CSE 486/586 Distributed Systems
Mid-Semester Overview

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We're at a Mid-Point: What We've Discussed So Far

- Main communication infrastructure: the Internet
- Communication between two processes
  - Socket API
  - RPC
- Communication between multiple processes
  - Multicast algorithms
- Concept of time in distributed systems
- Organization of distributed systems
  - Server-client
  - Peer-to-peer, DHTs
- Impossibility of consensus
- Distributed algorithms
  - Failure detection, global snapshots, mutual exclusion, leader election

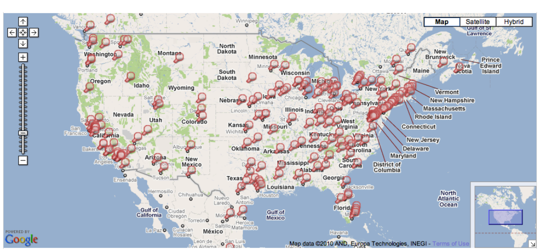
The Other Half of the Semester

- Distributed storage
- Consensus algorithm: Paxos
- BFT (Byzantine Fault Tolerance)
- Security

Data Centers

Data Centers

- Hundreds of Locations in the US

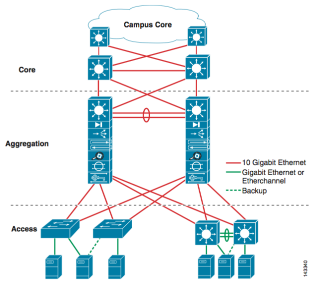


Inside

- Servers in racks
  - Usually ~40 blades per rack
  - ToR (Top-of-Rack) switch
- Incredible amounts of engineering efforts
  - Power, cooling, etc.

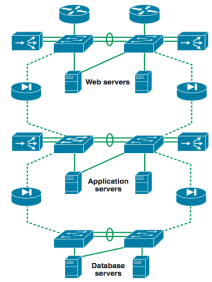
Inside

- Network



Inside

- 3-tier for Web services

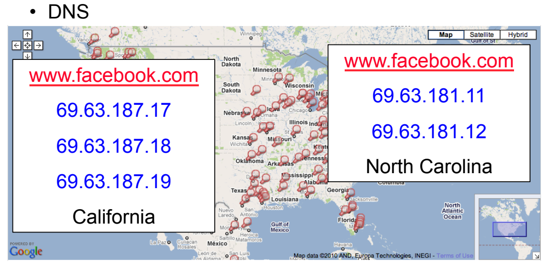


Web Services

- Amazon, Facebook, Google, Twitter, etc.
- World-wide distribution of data centers
  – Load balance, fault tolerance, performance, etc.
- Replicated service & data
  – Each data center might be a complete stand-alone web service. (It depends though.)
- At the bare minimum, you're doing read/write.
- What needs to be done when you issue a read req?
  – Server selection
- What needs to be done when you issue a write req?
  – Server selection
  – Replicated data store management

Server Selection Primer

- Can happen at multiple places
- Server resolution process: DNS -> External IP -> Internal IP
- DNS

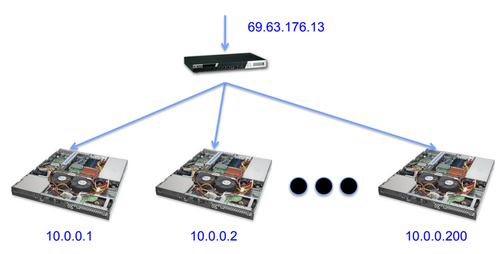


IP Anycast

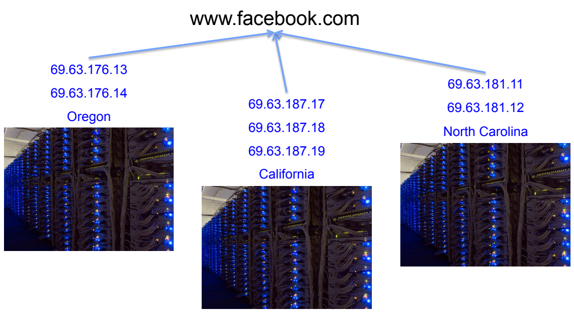
- BGP (Border Gateway Protocol) level

Inside

- Load balancers



Example: Facebook



Example: Facebook Geo-Replication

- (At least in 2008) Lazy primary-backup replication
- All writes go to California, then get propagated.
- Reads can go anywhere (probably to the closest one).
- Ensure (probably sequential) consistency through timestamps
  - Set a browser cookie when there's a write
  - If within the last 20 seconds, reads go to California.
- http://www.facebook.com/note.php?note_id=23844338919

Core Issue: Handling Replication

- Replication is (almost) inevitable.
  - Failures, performance, load balance, etc.
- We will spend most of our time looking at this in the second half of the semester.
- Data replication
  - Read/write can go to any server.
  - How to provide a consistent view? (i.e., what consistency guarantee?) linearizability, sequential consistency, causal consistency, etc.
  - What happens when things go wrong?
- State machine replication
  - How to agree on the instructions to execute?
  - How to handle failures and malicious servers?

CSE 486/586 Administrivia

- Midterm: 3/6 (Wednesday) in class
  - 45 minutes
  - Everything up to leader election
  - 1-page cheat sheet is allowed.
- Best way to prepare
  - Read the textbook & go over the slides
  - Go over the problems in the textbook
  - Will add more problems for the lectures this week & next
- PA3 will be out this weekend.
- No recitations next week
- Anonymous feedback form still available.
- Please come to me!

Today: Banking Example (Once Again)

- Banking transaction for a customer (e.g., at ATM or browser)
  - Transfer $100 from saving to checking account
  - Transfer $200 from money-market to checking account
  - Withdraw $400 from checking account
- Transaction
  1. savings.deduct(100)
  2. checking.add(100)
  3. mnymkt.deduct(200)
  4. checking.add(200)
  5. checking.deduct(400)
  6. dispense(400)

Wait…We've Seen This Before…

- What are some things that can go wrong?
  - Multiple clients
  - Multiple servers
- How do you solve this?
  - Group everything as if it's a single step
- Where have we seen this?
  - Mutual exclusion lecture
- So, we're done?
  - No, we're not satisfied.

Why Not Satisfied?

• Process 1	• Process 2

lock(mutex);
savings.deduct(100);
checking.add(100);
mnymkt.deduct(200);
checking.add(200);
checking.deduct(400);
dispense(400);
unlock(mutex);
	lock(mutex);
	savings.deduct(100);
	checking.add(100);
	mnymkt.deduct(200);
	checking.add(200);
	checking.deduct(400);
	dispense(400);
	unlock(mutex);

Why Not Satisfied?

A failure at these points means the customer loses money; we need to restore old state

1. savings.deduct(100)
2. checking.add(100)
3. mnymkt.deduct(200)
4. checking.add(200)
5. checking.deduct(400)
6. dispense(400)

A failure at these points does not cause lost money, but old steps cannot be repeated

Why Not Satisfied?

- What we discussed in mutual exclusion is one big lock.
  - Everyone else has to wait.
  - It does not necessarily deal with failures.
- Performance
  - Observation: we can interleave some operations from different processes.
- Failure
  - If a process crashes while holding a lock
- Let's go beyond simple locking!

Acknowledgements

- These slides contain material developed and copyrighted by Indranil Gupta (UIUC).