CS 425 / ECE 428
Distributed Systems
Fall 2020

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August 25 – December 8, 2020

Lecture 1-29

Web: courses.engr.illinois.edu/cs425/

We’ve Made it very far!

Congratulations to everyone who’s made it so far in the course!

It has been a challenging year (to say the least) for everyone.

Our goal for today: see how far we’ve learnt on the topic of Distributed Systems.

Our First Goal in this Course was…

(First lecture slide)

To Define the Term Distributed System

Can you name some examples of Distributed Systems?

(First lecture slide)

- Client-Server (NFS)
- The Web
- The Internet
- A wireless network
- DNS
- Gnutella or BitTorrent (peer to peer overlays)
- A "cloud", e.g., Amazon EC2/S3, Microsoft Azure
- A datacenter, e.g., NCSA, a Google datacenter, The Planet

What are other examples you've seen in class?

What is a Distributed System?

(First lecture slide)

FOLDOC definition

(First lecture slide)

A collection of (probably heterogeneous) automata whose distribution is transparent to the user so that the system appears as one local machine. This is in contrast to a network, where the user is aware that there are several machines, and their location, storage replication, load balancing and functionality is not transparent. Distributed systems usually use some kind of client-server organization.

Textbook definitions

(First lecture slide)

- A distributed system is a collection of independent computers that appear to the users of the system as a single computer.

  [Andrew Tanenbaum]

- A distributed system is several computers doing something together. Thus, a distributed system has three primary characteristics: multiple computers, interconnections, and shared state.

  [Michael Schroeder]

A working definition for us

(First lecture slide)

A distributed system is a collection of entities, each of which is autonomous, programmable, asynchronous and failure-prone, and which communicate through an unreliable communication medium.

- Entity=a process on a device (PC, PDA)
- Communication Medium=Wired or wireless network
- Our interest in distributed systems involves
  - design and implementation, maintenance, algorithmics
- *What Evidence/Examples have we seen?*

Problems we have seen since then

- Time and Synchronization
- Global States and Snapshots
- Failure Detectors
- Multicast
- Mutual Exclusion
- Leader Election
- Consensus and Paxos
- Gossiping
- Peer to peer systems – Napster, Gnutella Chord, BitTorrent
- Cloud Computing and Hadoop
- Sensor Networks
- Structure of Networks
- Datacenter Disaster Case Studies

Basic Theoretical Concepts

Cloud Computing

What Lies Beneath

Problems we have seen since then (2)

- RPCs & Distributed Objects
- Concurrency Control
- 2PC and Paxos
- Replication Control
- Key-value and NoSQL stores
- Stream Processing
- Graph processing
- Scheduling
- Distributed File Systems
- Distributed Shared Memory
- Security

← Basic Building Blocks

Distributed Services (e.g., storage)

Cloud Computing

Old but Important (Re-emerging)

What This Course is About

- US Elections
- Movies
- Travel to Mars
- Job Interviews
- (Not Kidding)

What This Course is About

- US Elections: HW1
- Movies: HW2
- Travel to Mars: HW3
- Job Interviews: HW4
- (Not Kidding)

What This Course is About (2)

- Midterm
- HW's and MP's

How to get good grades (and regrades,
and jobs in some cases)
(& that standard devs are important!)

  - (4 cr and Coursera) You've built a new cloud computing system from scratch!
  - And beaten a state of the art system!

How far is your design from a
full-fledged system?
Can you convince developers to use your
MapleJuice instead of Hadoop?

Rejoinder: Typical Distributed Systems Design Goals

- Common Goals:
  - Heterogeneity
  - Robustness
  - Availability
  - Transparency
  - Concurrency
  - Efficiency
  - Scalability
  - Security
  - Openness

(First lecture slide)

Do they make sense now?

Rejoinder: Typical Distributed Systems Design Goals

(First lecture slide)

- Common Goals:
  - Heterogeneity – can the system handle a large variety of types of PCs and devices?
  - Robustness – is the system resilient to host crashes and failures, and to the network dropping messages?
  - Availability – are data+services always there for clients?
  - Transparency – can the system hide its internal workings from the users?
  - Concurrency – can the server handle multiple clients simultaneously?
  - Efficiency – is the service fast enough? Does it utilize 100% of all resources?
  - Scalability – can it handle 100 million nodes without degrading service? (nodes=clients and/or servers) How about 6 B? More?
  - Security – can the system withstand hacker attacks?
  - Openness – is the system extensible?
  - (Also: consistency, CAP, partition-tolerance, ACID, BASE, and others …)

Problems we have seen in Class

(and their relation to other courses)

- Time and Synchronization
- Global States and Snapshots
- Failure Detectors
- Multicast Communications
- Mutual Exclusion
- Leader Election
- Consensus and Paxos
- Gossiping
- Peer to peer systems – Napster, Gnutella Chord
- Cloud Computing
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- Structure of Networks
- Datacenter Disaster Case Studies

Core Material of this course

Related to other graduate classes in department (e.g., CS523, CS525, CS 498ISE, CS598WSI)

Problems we have seen in Class

(and their relation to other courses)

- RPCs & Distributed Objects
- Concurrency Control
- 2PC and Paxos
- Replication Control
- Key-value and NoSQL stores
- Stream Processing
- Graph processing
- Scheduling
- Distributed File Systems
- Distributed Shared Memory
- Security

Core Material of this course

Related to CS 411/CS 511

Related to CS 525

Related to CS 421/CS 433

Related to CS 523/561

CS525: Advanced Distributed Systems (taught by Indy)

CS 525, Offered Spring 2021!

- Looks at hot topics of research in distributed systems: cutting-edge papers on clouds+datacenters, p2p, distributed machine learning, sensor/IoT networks, distributed algorithms, and other distributed systems
- We will read many papers (and webpages) for cutting-edge systems (research and production)
- If you liked CS425's material, it's likely you'll enjoy CS525!
- Project: Choose between Research project or Entrepreneurial project
  - Research Project: Your project will build a cutting-edge research distributed system, and write and publish a paper on it
  - Entrepreneurial Project: Your project will build a distributed system for a new startup company idea (your own!) and perform associated research with it
  - Projects are in groups of your choosing (2-3).
- Both graduates and undergraduates welcome! (UG fill this out for consent: https://my.cs.illinois.edu/ugradrecs/petitions/).
- Class size is around 70-100
- Previous research projects published in journals and conferences, some great startup ideas too!

Other Related Grad Courses

- CS525 – Indy (next offered SP 2021)
- CS598 CAL – Consensus, Blockchain (Ling Ren)
- CS523 – Tianyin Xu
- IoT classes: CS 598 WSI (Deepak Vasisht), CS 598 ISE (Matt Caesar)

- See also courses by Radhika Mittal (ECE, distributed storage), Andrew Miller (ECE, blockchain)

Questions?

A working definition for us

(First lecture slide)

A distributed system is a collection of entities, each of which is autonomous, programmable, asynchronous and failure-prone, and which communicate through an unreliable communication medium.

[Is this definition still ok, or would you want to change it?] Think about it!

Final Exam

- Office Hours: Regular [All TAs and Indy] until final exam window starts (usual schedule).
  - Exceptions posted on Piazza (check before heading out to an OH)
- **Final Exam Window: See website**
  - Syllabus: Includes all material since the start of the course. There may be more emphasis on material since midterm.
- Please check Piazza before (and during) finals: updates will be posted there

Course Evaluations

- Main purpose: to give us feedback on how useful this course was to you (and to improve future versions of the course)
- I won’t see these evaluations until after you see your grades
- Answer all questions
- Please write your detailed feedback – this is valuable for future versions of the course!