Our First Goal in this Course was…

To Define the Term Distributed System
Can you name some examples of Distributed Systems?

- 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?
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

• 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 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

• Sports
• Movies
• Travel to Mars
• Job Interviews
• (Not Kidding)
What This Course is About

• Sports: 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)

- 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 Sava instead of GraphX/PowerGraph/...?
Rejoinder: Typical Distributed Systems Design Goals

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

Do they make sense now?
Rejoinder: Typical Distributed Systems Design Goals

• **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
- Sensor Networks
- Structure of Networks
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### Core Material of this course

Related to **CS 525 (Advanced Distributed Systems Offered Spring 2018)**
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, Spring 2018

– Looks at hot topics of research in distributed systems: clouds, p2p, distributed algorithms, sensor networks, 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
  • Your project will build a cutting edge research distributed system, and write and publish a paper on it
  • Your project will build a distributed system for a new startup company idea (your own!) and perform associated research with it
– Both graduates and undergraduates welcome! (let me know if you need my consent).
– Class size is around 70-100
– Previous research projects published in journals and conferences, some great startup ideas too!
Questions?
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 only, not Indy] until Dec 18th (usual schedule).
  – Exceptions posted on Piazza (check before heading out to an OH)

• Final Exam: December 18 (Monday), 7.00 PM – 10.00 PM
  – Locations (also on Course Schedule)
    • Wohlers Hall. 1206 South Sixth Street Champaign, IL 61820
    • 241 Wohlers: if your last name begins with A-C
    • 243 Wohlers: if your last name begins with D-J
    • 141 Wohlers: if your last name begins with K-Z
    • Please go to your assigned classroom only!
  – Syllabus: Includes all material since the start of the course. There may be more emphasis on material since midterm.

• Please check Piazza before finals: updates will be posted there
Final Exam (2)

- **Cheat sheet**: Allowed to bring a *cheat sheet* to the exam (US letter size, two sides only, at least 1 pt font). Need to turn it in with exam. Physical copy only, no online access during exam.
- Can bring a calculator (but no other devices).
- Structure: Final will be similar in structure to Midterm, only longer. More detailed answers to long questions (partial credit).
- Preparing: HW problems, and midterm problems (and textbook problems).
After course eval, Collect HW4

- After you exit classroom, collect your HW4s graded (TAs are outside!)
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
• Use pencil only
• Answer all questions
• Please write your detailed feedback on the back – this is valuable for future versions of the course!
• After you’ve filled out, hand survey to volunteer, and return pencil to box
• Volunteer student:
  1. Please collect all reviews, and drop envelope in campus mail box
  2. Return the box of pencils to me (3112 SC)