Final Project Announcements

Monday December 12 – In-class Demos in 1240 CS
• CS 1240 is classroom across hall; nice, but no computers
  – Bring laptop with Scratch project loaded
• Attendance required for everyone! (Sign-in sheet)
• Groups of Two
  – One person must demo project, other person can walk around
• Group of One
  – Demo and/or walk around; your choice – you don’t have to demo

Final version due at 5pm
• Upload to “Card Game” dropbox in Learn@UW

More Announcements

Final Exam: 15% of final grade (others 10%)
• 12/21 (Wed) from 2:45 – 4:45 pm in Noland 132
• Part 3 of course: 10% – 1 hour
  – Practice exam available soon; 12/14 class for review
• Cumulative portion: 5%
  – On-line AP test (take: 100% or don’t take: 0%)
  – Must take on laptop or in lab with TA supervision
  – See demo sign-up sheet for TA hours
  – Due: Exam day (Dec 21st)
  – Bring laptop to Final exam if didn’t take beforehand

Announcements Part 2

Final Project Grading
• Use Google Doc to sign-up for 15 minute timeslot M-W next week
• Meet with TA in Lab (1370 CS)
• Every group must sign up (or will NOT be graded!)
• Both project partners must show up
• Will use version you uploaded to dropbox
  – Monday timeslots imply you are done a little early (before 5pm deadline)

Lab hours today
• Friday 11-1 Victor in Lab (1370 CS)

End of Announcements

Extra Credit: Fill out survey for College Board
• Screenshot to Dropbox HW11-Extra (1/2 hw grade)
• Due by 5pm Wednesday (12/14)

Homework 9 and 10 graded
• Check Learn@UW that all grades are as expected
Basic TCP Protocol

Concerns:
- Packets may arrive out of order
- Packet may be dropped and never arrive

Don’t have human hearing if message makes sense!

<table>
<thead>
<tr>
<th>Destination address</th>
<th>TCP</th>
<th>Book-keeping</th>
<th>Data</th>
</tr>
</thead>
</table>

What should be in book-keeping info to help?

Packet dropped?
Receiver
- Acknowledge packets that arrived (by sequence number)
Sender
- Resends packet if no acknowledgment in some time-out interval

Demo: Lost Packets

One bad router in our network
- Drops packets that are sent through it

What must receiver do now to reconstruct packet?

Why should the receiver send “acks” of what it has received instead of requests for missing packets (“negative ack -- nacks”)?

Challenge 3

How to cooperate when not in your selfish best interest?

Routers contain fixed amount of memory
- Queue full → packets dropped
Goal is to avoid stressing network and dropping packets
Not just one person’s fault that network is overloaded!

How should good sender react?

Packets getting dropped?
- Send fewer packets simultaneously → Halve transmission rate
- How do you know packets are being dropped?
  - Don’t receive acknowledgements

All packets getting through?
- Can probably send more → Increase transmission rate a little

Desired behavior included in TCP/IP software
- “Congestion control”

No enforcement mechanism in Internet!
- Allows cheating, VoIP Telephony, streaming media
How does Web work?

User-level apps run HTTP protocol on TCP/IP

Client (web browser): Sends requests to server
- Use TCP/IP to find server and ensure requests arrive
- HTTP protocol: "GET filename"

Server: Replies with requested file
- Reads file from file system; sends over network
  - Doesn’t know anything about contents of file
- Easy to make your own web server!

Client: Does work to interpret .html file, display in browser

Today’s Summary

Internet: Three Principles
- Use hierarchy for decentralized control in large system
- Build reliability (TCP) on top of unreliable layer (IP)
- Congestion control: Don’t send as many packets when you see problems

Island of Liars and Truth Tellers

Assumptions of logic puzzle:
- You are on an island populated by two tribes
- Members of one tribe always tell the truth
- Members of one tribe always lie
- Tribe members recognize one another, but you can’t tell them apart
# Puzzles

1. You meet a man on the island. You ask "Are you a truth teller?" He answers "Yes". Is he a truth teller or liar?

<table>
<thead>
<tr>
<th>Truth Teller or Liar</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT</td>
<td>Yes</td>
</tr>
<tr>
<td>Liar</td>
<td>Yes</td>
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2. You meet a man and ask if he is a truth-teller. A blaring siren prevents you from hearing his answer. You inquire, "Sorry, did you say you're a truth teller?" He responds, "No, I did not." To which tribe does he belong?

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# More Puzzles

3. You meet two people A and B. A says "Both of us are from the liars tribe." What is A? What is B?

<table>
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<th>B</th>
<th>Possible?</th>
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4. You meet two people C and D. C says "Exactly one of us is from the liars tribe." What is D? What is C?

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How do Liars Relate to Computers?

Distributed Systems
- “Collection of independent computers that appears to its users as a single coherent system”
- All interesting web services built this way!

Why are Web Services Built as Distributed Systems?

Great price/performance
- Use many commodity components (nodes and networks)

Incremental scalability
- Add x% new nodes to improve performance x%

Improved availability (Up 24x7)
- Continue operating when some nodes stop working

Improved reliability
- Deliver correct results when some nodes misbehave!
Why do Nodes “Misbehave”?

Hardware problems
- Bit flips in memory
- Disk returns data from wrong sector
- Over-clocked processor
- Power fluctuation

Software bugs
- Honest mistakes in millions of lines of code
- Don’t understand code written by someone else
- Concurrent events (race conditions)
- Misconfigured

Malicious software

Example Distributed Service

Connect to service using HTTP protocol
Customer can purchase and download favorite music

Customer does not know how service is implemented
- Could be one machine or 1000s
- Customer doesn’t care as long as get right music

How Should Distributed Service be Implemented?

Complexity and cost depend upon Failure Model
- Assumptions about how components can fail

Simplest (most naïve, optimistic) failure model?
- Assume nodes never fail!
- All components always give correct answer
- Corresponds to Truth teller
What if Computers Fail?

Failure model: Fail-Stop
- Very common assumption
- Computer either works correctly or stops (crashes)
  - Tells truth until it dies; others can recognize you are dead

How would you design with fail-stop computers?

Favorite song, please?

Music

What if Computers Lie?

Failure model: Consistent Liars
- Assume faulty computers always give wrong response (stuck at zero)
- Computers are either truth-tellers or liars

How would you design dist. system with lying computers?
- Assume system must be able to handle 1 failure (1 lying computer)
- How many computers are needed?
What if Computers Lie?

Failure model: Consistent Liars
- Assume faulty computers always give wrong response (stuck at zero)
- Computers are either truth-tellers or liars

How would you design dist. system with lying computers?
- Assume system must be able to handle 1 failure (1 lying computers)
- How many computers are needed?

To handle $f$ liars, must have $f+1$ truth tellers
Must have total of $2f+1$ computers

What if Computers Lie?

Failure model: Consistent Liars
- Assume faulty computers always give wrong response (stuck at zero)
- Computers are either truth-tellers or liars

How would you design dist. system with lying computers?
- Assume system must be able to handle 2 failures (2 lying computers)
- How many computers needed?

Liars, Randoms, and Truth Tellers

Assumptions of puzzle:
- You are on an island populated by three tribes
- Members of one tribe always tell the truth
- Members of one tribe always lie
- Members of one tribe either tell truth or lie, completely at random
- Tribe members recognize one another, but you can’t tell them apart
You meet three people (A, B, C) from the island, one from each tribe. How can you tell who is from each tribe by asking only three yes/no questions? Each question must be directed at only one person. You can ask the same person multiple questions. Can ask different questions (or to different people) depending upon previous answers.

Hint: Which tribe gives the worst answers?
• Random → Gives no useful information
• Try to avoid them as much as possible

Hint: What possible orders for ABC are there?
Enumerate...
• RLT, RTL, TRL, TLR, LTR, LRT → 6 possibilities

How many different answers might we be able to identify with 3 yes/no questions?
**Puzzle with Random Info**

Hint: Which tribe gives the worst answers?
- Random → Gives no useful information
- Try to avoid them as much as possible

Hint: What possible orders for ABC are there?
Enumerate...
- RLT, RTL, TRL, TLR, LTR, LRT → 6 possibilities

How many different ordering might we be able to identify with 3 yes/no questions?
- Could identify $2^3 = 8$ possibilities (given no randoms)

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**Puzzle with Random Info**

Possibilities: RLT, RTL, TRL, TLR, LTR, LRT

Strategy:
- Ask question to divide into two groups (of 4 each)
Ask first person: Is R immediately after L in list?
- Don’t know what type first person is!
  - If R is first: Will get random info
  - If T first: Truth
  - If L first: Lie

Determine answer for all 6 possibilities
- Red → Person answers no
- Green → Person answers yes

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**Puzzle with Random Info: Solution**

Yes: RLT, RTL, TLR, LTR
No: RLT, RTL, TRL, LRT

Imagine Answer is “Yes”; Which person ask next?
Puzzle with Random Info: Solution

Yes: RLT, RTL, TLR, LTR
No: RLT, RTL, TRL, LRT

Imagine Answer is “Yes”; Which person ask next?
- R never 2nd so ask 2nd person

So, if get “yes”, ask question of 2nd person to tell if T or L?
- 2nd: Are you a Random?

If answer “yes”, what is 2nd person? Possible orders?

Imagine Answer is “No”; Which person ask next?
- R never 2nd so ask 2nd person

So, if get “no”, ask question of 2nd person to tell if T or L?
- 2nd: Are you a Random?

If answer “yes”, what is 2nd person? Possible orders?
- Liar: RLT, TLR
  - Else if answer “no”, 2nd person is Truth Teller; Possible orders?
    - RTL, LTR

What is useful for 3rd question?
- 3rd: Ask 2nd person about 3rd person to identify case

Puzzle with Random Info: Solution

Yes: RLT, RTL, TLR, LTR
No: RLT, RTL, TRL, LRT

Imagine Answer is “No”; What is same about all No answers?
- R never 3rd

So, if get “No”, ask 3rd instead of 2nd
- 3rd: Are you a Random?

If answer “yes”, what is 3rd person?
- Liar; Possible orders?
  - RTL, TRL
  - Else if answer “no”, 3rd person is Truth Teller; Possible orders?
    - RLT, LRT

What is useful for 3rd question?
- 3rd: Ask 3rd person about 2nd person to uniquely identify case

What 3 Questions to Identify Order?

Enumerate possible orderings
Use decision tree to show one ordering by time reach leaf nodes

---

Q1: Ask P1
  - Is R in 3rd after L?

Q2: Ask P2 (if yes) or P3 (if no)
  - Are you a Random?

Q3: Ask same P as Q2
  - Is L in 3rd?
What 3 Questions to Identify Order?

Enumerate possible orderings.
Use decision tree to show one ordering by time reach leaf nodes.

Q1: Ask P1 – Is R before L?

Q2: Ask P2 (if yes) or P3 (if no) – Are you R?

Q3: Ask same P as Q2 – Is P1 R?

Insert Demo

I think you are...Random Truth Liar

 RTL, RLT, TLR, LTR, LRT, LTR

TLR, LRT, RTL, LTR

L L T T

L L T T

TLR, LRT, RTL, LTR

Conclusion: Random Info

Random information (sometimes lying and sometimes truth) complicates logic
• Very hard to conclude which are right

Byzantine: Give response calculated to worst possible harm (malicious)

Voting across answers still works well in most circumstance
• 3 Replicas often used (can handle 1 liar or random)

Today’s Summary

Distributed Systems
• Used to implement most all web services
  – Improve performance, availability, reliability
• Complexity and cost depend upon f and fault model
  – Fail-stop: Need f+1 nodes
  – Simple Liars: Need to vote with 2f+1 nodes
  – Byzantine (Random) Liars: Very difficult to cope with!