DSO Students need to use a proctor for the exams (in the past Coursera has used ProctorU), we will let you know (otherwise Coursera students will take the midterm and final open book/notes). By default, we expect everyone to take the regular exams (midterm and final). We cannot offer a conflict if you have double-booked your timeslot with another course (an instructor has already informed you about this when you emailed them). Exceptions and makeup exams are very rare (due to the size of the course, we keep it streamlined). DRES students must email instructors at least 2 weeks before the exam time (DRES exams are offered at the same time and date, except in and by the DRES office.) If you need an exception, email instructors at least 2 weeks before the exam day—requests are not approved until an instructor replies positively. (Medical exceptions will need a doctor's certificate, and are not approved until an instructor replies positively. Interviews, travel, and other deadlines are not acceptable reasons for seeking a conflict.).

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7. **Start** your HWs and MPs (and for MCS Online/DSO students: quizzes, programming assignments, and exams) **early**. We recommend **attempting each HW problem right after the lecture that covered it**. DO NOT start the entire HW or MP at the last minute – these assignments involve more time than you think. If you start an assignment a day before the deadline, you may already be too late. Did we say **start early**?

**Grading (tentative splits):**

For the 3 groups of students:

1. 3 credit students will have total course grades out of 90 points (this group will be curved and graded separately). We do curve the 3cr undergraduate and 3cr graduate students separately from each other (we realize the two groups have different backgrounds!).

2. 4 credit students will have total course grades out of 130 points (this group will be curved and graded separately). We do curve the 4cr undergraduate and 4cr graduate students separately from each other (we realize the two groups have different backgrounds!). Note: 4cr CS425 satisfies the department's team project/one-term capstone project requirements (which requires the programming project be at least 30% of course grade)

3. MCS Online/DSO students will have total course grades out of 156.75 points (this group will be curved and graded separately).

**Grading (tentative splits) - Detail:**

- On-campus Homework sets (HWs) 40 points (**For all students**: 3 credit and 4 credit students, and MCS Online/DSO students)

- On-campus Programming Assignments (MPs) 40 points **(Only for 4 credit students, not for 3 credit or MCS Online/DSO)**. Note: This means the 4cr CS425 satisfies the department's team project/one-term capstone project requirements (which requires the programming project be at least 30% of course grade).

- On-campus Midterm Exam 15 points (**For all students**: 3 credit and 4 credit students, and MCS Online/DSO students)

- On-campus Final Exam 35 points (**For all students**: 3 credit and 4 credit students, and MCS Online/DSO students)

Additional work **for MCS Online/DSO** students:

- Coursera Quizzes (5+5=10 quizzes): 67 + 60 = 127 questions. With 0.25 points per question (on average), that is a total of 31.75 points. (The "+" indicates the split between C3 Part 1 and C3 Part 2. C3 = Cloud Computing Concepts course on Coursera.). Note that individual questions are not graded, but each Coursera quiz is pass/fail with cutoff of 70%. E.g., If a quiz has 10 questions, you either get 2.5 points if you get 7 or more questions correct, or 0 points otherwise.

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- Coursera Final Exams: 30 + 30 = 60 questions. With 0.25 points per question, that is a total of 15 points.
- Coursera Programming Assignments: 10 + 10 = total of 20 points.
- While the Coursera points for each of the above may be different (e.g., Programming Assignments are 90 points on Coursera), they will be scaled down and weighted according to the numbers above.

Grades will be available in Canvas for on-campus students (3 cr and 4 cr), and for MCS Online/DSO students on Coursera.

Grading for undergraduate and graduate students will be separated. Grades will be assigned on a curve (relative grading). The fraction of students receiving any grade (e.g., A's) is not fixed a priori, and there are no hard cutoffs (because every semester's batch and questions are different!), and so the curve depends on the overall class performance. In past years, the median grade in each of the 5 groups in this class (UG-3, UG-4, G-3, G-4, MCS-Online) has been a B+/B.

**On-campus 3 credit vs 4 credit Students: The MPs are only for 4 credit on-campus students.** We will be grading and evaluating only MPs submitted by on-campus 4 credit students. Due to TA staffing shortages, we are alas unable to provide support to, or grade, or give extra credit to, MPs done by 3 credit students or MCS Online/DSO students. If you're a 3 credit student on-campus and wish to do the MPs, please upgrade yourself to 4 credits!

We expect all partners on an MP group to contribute equivalent amounts of effort to the MP. There are no exceptions to this rule—the best way to learn is to actually do it! Any violations will result in a zero for the student deemed to have contributed less than their fair share. (We understand that contributions can never be exactly equal from all partners. So we expect partners to do their utmost best and share the load fairly and do equivalent amount of efforts as the other partner.)

If you are a 4 cr student and already found a partner, and subsequently want to drop to 3cr or to drop the course, we expect that you will (1) first help your MP partner find another partner (this is required), (2) drop only right after an MP deadline (and before the next MP is released) so that your (4cr) partner can find a new MP partner. Please be nice to your partner! Before you drop, we expect you will contribute your equivalent share to the MP effort. Dropping requires both partners to send email to the instructor with all partners (dropping/old and new) cc-ed, and approval from instructor.

**MP Groups:**

- All MCS Online/DSO students must do their (Coursera) programming assignments individually (see "Academic Integrity Policy" on the next page of this document).
- On-campus MPs must be done only in **groups of 2**. Groups of size 1, 3 (or more), or groups of size zero or negative, are not accepted. Here's your chance to practice pair programming! Please read the "Academic Integrity Policy" on the next page of this document.

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**HW Groups:** There are no HW groups. All HWs must be done individually. You cannot discuss solutions or ideas with anyone else other than course staff (but you can discuss lecture concepts and the HW question itself). Please read the "Academic Integrity Policy" on the next page of this document.

**Lecture Participation:**

- For on-campus students: Attending the lectures is important. Some lectures may have a quiz or in-class homework solving (included in your grade) - if you miss the class, you've lost the points. If you can't attend an occasional lecture, you can see the lecture video (posted a few days after the lecture; links on course website).
- For MCS Online/DSO students: viewing all Coursera lectures is a must. Do not attempt quizzes, homeworks, or exams without viewing and studying lecture material carefully.

## § Course Policies

**Best 3 of 4 Homeworks Policy** Each HW is worth 10 points, and there are 4 HWs. Starting Fall 2024 (and subsequent semesters), we are trialing a new policy wherein we will use only the **the highest 3 of your 4 individual HW scores** to calculate these 40 points (so, note that each HW will then be worth 13.33% points). However, to be eligible for this, you **must submit all 4 HWs**, i.e., *if you miss submission of any HW, then we will calculate your 40 total HW points from all your 4 HWs, rather than your best 3.* Note that this policy applies only to the HWs, and not to any other components of the course (it does **not** apply to MPs or exams). This policy is applicable to all students in class (on-campus, MCS Online, and everyone else).

**Academic Integrity Policy** We adhere by the CS academic integrity policies outlined at the webpage https://wiki.cites.illinois.edu/wiki/display/undergradProg/Honor+Code. It is the course policy that all of the work you submit for grading, or in support of graded material, as an individual or project group, shall be your own product, from inception to completion. The only resources you can avail of in your HWs and MPs are the provided course materials (slides, textbooks, etc.), and communication with instructor/TA via newsgroup and email. Please do not reveal solutions on any of these fora. Exams are closed-book, closed-notes, unless otherwise specified.

**All homeworks are individual**. Other than with course staff, you should discuss, or share, or work together on, **solutions** with **no one else** (whether in the class or outside). You can however discuss with other students **lecture concepts** or **the HW question itself** (but not the solution or any ideas for the solution).

For MP groups, other than with the course staff, you can discuss, share the **solution** (or ideas or code or whatever), or work together on, the MP, **only with your group partners**. You cannot discuss, work on, or share, the MP solution with anyone else. You can however discuss with other students **lecture concepts** or **the MP spec itself** (but not the solution or any ideas for the solution).

Please use the Piazza discussion forum for all questions/discussion on HWs and MPs. **All students, on-campus and MCS Online/DSO, must use Piazza for all course-related questions. MCS**

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**Online/DSO students – if you use Coursera forums to post questions, your question may be answered very late (or never). So please use Piazza.** (MCS Online/DSO students must use Zendesk for non-technical issues, e.g., issues related to features on the Coursera platform).

On the Piazza forum, if you post a solution (code or write-up) to the forum, that is a violation of academic integrity, and the rules below will apply, i.e., you will lose all points for that particular assignment and it is treated as a first violation. Email the staff only when you cannot use the discussion forum, e.g., if you have an urgent question, or if you have a personal matter to ask/discuss.

**Regrading Policy:** This applies to both on-campus and Coursera students:

- All regrade requests must be submitted back within 1 week of the graded HW/MP being returned. Regrade requests must be submitting in the same system as the original HW was submitted in (Gradescope or Coursera). Be sure to clearly indicate the reason for the regrade request.
- Regrade requests submitted after one week of the HW/MP being returned will not be regraded.
- All regrading decisions by the TA will be final (i.e., no regrade requests on regrades). Please do not engage in back-and-forth discussion with the TA(s).

**Result of Cheating** Violations of this academic integrity policy will be treated seriously. A first violation of these academic integrity guidelines will result in a zero grade on that HW/MP. A second violation will result in an F grade for the entire course. (And yes, in the past, we have caught almost all cheating students. And these cheating students have suffered both above types of consequences.)

Just don't cheat – your time is not worth it. If you cheat in this course and get away with it miraculously, later in life, when you are working in a job and need to use these concepts, you will be at a loss (Karma comes around).

**Anti-Racism/Anti-Bias/Anti-Microaggression Policy for CS425/ECE428** (This statement borrows heavily from a draft statement from the Anti-Racism Task Force in the Grainger College of Engineering). This course believes in a truly inclusive Illinois that is free from overt racism, prejudice, bias, as well as from micro-aggressions (commonplace hostile, derogatory, or negative prejudicial slights and insults)–these have no place in this course, in the classroom or outside, or on campus. We believe that Black Lives Matter. We believe that students (and faculty) who are African American/Black, Hispanic/Latino(a), Native American/Alaskan Native, and women, can live and learn without marginalization and without suffering racism, bias, and prejudice–from anyone else in the class, on campus, in our community, or in the world.

In this course, if you face any kind of bias, prejudice, or racism, from fellow students or course staff, please be courageous and speak up. If you are apprehensive to do so, or face sustained incidents, please contact the instructors via email. If you have feedback or constructive suggestions on how to improve the anti-racist environment in this course, please contact the instructors via email. Each of us is unique, due to our backgrounds and experiences, and so each of us makes our campus environment richer. At the same time, each of us is continually learning to be a better human being and become more aware of our own biases. A famous quote by Dr. Mae Jemison (first Black astronaut in space)

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captures this beautifully, "Never limit yourself because of others' limited imagination; never limit others because of your own limited imagination."

**Policy on Late Submission:** Unless otherwise specified, **all MP assignments**, or components thereof, that are to be electronically submitted are usually **due at 11:59 PM US Central Time** on the due date. Similarly, with some exceptions, **homework sets**, or components thereof, that must be submitted by other means are usually **due at the beginning of class** on the due date (US Central time zone), so online students please be mindful of what this time translates to in your local timezone (please watch for exceptions to this rule).

**All MP and HW submission deadlines are hard and will not be extended.** No late homework sets or MPs will be accepted except under extremely rare non-academic circumstances (which usually require approval from the Dean's office). So please ensure you have submitted everything necessary by the deadline time.

**Conflict Exams Policy:** If you need a makeup/conflict exam, please contact instructors at least 2 weeks before the posted exam date (midterm/final). Conflict exams are not given for routine reasons (includes interviews, trips, etc.). Conflict exams are not given for course conflicts–this is clarified before semester starts, when the student requests permission from instructor to double sign-up for another course. Conflict request is approved only upon a positive acknowledgement from instructors. We will of course accommodate genuine emergencies, including medical emergencies. All medical reasons must come with a doctor's letter that is for the patient in question, and the letter is not generic. Request is not approved until an instructor responds positively. Instructors' decision is final on each case.

Midterm date is posted on the course schedule ("Lectures" link")–plan accordingly. Final exam date is decided by campus, so please wait until they announce it–do not book travel, etc., before you know it (we don't offer conflicts for travel).

**DRES On-Campus Student Policy:** DRES Students – Please note:

1. Our lecture videos are on DRES' list for being closed captioned.
2. We also release our slides before the lecture (see Course schedule page).
3. Please plan to take your midterm exam and final exam at the DRES center, as they can accommodate the quiet environment and the 1.5X extra time you need. Please plan to take your (respective) exam on the same day as the on-campus exam (for midterm and for final), anytime is ok. We will send DRES the exam directly. Please schedule the DRES exam request EARLY (at least 3 weeks before exam day), as time slots get filled quickly for exam days!

## § Supplementary Textbooks

We will use many readings off the Web - these will be available under the Lectures link on the course website. The following textbooks may be used for supplementary course material. You are not re-

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quired to own these books. They are on reserve at the Grainger Library (if available). You *may* be able to use a prior edition of the textbook if you own one.

1. Fourth edition of the Coulouris-Dollimore-Kindberg textbook.
2. "Distributed Systems: An Algorithmic Approach," Sukumar Ghosh, CRC Press, 2006, ISBN: 1584885645. (Available online free at the Illinois Library Catalog).
3. "Distributed systems: principles and paradigms," A. Tanenbaum and M. Steen, Prentice Hall, Second Edition, 2005, ISBN: 0132392275.
4. "Distributed algorithms: concepts and design," N. Lynch, Morgan-Kaufmann, 1ed, 1996, ISBN: 1558603484.

§ **Copyright** All material used in this version of the course is copyrighted by Indranil Gupta and the University of Illinois. This version of the course has evolved based on past lectures given by the following professors during the 1990s and 2000s: Jennifer Hou, Mehdi Harandi, Nitin Vaidya, Klara Nahrstedt, and Sayan Mitra.

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