Distributed Systems and Security: An Introduction

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CS GZ03 / M030
9th October 2015
Today’s Lecture

• Administrivia

• Overview of Distributed Systems
  – What are they?
  – Why build them?
  – Why are they hard to build well?

• Operating Systems Background

• Questionnaire
Prerequisites

• Undergraduates: must have taken UCL CS 3035, Networked Systems, or equivalent experience (3rd-year undergrad networking class, covering Internet protocols and architecture in depth)

• Graduates: must be concurrently enrolled in UCL CS GZ01, Networked Systems, or equivalent prior experience (3rd-year undergrad networking class, covering Internet protocols and architecture in depth)
Course Staff and Office Hours

• Instructor:
  – Brad Karp, MPEB 6.20, Tue 5 – 6 PM, ext. 30406

• Teaching Assistant:
  – Steve Dodier-Lazaro, MPEB 6.07, Wed 4:10 – 5:10 PM, ext. 33644

• Office hours begin next Tuesday
• Time reserved for answering your questions
• Outside office hours, email to schedule appointment
Meeting Times and Locations

- (Most) Mondays 11 AM – 12:30 PM, 25 Gordon Street (Math), Room 500
- (Most) Wednesdays 9:30 – 11 AM, 16 Taviton St. (SSEES), Room 347
- (A Few) Fridays 5 – 6:30 PM, Chadwick B05 LT
- Lecture will usually run 90 minutes
- Occasionally lecture will be followed by a 30-minute discussion of an additional topic (e.g., Q&A on a coursework); on these dates, full two hours!
- No lecture (5\textsuperscript{th}, 7\textsuperscript{th} October); 25\textsuperscript{th} November; 16\textsuperscript{th} December
- Reading week: 9\textsuperscript{th} – 13\textsuperscript{th} November, no lecture!
Class Communication

• Class web page
  – http://www.cs.ucl.ac.uk/staff/B.Karp/gz03/f2015/
  – Detailed calendar, coursework, class policies
  – Your responsibility: check page daily!

• M030/GZ03 Piazza Page
  – https://piazza.com/ucl.ac.uk/fall2015/computersciencem030gz03
  – Important announcements from class staff (also forwarded to you by email)
  – Postings from class staff and students
  – Subscribe using enrollment key
  – You must subscribe (class policy)
  – Your responsibility: check email daily!
Using Piazza

• Please post questions on class material on Piazza, rather than emailing course staff.
• Whole class benefits from seeing your question and its answer.
• Students are encouraged to answer one another’s questions!
• When discussing something private (e.g., your marks, or details of your specific solution to a coursework), mark your post as private, so only class staff see it!
Readings, Lectures, and Lecture Notes

- Readings must be read before lecture; lectures assume you have done so
- Lecture notes will be posted to the class web site just after lecture
- Class calendar shows all reading assignments day by day...
Readings

• No textbook
• Classic and recent research papers on real, built distributed and secure systems
• Available on class web page; print these yourselves
• All readings examinable
• Research papers are dense and complex; they are often challenging
  – Be prepared to read and re-read the papers
  – Come to lecture with questions, and/or use office hours
Grading

• Final grade components:
  – One programming coursework: 15%
  – One problem set coursework: 15%
  – Final exam: 70%
Late Work Policy

- N.B. that **M030/GZ03 policy differs from that for other CS classes!**
- For every day late or fraction thereof, **including weekend days**, 10% of marks deducted
- Each student receives budget of **3 late days** for entire term
  - Each late day “cancels” one day of lateness
  - Goal: give you flexibility, e.g., in case you can’t find a bug, or encounter unexpected other snag
  - You declare how many late days to use when turning in a coursework late; **cannot declare or change later!**
  - Must use whole late days—cannot use fractional ones!
Late Days (cont’d)

• If submission more than 2 days late after taking late days into account, zero marks

• Programming coursework turned in online; may be submitted 24/7

• Problem set coursework turned in on paper in lecture; can be submitted M – F only
  – Weekend days after deadline still count as elapsed days
Late Days (cont’d)

- If submission more than 2 days late after taking late days into account, zero marks

**Late days give you flexibility.** No other extensions given on coursework, unless for unforeseeable, severely extenuating circumstances!

paper in lecture; can be submitted M – F only
- Weekend days after deadline still count as elapsed days
Academic Honesty

- All courseworks must be completed individually
- May discuss understanding of problem statement, general sketch of approach
- May not discuss details of solution
- May not show your solution to others (this year or in future years)
- May not look at others’ solutions (this year or from past years)
Academic Honesty (cont’d)

• We use code comparison software
  – Compares parse trees; immune to obfuscation
  – Produces color-coded all-student-pairs code comparisons

• Don’t copy code—you **will** be caught!

• Penalty for copying: automatic zero marks, referral for disciplinary action by UCL (usually leads to exclusion from all exams at UCL)
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What Is a Distributed System?

• Multiple computers (“machines,” “hosts,” “boxes,” &c.)
  – Each with CPU, memory, disk, network interface
  – Interconnected by LAN or WAN (e.g., Internet)

• Application runs across this dispersed collection of networked hardware

• But user sees single, unified system
What Is a Distributed System? (Alternate Take)

“A distributed system is a system in which I can’t do my work because some computer that I’ve never even heard of has failed.”

– Leslie Lamport, Microsoft Research (ex DEC), 2013 Turing Award winner
Start Simple: Centralized System

• Suppose you run Gmail

• Workload:
  – Inbound email arrives; store on disk
  – Users retrieve, delete their email

• You run Gmail on one server with disk
Start Simple: Centralized System

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• Workload:
  – Inbound email arrives; store on disk
  – Users retrieve, delete their email

What are shortcomings of this design?

• You run Gmail on one server with disk
Why Distribute?
For Availability

- Suppose Gmail server goes down, or network between client and it goes down
- No incoming mail delivered, no users can read their inboxes
- Fix: replicate the data on several servers
  - Increased chance some server will be reachable
  - Consistency? One server down when delete message, then comes back up; message returns in inbox
  - Latency? Replicas should be far apart, so they fail independently
  - Partition resilience? e.g., airline seat database splits, one seat remains, bought twice, once in each half!
Why Distribute?
For Scalable Capacity

• What if Gmail a huge success?
• Workload exceeds capacity of one server
• Fix: spread users across several servers
  – Best case: linear scaling—if \( U \) users per box, \( N \) boxes support \( NU \) users
  – Bottlenecks? If each user’s inbox on one server, how to route inbound mail to right server?
  – Scaling? How close to linear?
  – Load balance? Some users get more mail than others!
Performance Can Be Subtle

- **Goal:** predictable performance under high load
- **2 employees run a Starbucks**
  - **Employee 1:** takes orders from customers, calls them out to Employee 2
  - **Employee 2:**
    - writes down drink orders (5 seconds per order)
    - makes drinks (10 seconds per order)
- **What is throughput under increasing load?**
Starbucks Throughput

- Peak system performance: 4 drinks / min
- What happens when load > 4 orders / min?
- What happens to efficiency as load increases?
Starbucks Throughput

- Peak system performance: 4 drinks / min
- What happens when load > 4 orders / min?
- What happens to efficiency as load increases?
- What would preferable curve be?
- What design achieves that goal?
Why Are Distributed Systems Hard to Design?

- **Failure: of hosts, of network**
  - Remember Lamport’s lament
- **Heterogeneity**
  - Hosts may have different data representations
- **Need consistency (many specific definitions)**
  - Users expect familiar “centralized” behavior
- **Need concurrency for performance**
  - Avoid waiting synchronously, leaving resources idle
  - Overlap requests concurrently whenever possible
Security

• Before Internet:
  – Encryption and authentication using cryptography
  – Between parties known to each other (e.g., diplomatic wire)

• Today:
  – Entire Internet of potential attackers
  – Legitimate correspondents often have no prior relationship
    – Online shopping: how do you know you gave credit card number to amazon.com? How does amazon.com know you are authorized credit card user?
    – Software download: backdoor in your new browser?
    – Software vulnerabilities: remote infection by worms!
  – Crypto not enough alone to solve these problems!