Distributed Systems

CS425/ECE428

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

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Examples of distributed systems

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

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**.

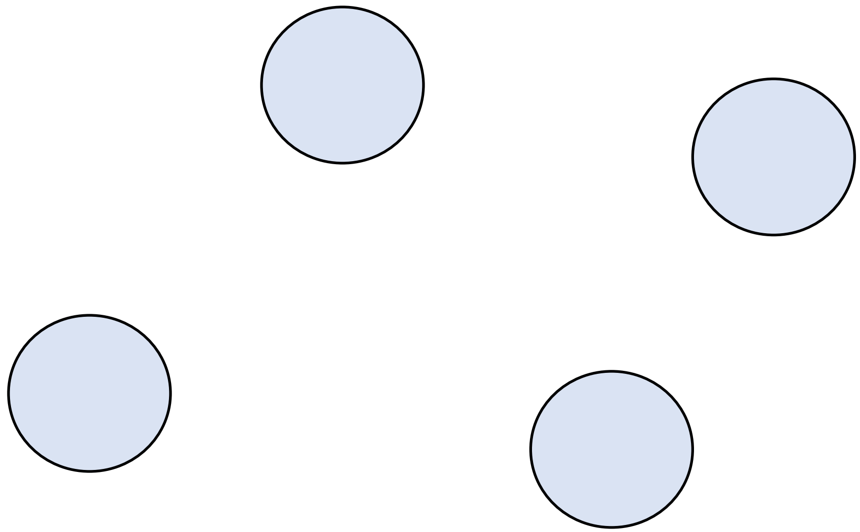
- *Steen and Tanenbaum*

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*

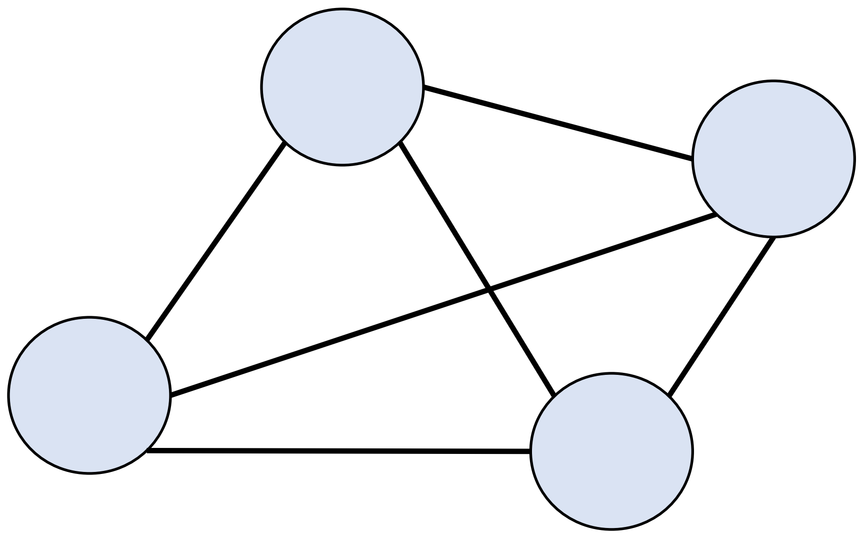
What is a distributed system?



Independent components or elements

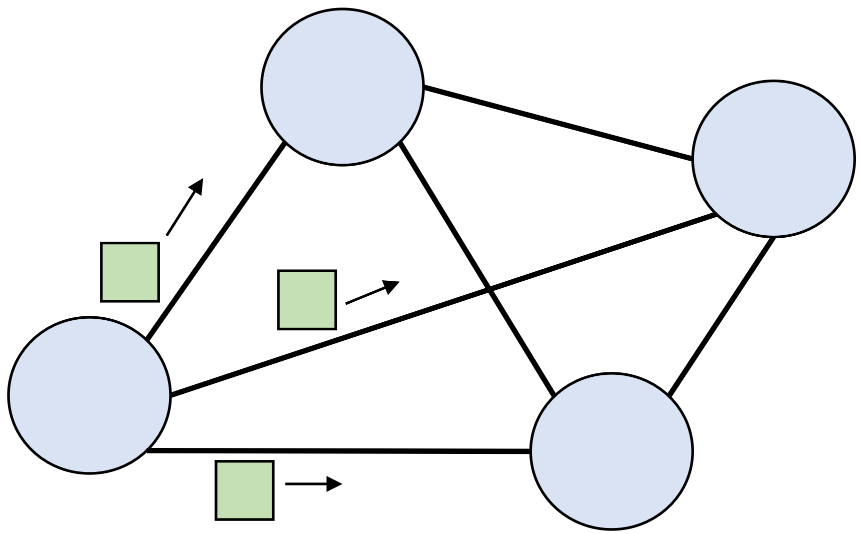
(software processes or any piece of hardware used to run a process, store data, etc)

What is a distributed system?



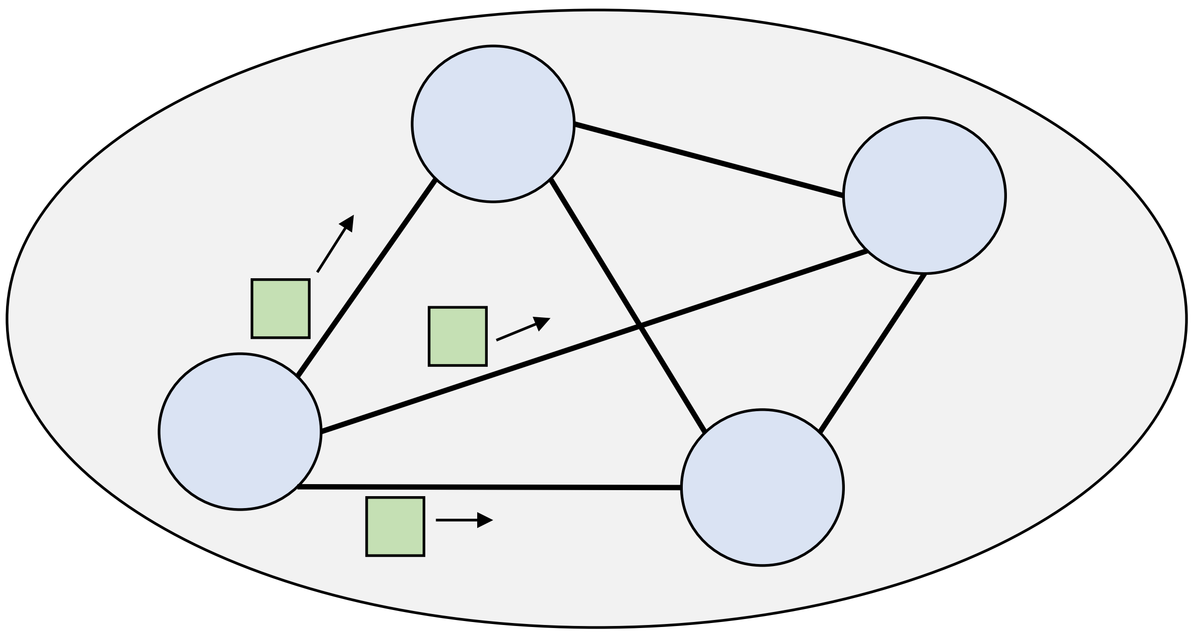
Independent components or elements that are **connected by a network.**

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*

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 up Facebook

- 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

How do we scale up?

Example: scaling up Facebook

- One server running both webserver and DB

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

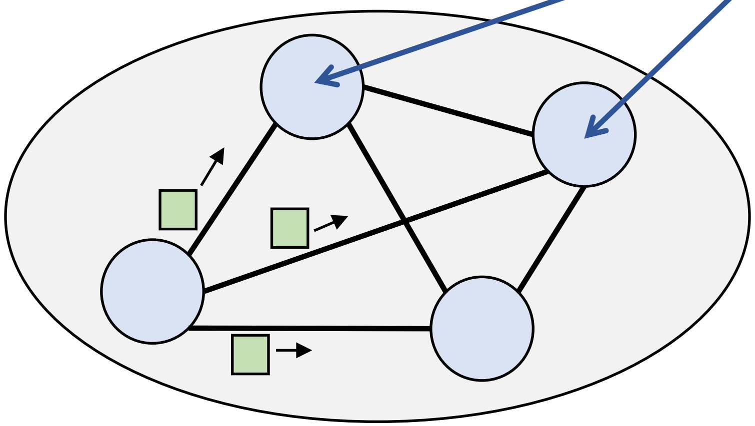
- Server pair for each social community
  - *E.g., school or college*
  - *What if server fails?*
  - *What if friends cross servers?*

Example: scaling up Facebook

- 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.

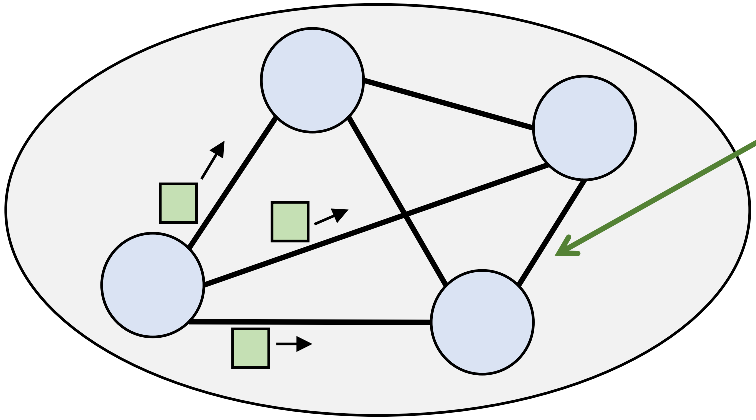
Challenging properties



Multiple computers

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

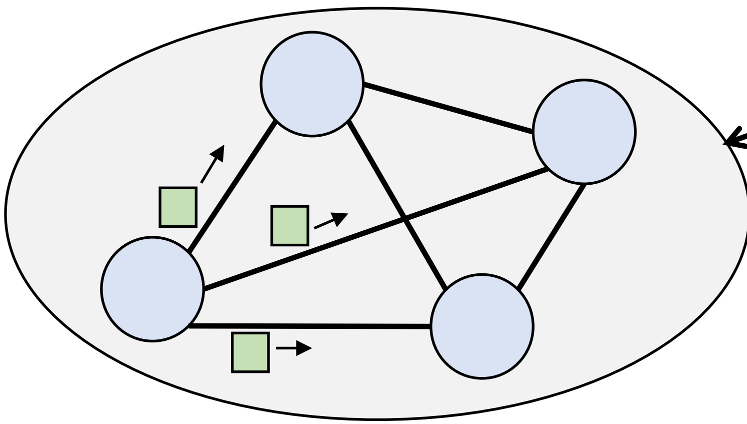
Challenging properties



Networked communication

- Asynchronous
- Unreliable
- Insecure

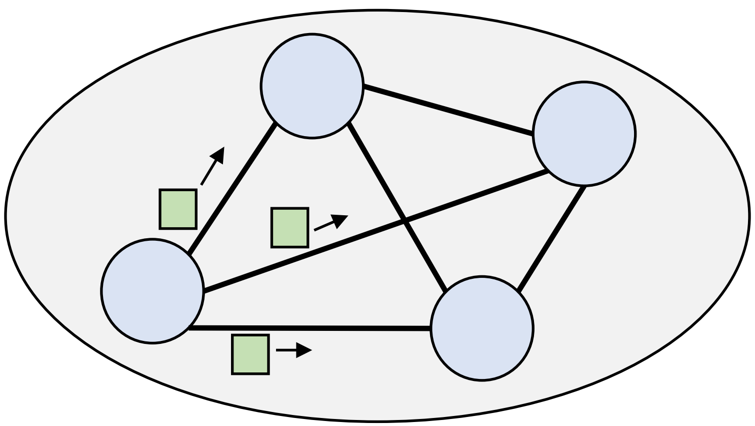
Challenging properties



Common goal

- Consistency
- Transparency

Challenging properties



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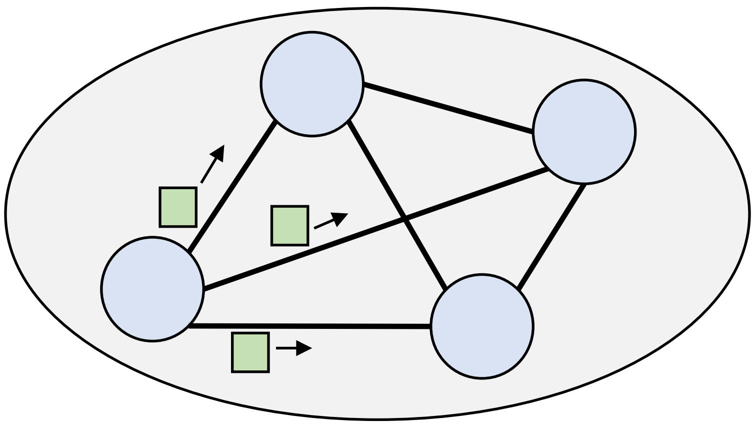

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Rest of the course

- **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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- Logistics
- Distributed System Model (if time)
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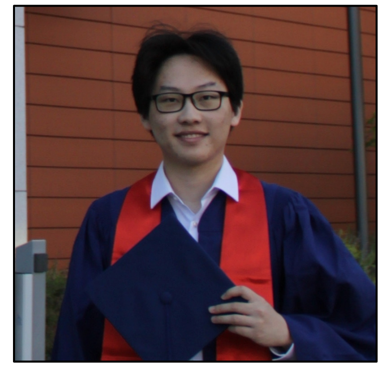
Course Staff

Radhika Mittal
Asst. Prof.
ECE and CS

Ammar Tahir, PhD, CS



Jiangran Wang, MS, ECE

Sanchit Vohra, MS, ECE

Zhenwei He, MS, CS

Mode of lecture delivery

The classes will be held over Zoom for the entire semester, unless announced otherwise.

Sources of information

- **Course website**
  - https://courses.grainger.illinois.edu/ece428/sp2022/
    - https://courses.grainger.illinois.edu/cs425/sp2022/ also works.
  - Course Calendar
    - Time slots and Zoom links for office hours
  - Homeworks, MPs
  - Lecture schedule, readings, and slides

- **CampusWire**
  - Announcements, questions, clarifications
  - Access link emailed to registered students.

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

Relevant Online Platforms

- CampusWire
  - Link with access code has been shared over email and Zoom chat.
  - Reach out to Sanchit (netID: sv4) if you need access.
- Gradescope
  - We will add students soon……stay tuned.
- (Possibly) PrairieLearn for exams
  - More instructions to follow.

For students with conflicts

- Lecture videos will be uploaded to Echo360.
  - Please make sure you view them timely and regularly.
  - Ask clarifying questions on CampusWire or during office hours.

Grade components

- **Homeworks**
  - 6 homeworks in total.
  - Approx every 2 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 on Thursday!
  - Groups of up to 2
    - Need to fill up a form to activate VM clusters.
  - MP0, MP1, and MP3 can be in any language
    - Supported languages: Python, Go, C/C++, Java
  - MP2 must be implemented in Go.

Grade components

- **Homeworks**
- **MPs (only for 4 credit version)**
- **Exams**
  - One midterm
    - Tentative date and time:
      - Thursday, March 10th, 11am-12:15pm
  - Comprehensive final.

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)
Midterm	23%	17%
Final	43%	33%
MPs	N/A	33%
Participation	1%	1%

Switching between credits

- Multiple sections:
  - *ECE428/CS425 T3*
  - *ECE428/CS425 TU4*
  - *ECE428/CS425 T4*

- If you'd like to switch between 3 and 4 credits, try to get on the wait list for the desired section.

- If you are unable to make the switch, reach out to Heather Mihaly (hmihal2) after the drop deadline.

Integrity

- Academic integrity violations have serious consequences.
  - Min: 0% on assignment
  - Max: expulsion
  - All cases are reported to CS, your college, and senate committee.
- **As students, it is your responsibility to uphold academic integrity.**
- Example of violations:
  - Sharing of code outside group.
  - Copying homework solutions (from colleagues, from previous years', from the web).
  - Collaborating in exams.
  - ……

Questions?

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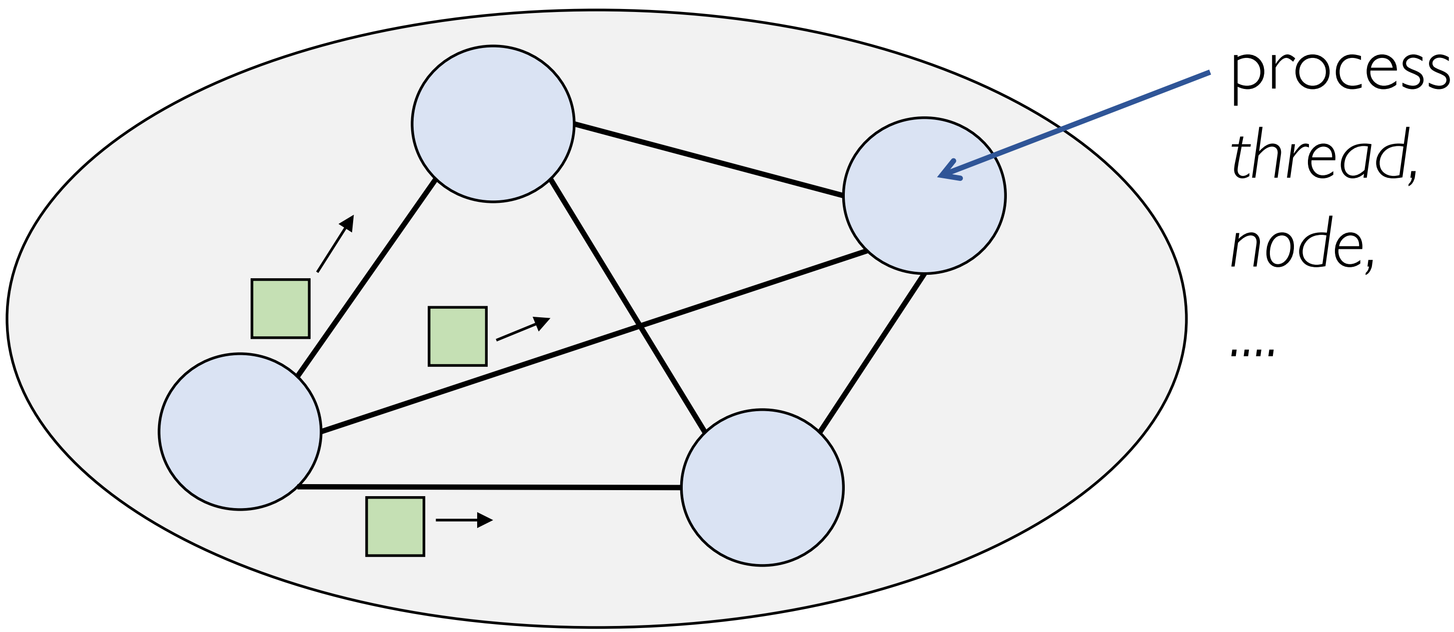


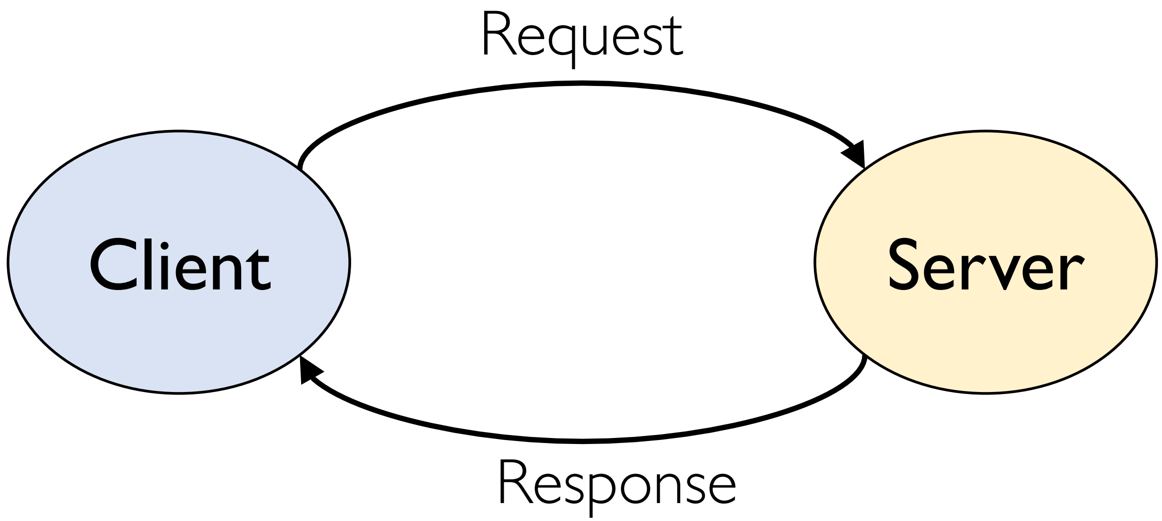
Independent components that are **connected by a network** and communicate by **passing messages** to achieve a common goal, appearing as **a single coherent system**.

Relationship between processes

- Two main categories:
  - Client-server
  - Peer-to-peer

Relationship between processes

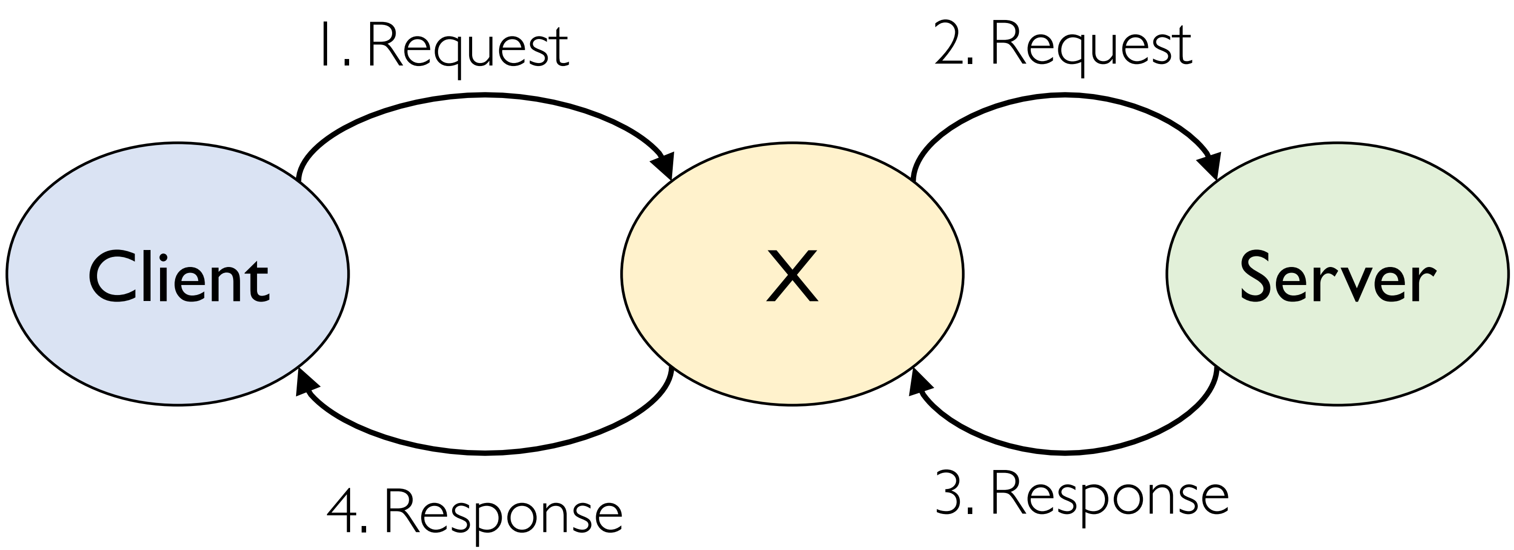
- Client-server



Clear difference in roles.

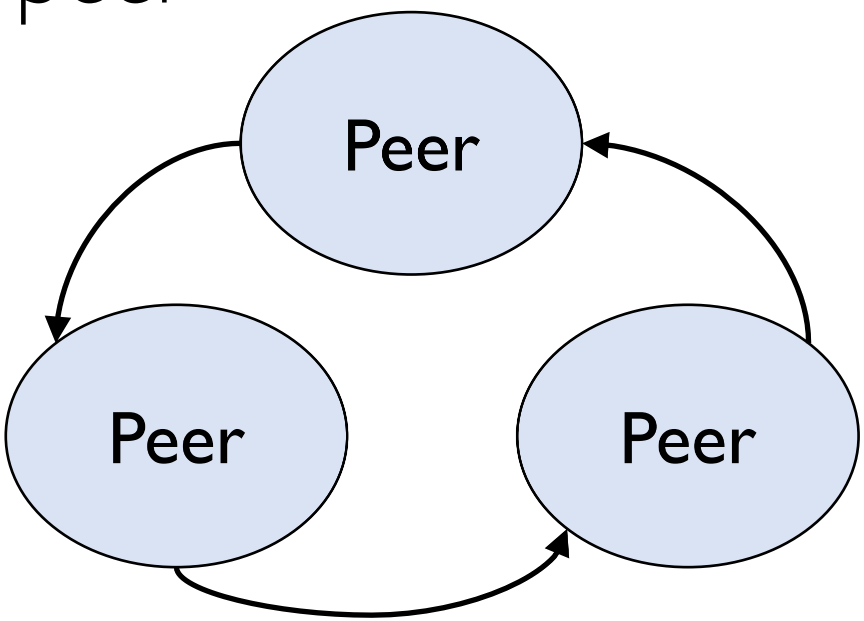
Relationship between processes

- Client-server



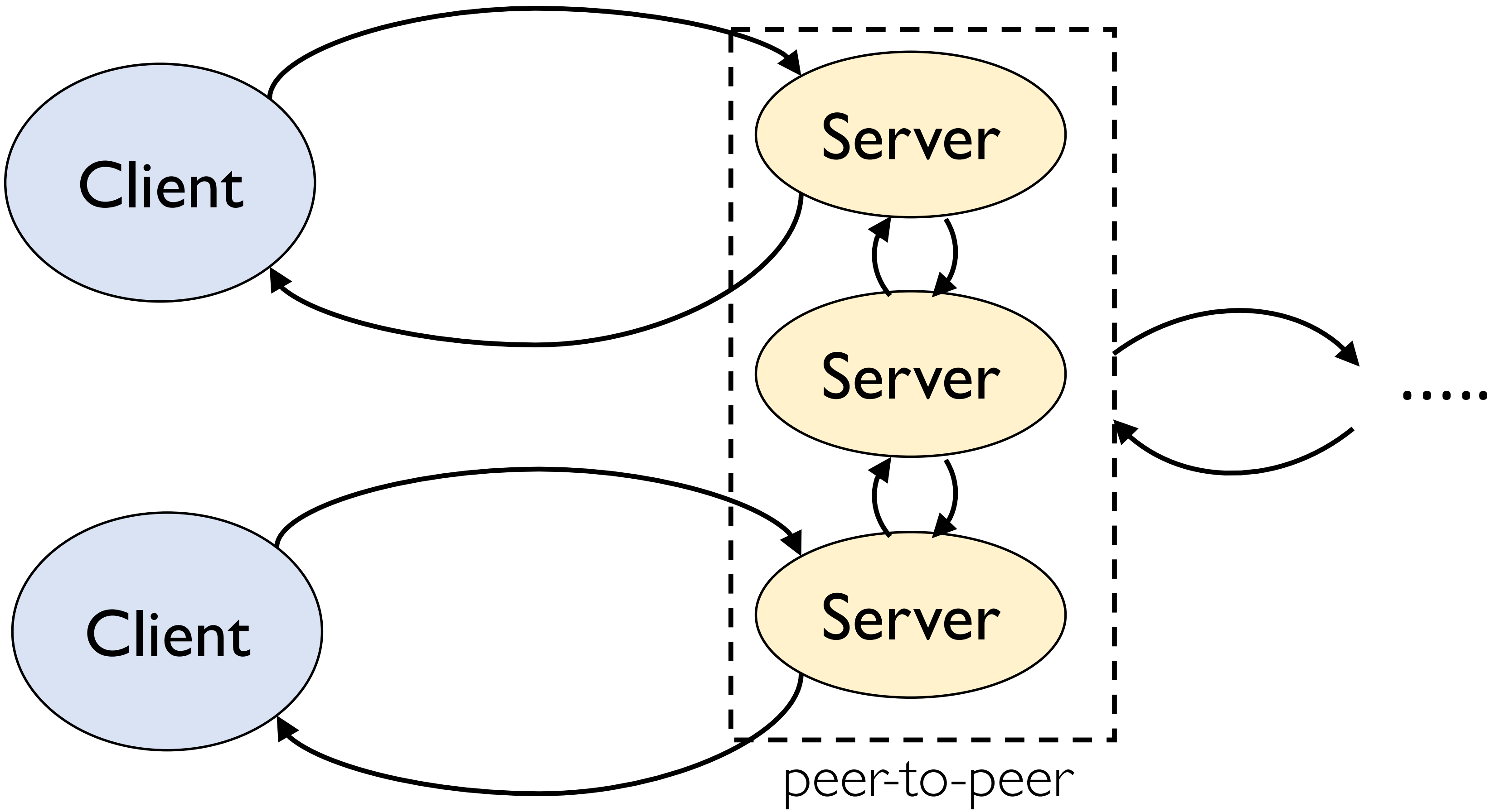
Relationship between processes

- Peer-to-peer



Similar roles.
Run the same program/algorithm.

Relationship between processes



Relationship between processes

- Two broad categories:
    - Client-server
    - Peer-to-peer

Distributed algorithm

- Algorithm on a single process
    - Sequence of steps taken to perform a computation.
    - *Steps are strictly sequential.*

- Distributed algorithm
    - Steps taken by each of the processes in the system (including transmission of messages).
    - *Different processes may execute their steps concurrently.*

Key aspects of a *distributed* system

- Processes must communicate with one another to coordinate actions. Communication time is variable.

- Different processes (on different computers) have different clocks!

- Processes and communication channels may fail.

Lecture Summary

- Distributed System
  - Multiple computers (or processes)
  - Networked communication
  - Common goal
- Distributed systems are fundamentally needed.
- They are challenging to build.
  - Variable communication time, clock drifts, failures.
- Course goals: concepts, designs, case studies

Acknowledgements

- Arvind Krishnamurthy
- Nikita Borisov

Questions?