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

• Main communication infrastructure: the Internet
• Communication between two processes
  – Socket API
• 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

• 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.
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

Hey, I know where 69.63.187.17 is... in California
Hey, I know where 69.63.187.17 is... in New York

IP Anycast

- BGP (Border Gateway Protocol) level

Hey, I know where 69.63.187.17 is... in California

Inside

- 3-tier for Web services

Inside

- Network
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.


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 guaranteed?) 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: 3/11 (Wednesday) in class
  - 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.
- PA2-B due this Friday
  - Please remember that we’ll be running code similarity checkers (automatic F if found too similar).

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

• Process 2
  
  - lock(mutex);
  - savings.deduct(100);
  - checking.add(100);
  - mnymkt.deduct(200);
  - checking.add(200);
  - checking.deduct(400);
  - dispense(400);
  - unlock(mutex);

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!

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