Welcome to CS425/ECE428!

Distributed Systems

Instructor: Radhika Mittal

Today's agenda

- Course overview
- Logistics
- Distributed System Model (if time)
    - Chapter 2.4 (except 2.4.3), parts of Chapter 2.3 from your textbook.

Today's agenda

- Course overview
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What is a distributed system?

Hardware or software **components** located at **networked** computers that communicate or **coordinate** their actions only by **passing messages**.

- *Your textbook*

(Coulouris, Dollimore, Kindberg, Blair)

What is a distributed system?

A collection of **autonomous computing elements**, connected by a **network**, which appear to its users as a **single coherent system**.

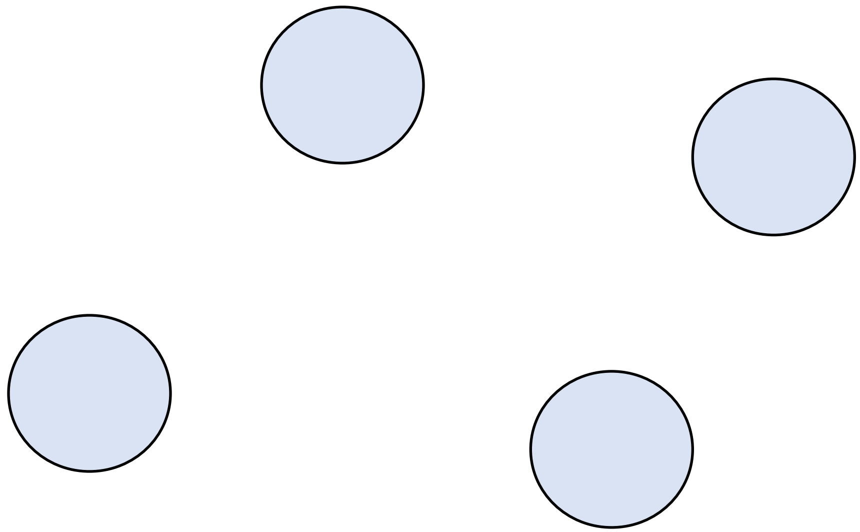
- *Steen and Tanenbaum*

What is a distributed system?

A system in which **components** located on **networked** computers communicate and **coordinate** their actions by **passing messages**. The components interact with each other in order to achieve a **common goal**.

- *Wikipedia*

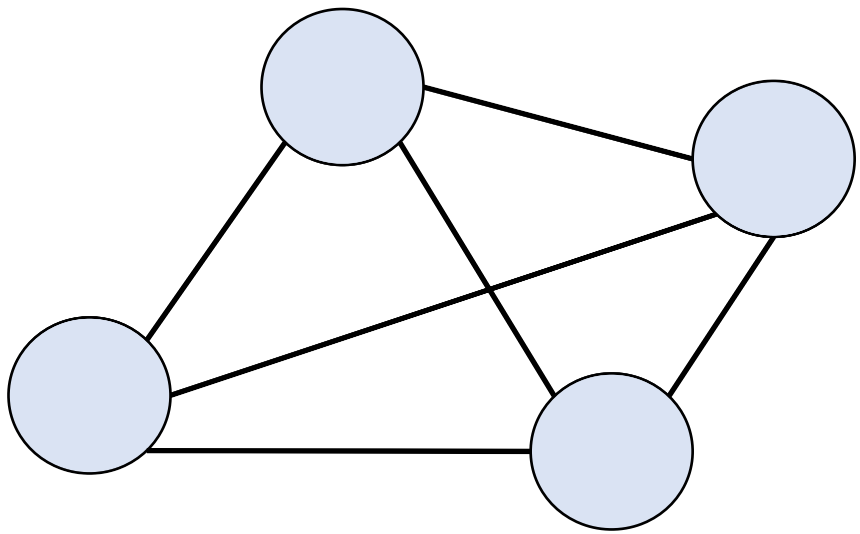
What is a distributed system?



Independent components or elements

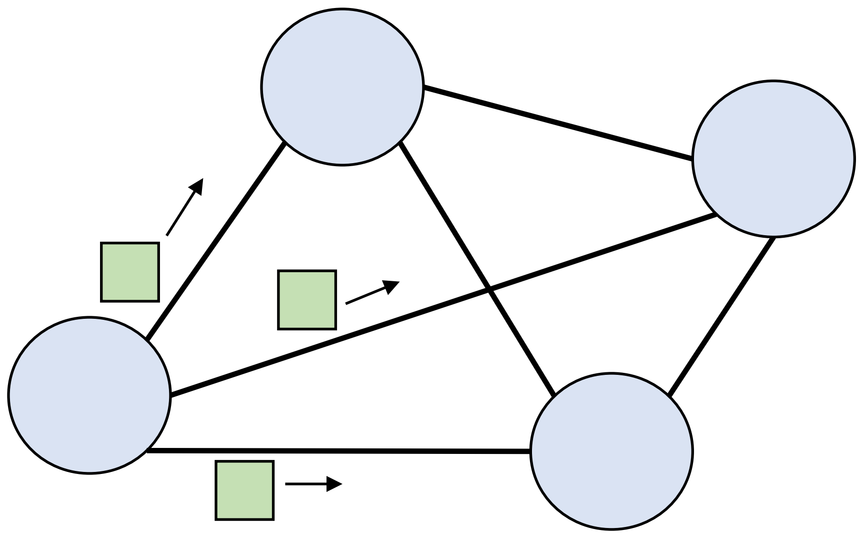
(software processes or any piece of hardware used to run a process, store data, etc)

What is a distributed system?



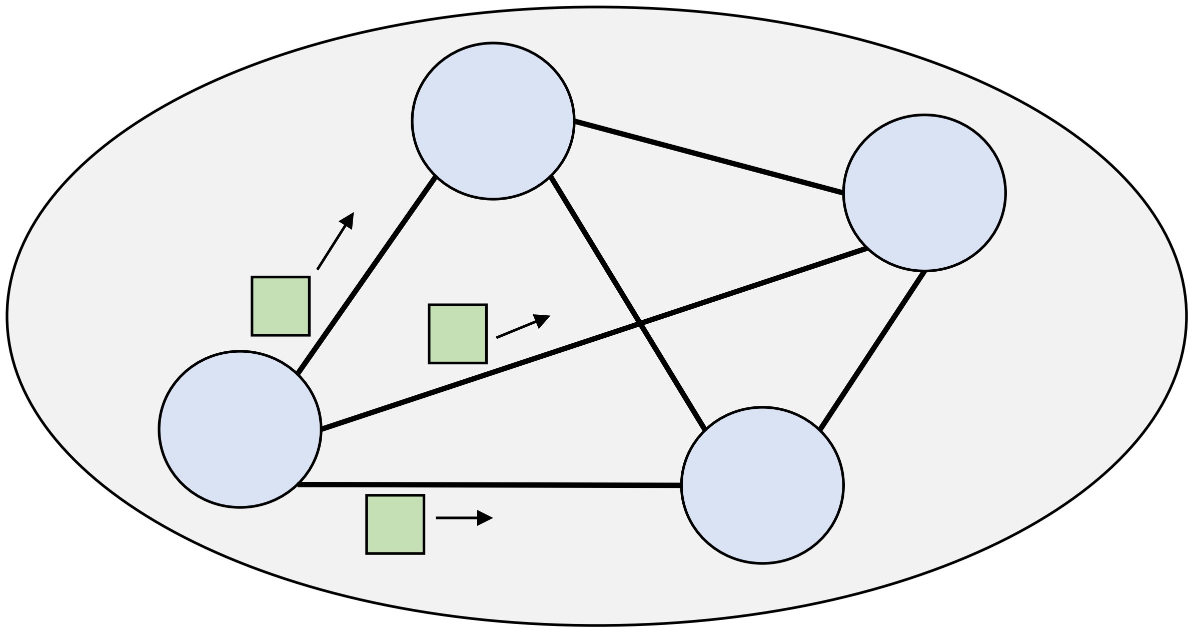
Independent components or elements that are **connected by a network**.

What is a distributed system?



Independent components or elements that are **connected by a network** and communicate by **passing messages**.

What is a distributed system?



Independent components or elements that are **connected by a network** and communicate by **passing messages** to achieve a **common goal**, appearing as a single coherent system.

What is a distributed system?

A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable.

- *Leslie Lamport*

Examples of distributed systems

- World Wide Web
- A cluster of nodes on the cloud (AWS, Azure, GCP)
- Multi-player games
- BitTorrent
- Online banking
- Bitcoin
- ….

Why distributed systems?

- Nature of the application
  - *Multiplayer games, P2P file sharing, client requesting a service.*
- Availability despite unreliable components
  - *A service shouldn't fail when one computer does.*
- Conquer geographic separation
  - *A web request in India is faster served by a server in India than by a server in US.*
- Scale up capacity
  - *More CPU cycles, more memory, more storage, etc.*
- Customize computers for specific tasks
  - *E.g. for storage, email, backup.*

Example: scaling Facebook (Meta)

- 2004: Facebook started on a single server
  - Web server front end to assemble each user's page.
  - Database to store posts, friend lists, etc.
- 2008: 100M users
- 2010: 500M users
- 2012: 1B users
- 2019: 2.5B users
- 2023: 3B users

How do we scale?

Example: scaling up Facebook (Meta)

- One server running both webserver and DB

- Two servers: one for webserver, and one for DB
  - *System is offline 2x as often!*

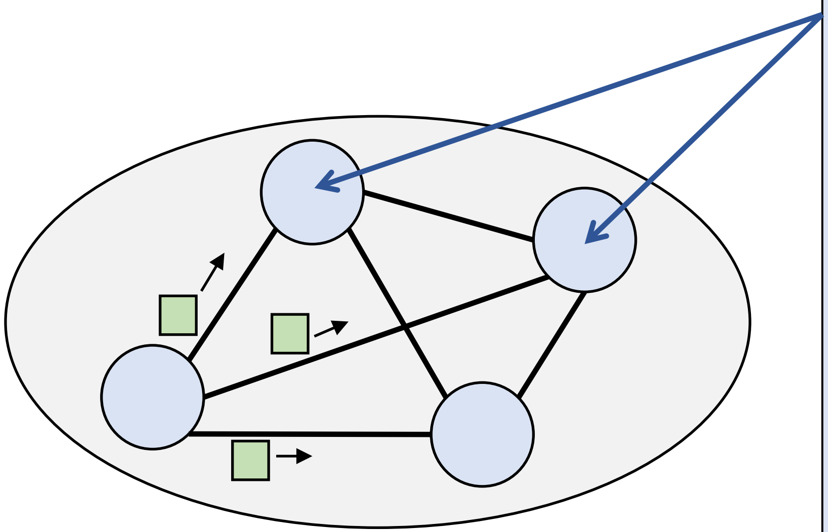
- Server pair for each social community
  - *E.g., school or college*
  - *What if server fails?*
  - *What if friends cross servers?*

Example: scaling up Facebook (Meta)

- Scalable number of front-end web servers.
  - Stateless: if crash can reconnect user to another server.
  - Use various policies to map users to front-ends.

- Scalable number of back-end database servers.
  - Run carefully designed distributed systems code.
  - If crash, system remains available.

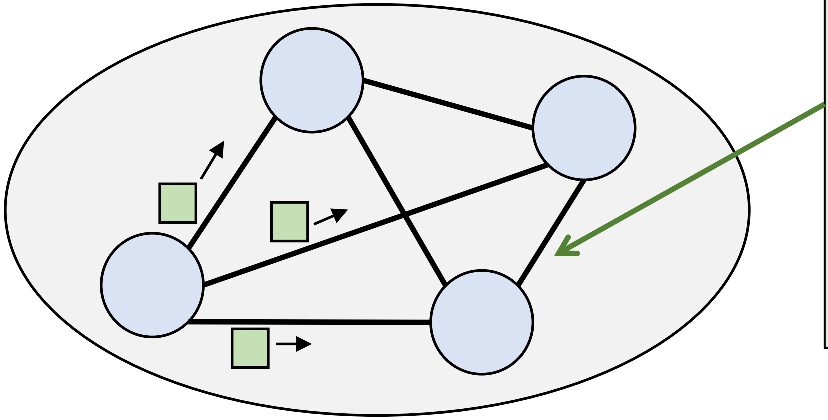
Challenging properties



Multiple computers

- Concurrent execution.
- Independent failure.
- Autonomous administration.
- Heterogeneous.
- Large numbers.

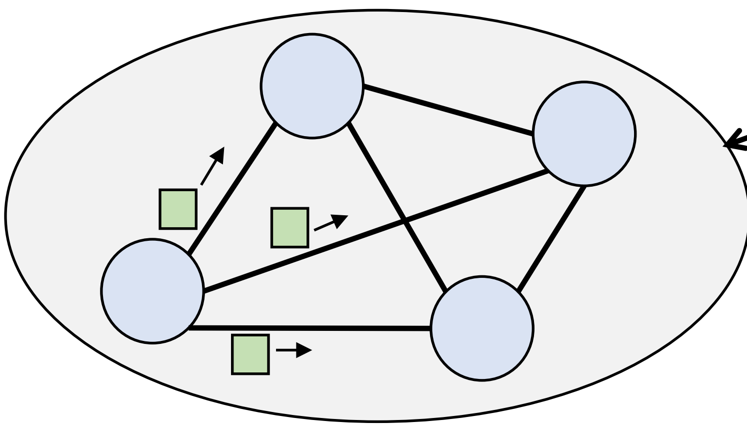
Challenging properties



Networked communication

- Asynchronous
- Unreliable
- Insecure

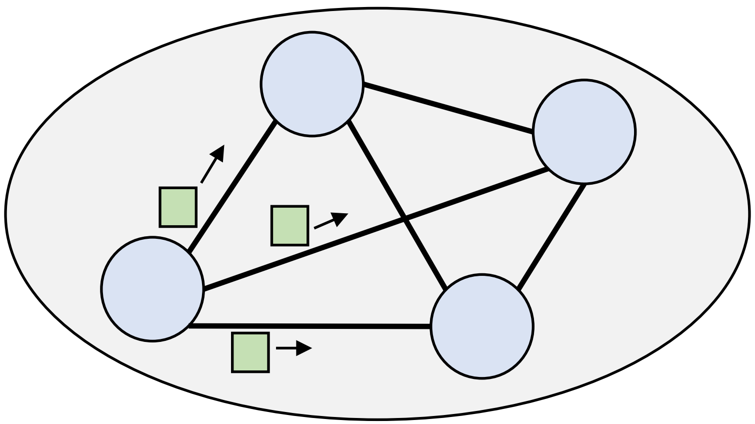
Challenging properties



Common goal

- Consistency
- Transparency

Challenging properties



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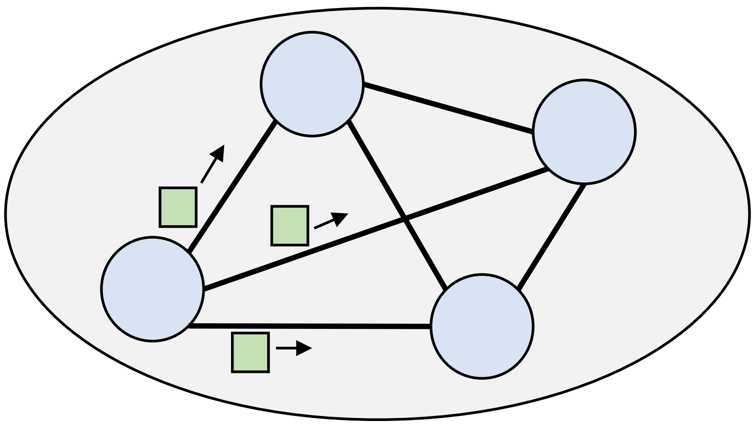

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Common goal

- Consistency
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What you will learn in this course

- **Distributed system concepts and algorithms**
  - How can failures be detected?
  - How do we reason about timing and event ordering?
  - How do concurrent processes share a common resource?
  - How do they elect a "leader" process to do a special task?
  - How do they agree on a value? Can we always get them to agree?
  - How to handle distributed concurrent transactions?
  - ….
- **Real-world case studies**
  - Distributed key-value stores
  - Distributed file servers
  - Blockchains
  - …

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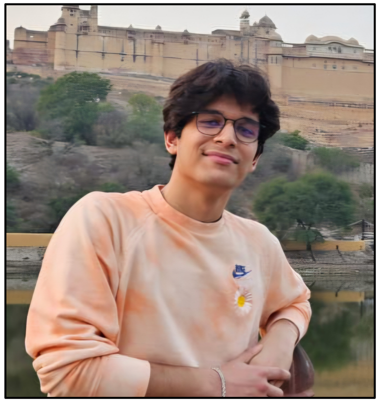
Course Staff

Radhika Mittal
Asst. Prof.
ECE and CS



Naman Raina
(MS, ECE)

Lyuwei Su
(MS, ECE)

Talha Waheed
(PhD, CS)

Yu Li
(MS, ECE)

Sources of information

- **Course website**
  - https://courses.grainger.illinois.edu/ece428/sp2026/
    - https://courses.grainger.illinois.edu/cs425/sp2026/ also works.
  - Time slots and locations for office hours (to be updated)
  - Homeworks, MPs
  - Lecture schedule, readings, and slides

- **Campuswire**
  - Announcements, questions, clarifications

Books

- *Distributed Systems: Concepts and Design*, Coulouris et al., 5th edition.
  - Earlier editions may be acceptable.
  - Your responsibility to find correct reading sections.

- Other texts
  - *Distributed Systems: An Algorithmic Approach*, Ghosh
  - *Distributed Systems: Principles and Paradigms,* Tanenbaum & Steen
  - *Distributed Algorithms*, Lynch

Class Timings and my OHs

- Wednesdays and Fridays, 12:30-1:45pm.
- My office hours: right outside class, right after class on WF (1:45-2:15pm).

Lecture Videos

- Lecture videos will be uploaded to MediaSpace.
- Plan on attending classes for a better learning experience.
  - Use lecture videos only to fill in gaps in understanding.
- Students with conflicts during class timings:
  - Please make sure you view the lectures timely and regularly.
  - Ask clarifying questions on Campuswire or during office hours.

Relevant Online Platforms

- Campuswire
  - Link with access code has been shared over email.
  - Reach out to Yu Li (yuli9@illinois.edu) if you need access to CampusWire.

- Gradescope
  - We will add students soon……stay tuned.

- PrairieLearn and CBTF for exams
  - More instructions to follow.

Those waiting to register

- A few more seats might open this week.
- Please start attending classes.
- More sure you have Campuswire access.

Grade components

- **Homeworks**
    - 5 homeworks in total.
    - Approx every 2-3 weeks.
    - Will be submitted using Gradescope.
    - Must be **typed** (hand-written diagrams are fine).
    - Must be done **individually**.

Grade components

- **Homeworks**
- **MPs (only for 4 credit version)**
    - 4 mini projects.
    - First (warm-up) MP0 will be released next Wednesday!
    - Groups of up to 2
        - Need to fill up a form to activate VM clusters (will be shared on Friday)
    - MP0, MP1, and MP3 can be in any language
        - Supported languages: Python, Go, C/C++,
        - You can also use other languages (e.g. Java, Rust), but might get limited help from course staff.
    - *MP2 must be implemented in Go.*

Late Policy

- For homeworks:
  - Can use a total of 48 late hours across the entire semester.

- For MPs
  - Can use a total of 168 late hours (1 week) across the entire semester.
  - Counted individually for each student, so keep your late hours in mind if you end up changing groups over the course of the semester.

Grade components

- Homeworks
- MPs (only for 4 credit version)
- Exams via CBTF
  - Two midterm
    - Midterm 1: Mar 4 – Mar 6
    - Midterm 2: Apr 12 – Apr 14
    - More details to follow.
  - Comprehensive final: May 7 – May 15

Grade components

- Homeworks
- MPs (only for 4 credit version)
- Exams
- CampusWire / Class participation

Grade distribution

	3-credit	4-credit
Homework	33%	16% (drop 2 worst HWs)
Midterms	33%	25%
Final	33%	25%
MPs	N/A	33%
Participation	1%	1%

Switching between credits

- If you'd like to switch between 3 and 4 credits, you should be able to do so using self-service.
- If you are unable to make the switch, reach out to CS advising office for help.

Grading

- Homeworks will not be curved.
  - For 3-credit students:
    - (sum of all 5 homework scores) * 100 * 0.33 / 200
  - For 4-credit students:
    - (sum of best 3 homework scores) * 100 * 0.16 / 120

- MPs will not be curved.
  - (sum of all four MP scores) * 100 * 0.33 / 330
  - MPs have different weightage: MP0:30, MP1: 110, MP2: 110, MP3: 80

- Participation score: directly taken from Campuswire
  - if reported score > 100, you get full 1%
    - Else you get (reported score /100)%
  - Upto 100% bonus for active participation in class.

Grading

- Exam curving formula:
  - Average score across undergraduate students = 80%
  - relative: 80 + 10*(your score – avg_UG_score) / standard_dev
  - We will use max(absolute, relative) to get final score out of 100.

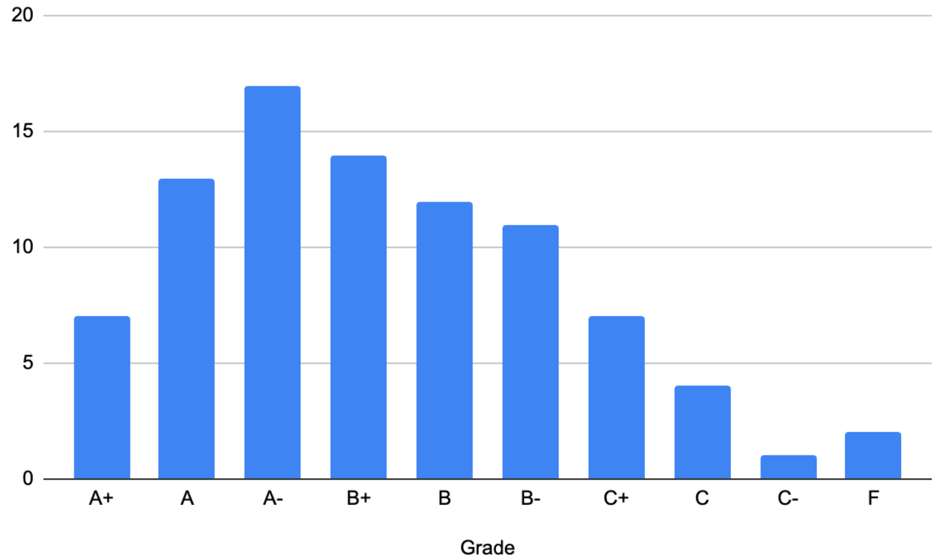
- Multiply the resulting score (out of 100) for each midterm by:
  - 0.165 for 3-credit students
  - 0.125 for 4-credit students

- Multiply the resulting score (out of 100) for the final by:
  - 0.33 for 3 credit students
  - 0.25 for 4-credit students

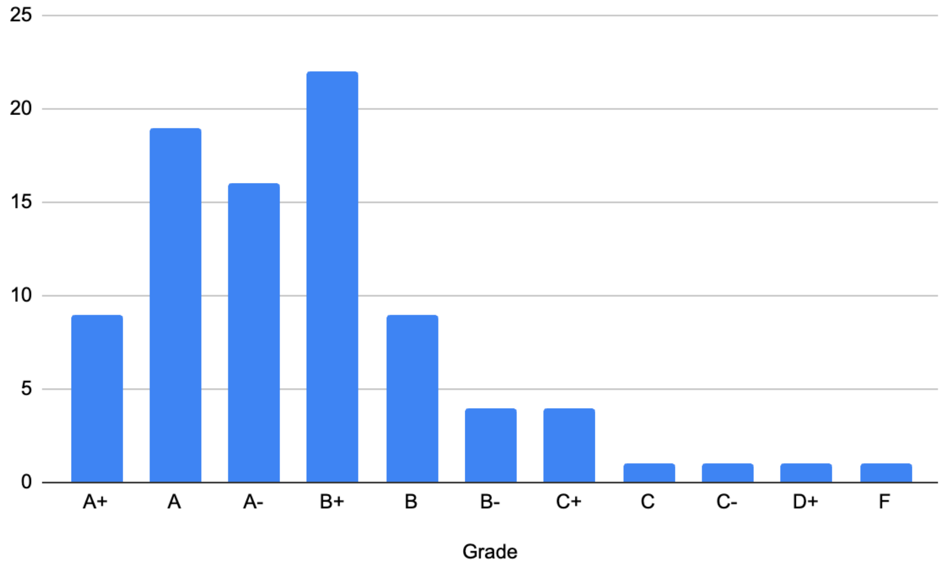
Tentative Grades Cutoff

- Tentative mapping from score to grade (*rough estimate*):
  - Cutoff for B: 80%
  - Bump up a grade for each 4% leap above 80%.
    - B+ 84%, A- 88%, A 92%, A+ 96%
  - Bump down a grade for each 4% leap below 80%
    - B- 76%, C+ 72%, …..
- This is subject to change!
- Technically possible for all of you can get an A (if you all score above ~92%), but……

Expectations



3 credit grade distribution from 2025



4 credit grade distribution from 2025

Expectations

- My teaching goal:
    - ~~high score on your exams for this course~~
    - learn concepts that will be useful to you for years to come!

Expectations

- Doing well in assignments and exams will require thorough understanding of concepts taught in class.

- No practice exams (set as template of actual exams) will be provided!

- Abridged version of class slides will be made available during the exams.
  - Given limited time and the nature of the questions, you cannot rely on simply scrolling through it to answer questions.

- You need to study hard!

Expectations for 4 credits

- MPs are difficult and require significant amount of work.
- MP0, that will be released next week, is only a light warm-up to familiarize you with the cluster environment.
- Subsequent MPs will be much much harder, requiring you to build complete systems using concepts taught in class.
- Dealing with the risks associated with your partner not doing their fair share of work or dropping/switching midway through the course is your responsibility.

Integrity

- Academic integrity violations have serious consequences.
  - Min: 0% on assignment
  - Max: expulsion
  - All cases are reported via the FAIR system.
- **As students, it is your responsibility to uphold academic integrity.**
- Example of violations:
  - Sharing of code outside group.
  - Copying homework and MP solutions (from colleagues, from previous years', from the web).
  - Using AI assistance for auto-completing MPs.
  - Collaborating in exams.
  - ……

Questions?