Distributed Systems

CS425/ECE428

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Acknowledgements

- Nikita Borisov
- Radhika Mittal
- Indy Gupta
- Nitin Vaidya

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 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**.

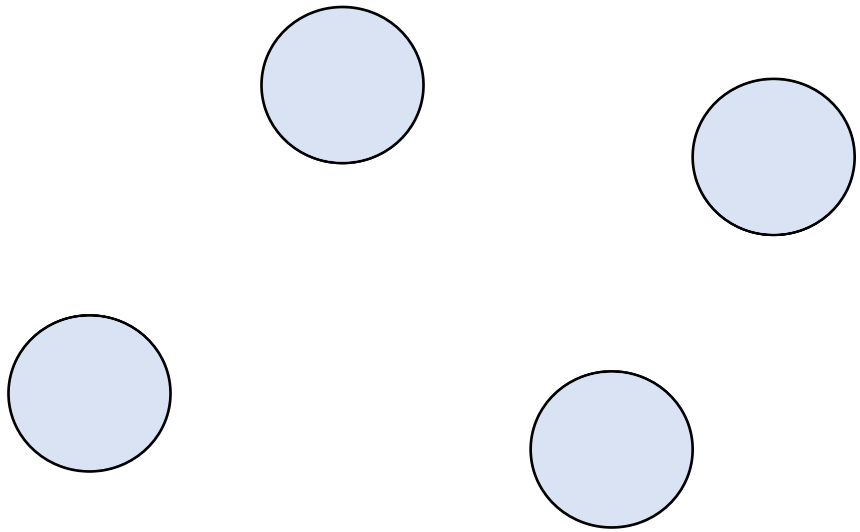
- Steen and Tanenbaum

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*

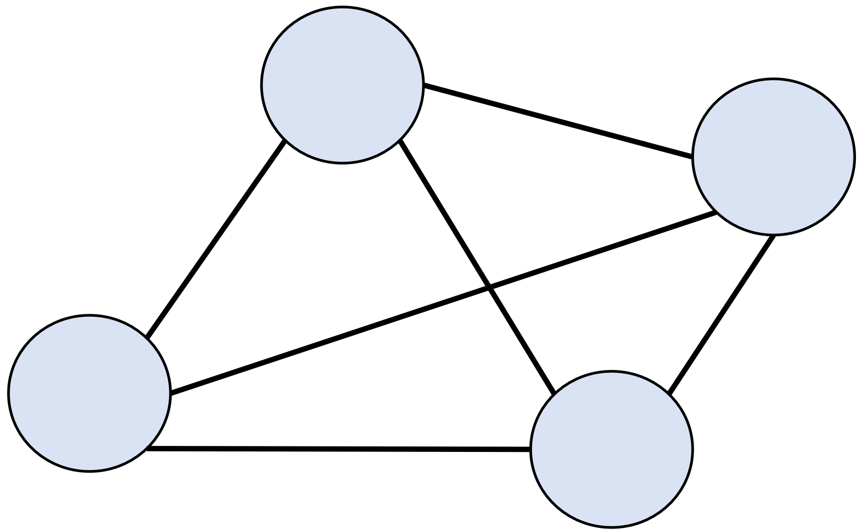
What is a distributed system?



Independent components or elements

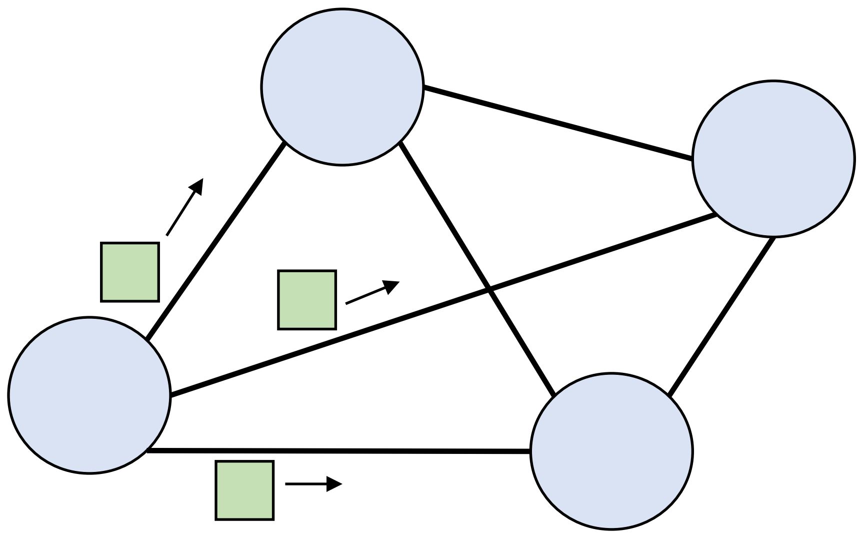
(software processes or any piece of hardware used to run a process, store data, etc)

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**.

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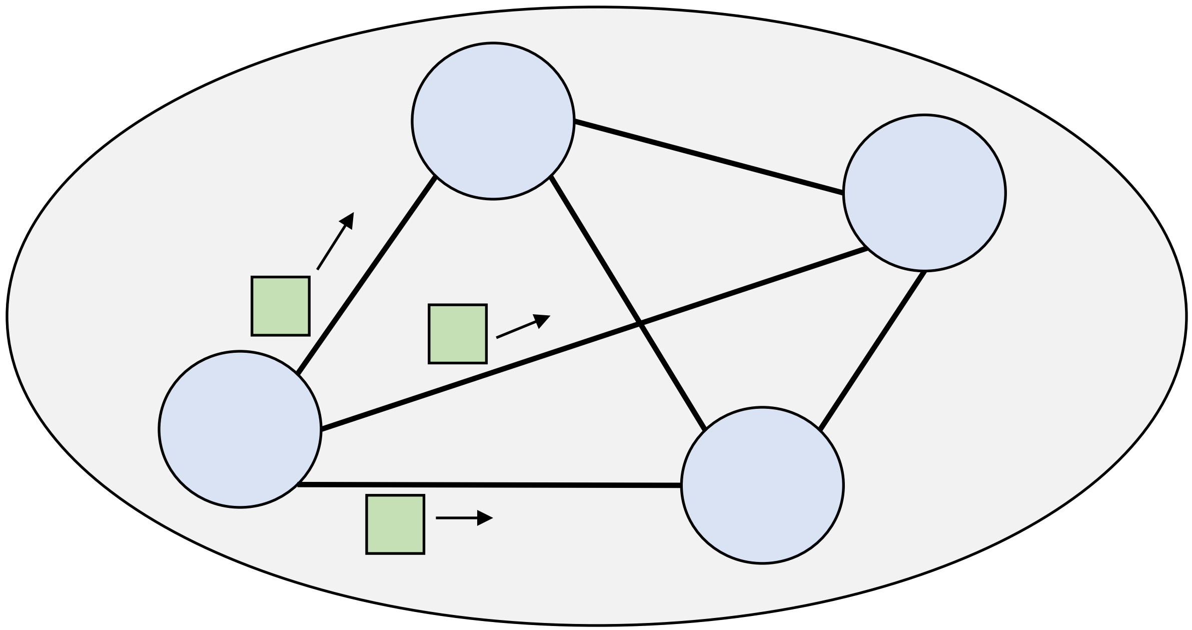


Independent components or elements that are **connected by a network** and communicate by **passing messages** to achieve a common goal, appearing as a single coherent system.

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!*

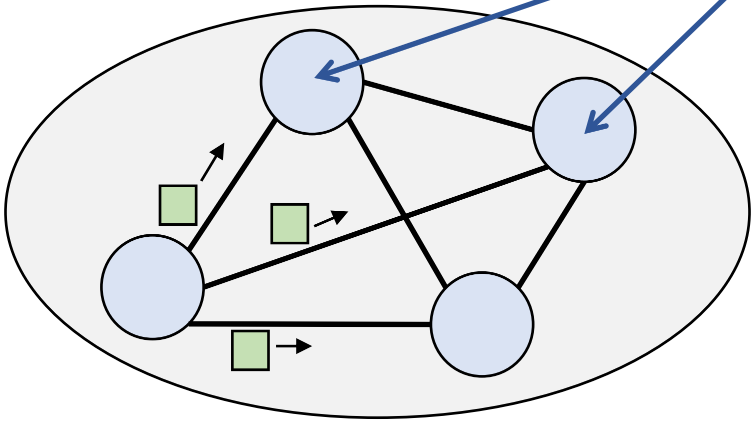
- Server pair for each social community
  - *E.g., school or college*
  - *What if server fails?*
  - *What if friends cross servers?*

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.

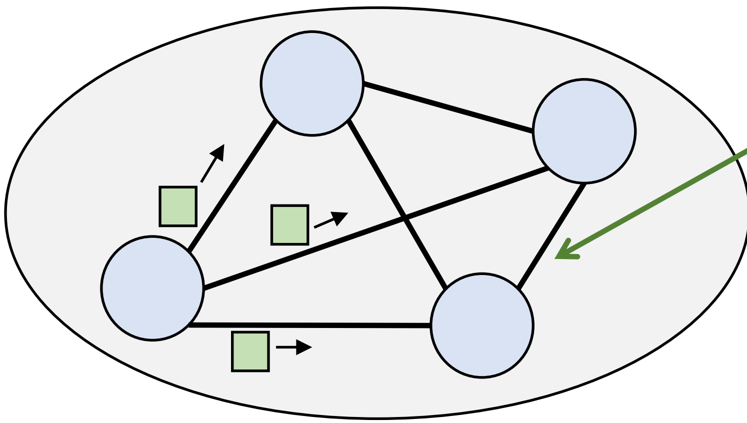
Challenging properties



Multiple computers

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

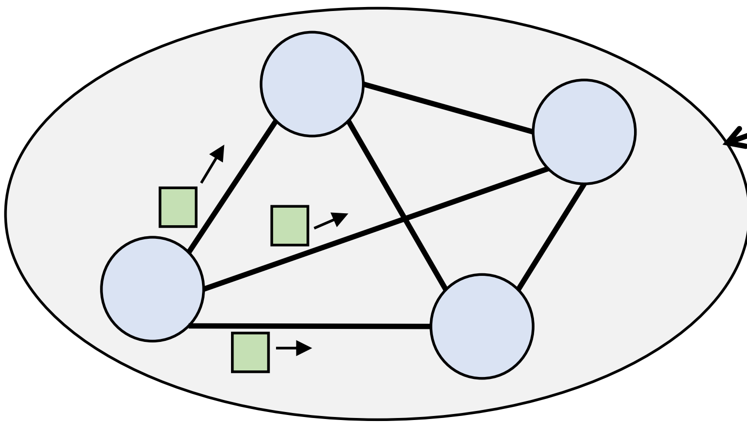
Challenging properties



Networked communication

- Asynchronous
- Unreliable
- Insecure

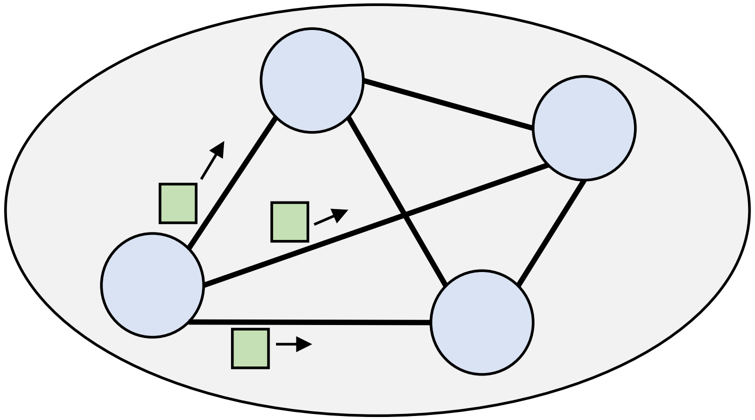
Challenging properties



Common goal

- Consistency
- Transparency

Challenging properties



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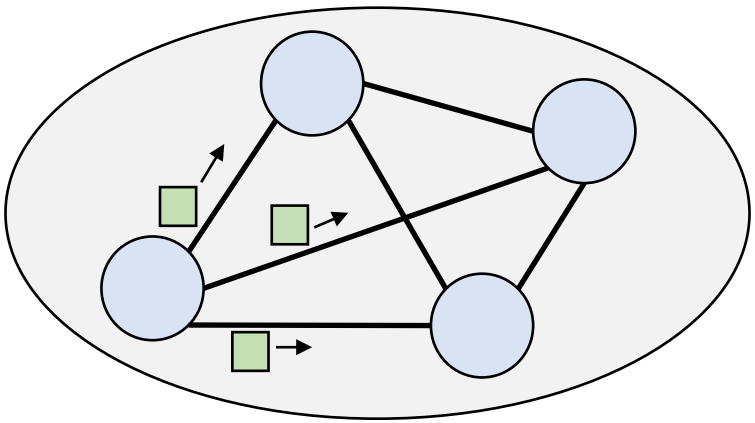

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Common goal
- Consistency
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Rest of the course

- **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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- Distributed System Model (if time)
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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

Grade components

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

Grade components

- Homeworks

- MPs (only for 4 credit version)
    - 3 mini projects.

Grade components

- Homeworks (5)
- MPs (3)
- Exams
    - Midterm
    - Comprehensive final

Grade distribution

Assessment	Percentage
Homework	10%
Midterms	20%
Final	40%
MPs	30%

Integrity

- Academic integrity violations have serious consequences.
  - Minimum 0% on assignment + 2 letter grade reduction
  - All cases are reported on FAIR
- **As students, it is your responsibility to know the rules and 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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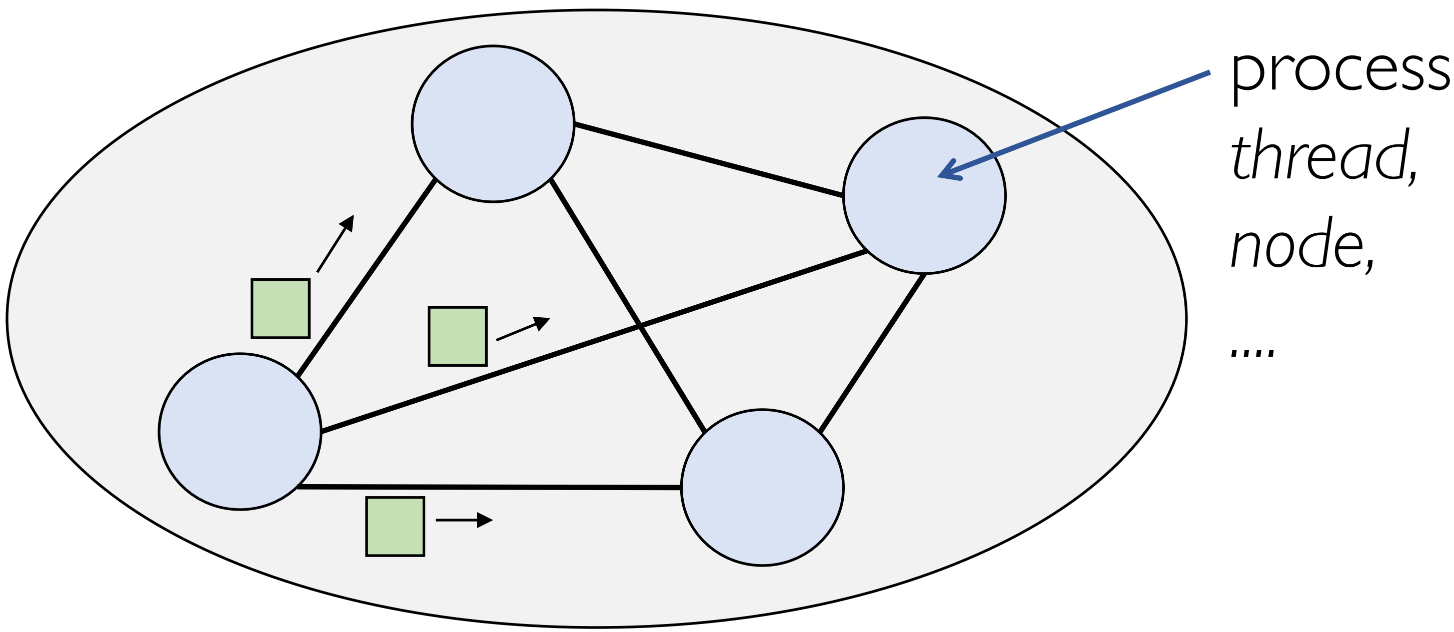


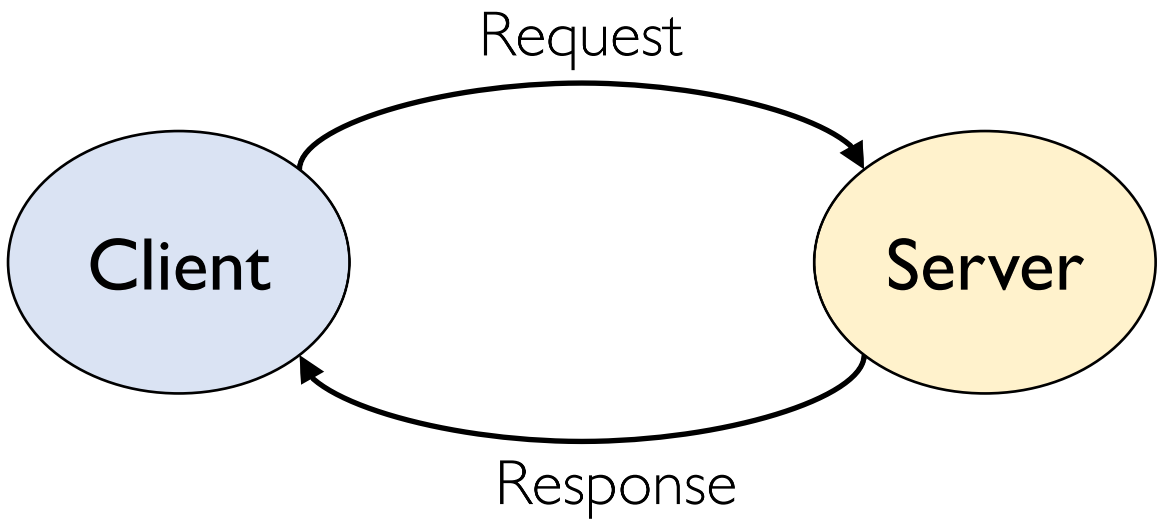
Independent components that are **connected by a network** and communicate by **passing messages** to achieve a common goal, appearing as **a single coherent system**.

Relationship between processes

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

Relationship between processes

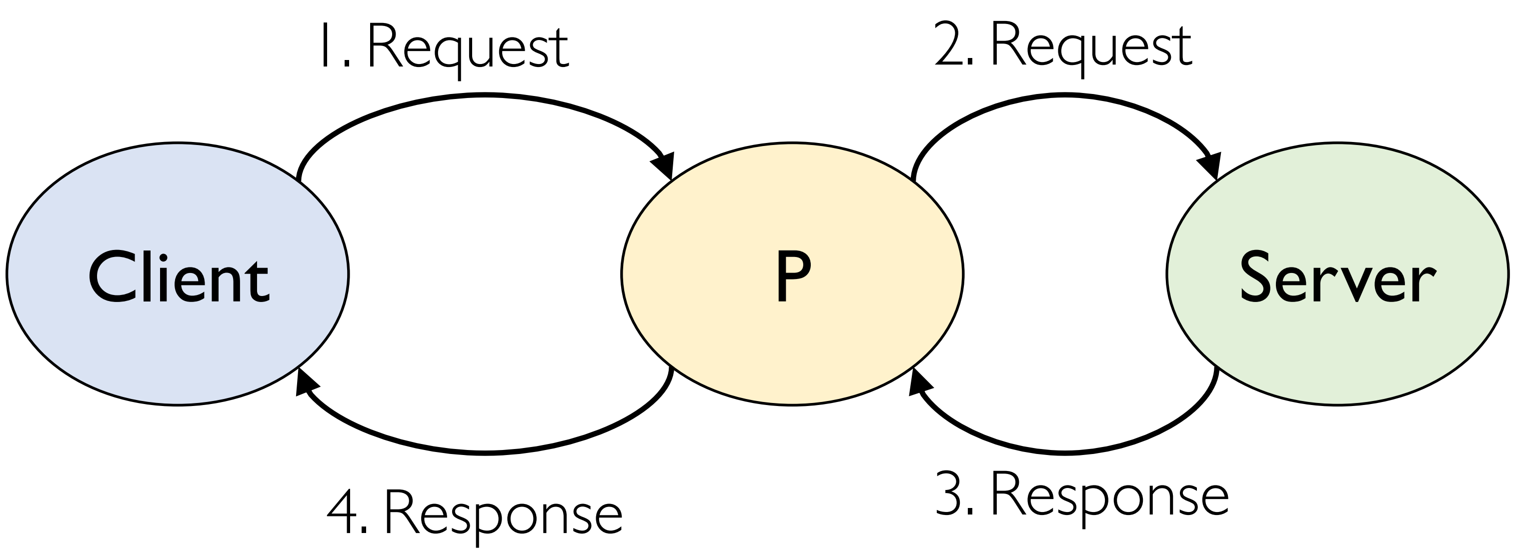
- Client-server



Clear difference in roles.

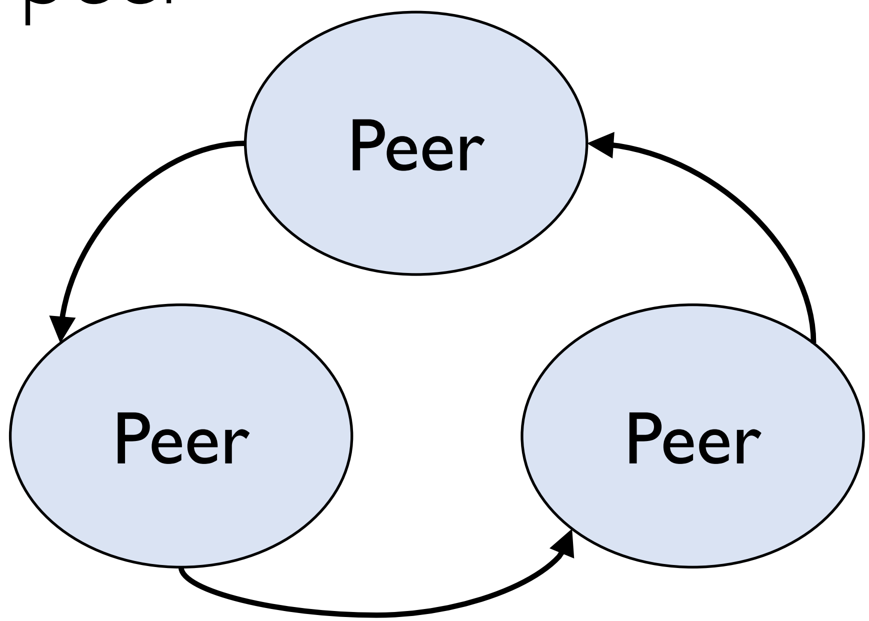
Relationship between processes

- Client-server



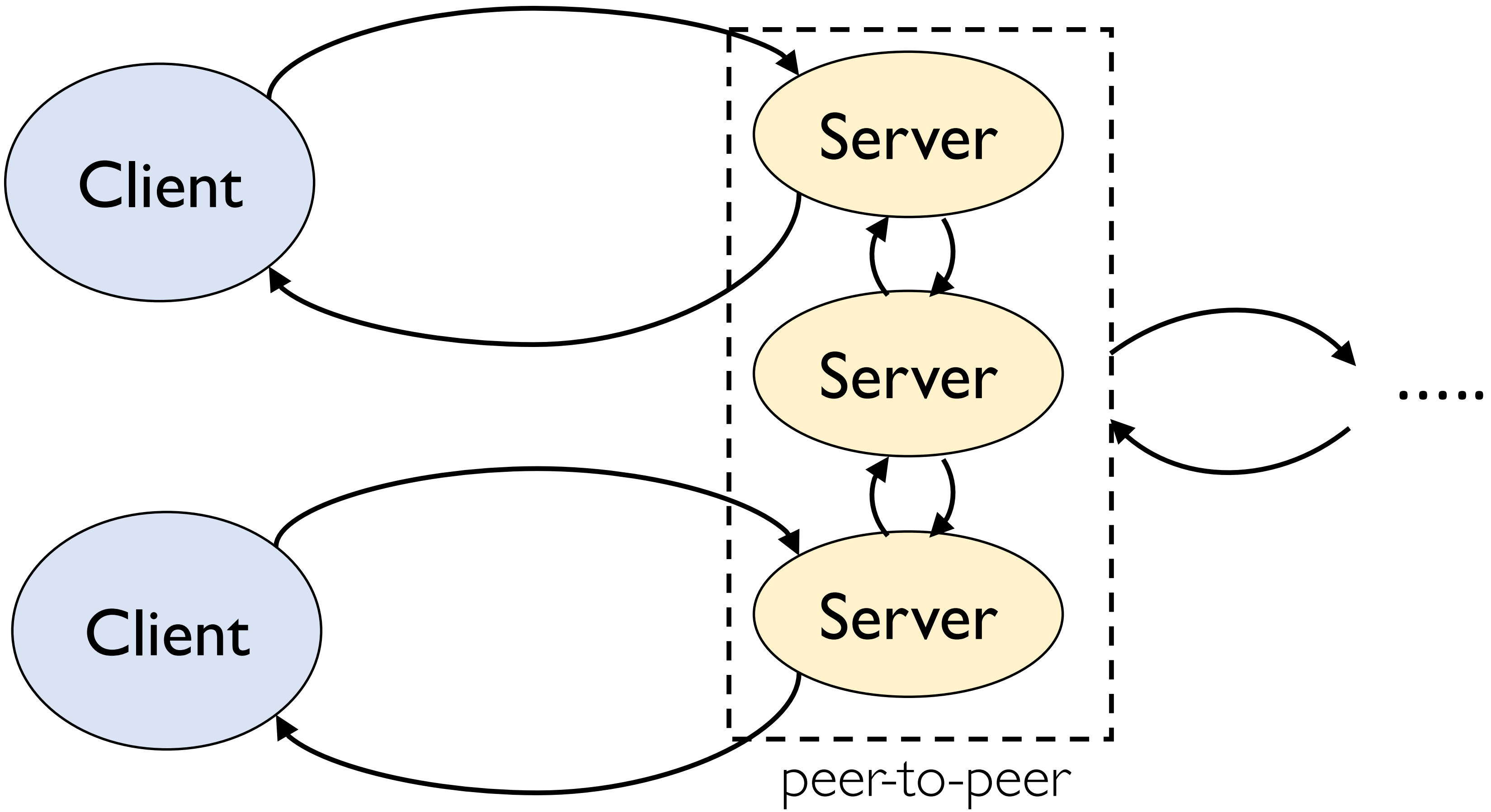
Relationship between processes

- 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

Questions?