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

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)

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

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!

Destination address	TCP Book-keeping	Data

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

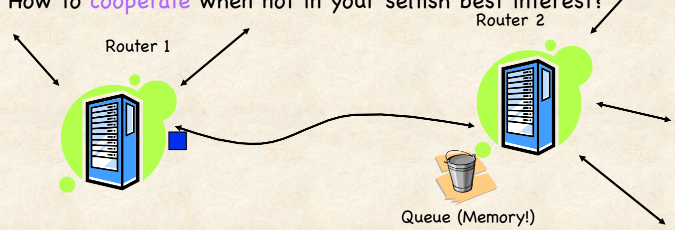
- Drops packets that are sent through it

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

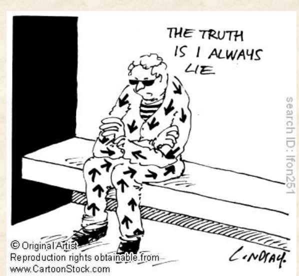
- Use hierarchy for decentralized control in large system
- Build reliability (TCP) on top of unreliable layer (IP)
- Congestion control: Don’t send as many packets when you see problems

UNIVERSITY of WISCONSIN-MADISON
Computer Sciences Department

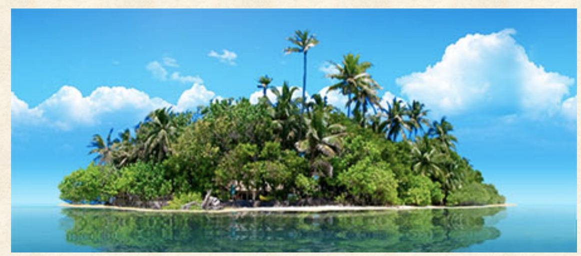
CS 202: Introduction to Computation

Professor Andrea Arpaci-Dusseau

Why must a computer… detect liars and cheaters?



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?


Truth Teller or Liar?	Answer
TT	
Liar	

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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   To which tribe does he belong?
   - Liar

Truth Teller or Liar?	Answer
TT	Yes, I did.
Liar	No, I did not

More Puzzles

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

A	B	Possible?
TT	TT	
TT	Liar	
Liar	TT	
Liar	Liar	

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?

C	D	Possible?
TT	TT	
TT	Liar	
Liar	TT	
Liar	Liar	

More Puzzles

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

A: Liar
B: TT

A	B	Possible?
TT	TT	No
TT	Liar	No
Liar	TT	Yes
Liar	Liar	No

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?

C	D	Possible?
TT	TT	
TT	Liar	
Liar	TT	
Liar	Liar	

More Puzzles

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

A: Liar
B: TT

A	B	Possible?
TT	TT	No
TT	Liar	No
Liar	TT	Yes
Liar	Liar	No

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?

D: Liar
C: Can't tell!

C	D	Possible?
TT	TT	No
TT	Liar	Yes
Liar	TT	No
Liar	Liar	Yes

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

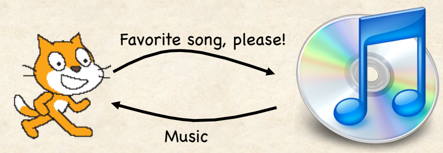
Software bugs
- Honest mistakes in millions of lines of code
- Don't understand code written by someone else
- Concurrent events (race conditions)
- Misconfigured

Malicious software

Example Distributed Service

Connect to service using HTTP protocol

Customer can purchase and download favorite music

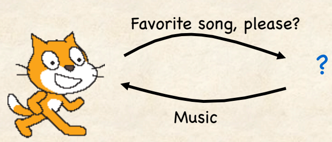


Customer does not know how service is implemented
- Could be one machine or 1000s
- Customer doesn't care as long as get right music

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?



How Should Distributed Service be Implemented?

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

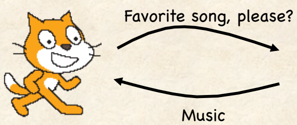
Simplest (most naïve, optimistic) failure model?
- Assume nodes never fail!
- All components always give correct answer
- Corresponds to Truth teller

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?



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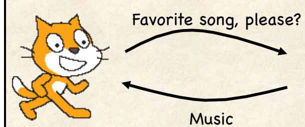
  - Tells truth until it dies; others can recognize you are dead

How would you design with fail-stop computers?

- How do you know how many computers to use?
  - Declare system can handle "f" failures; Assume f = 2
  - How many total computers needed?

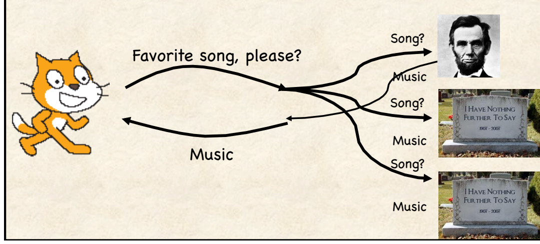


What if Computers Fail?

Failure model: Fail-Stop

- Very common assumption
- Computer either works correctly or it stops (e.g., crashes)
  - Tells truth until it dies; others can recognize you are dead
- Declare system can handle some number (f) of failures; Assume f=2

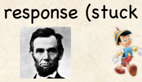
Use f+1 = 3 computers



What if Computers Lie?

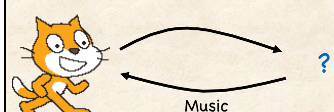
Failure model: Consistent Liars

- 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 1 failure (1 lying computers)
- How many computers are needed?



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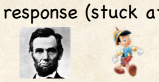
- Computers are either truth-tellers or liars 

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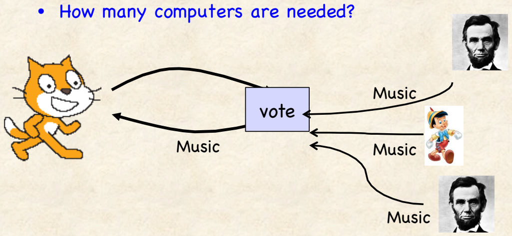

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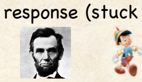
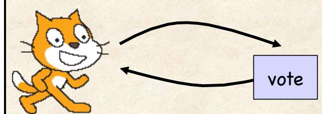
- Computers are either truth-tellers or liars 

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?



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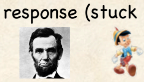
- Computers are either truth-tellers or liars 

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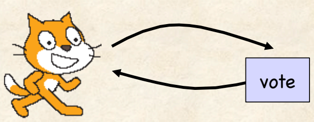
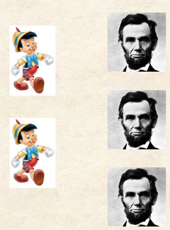
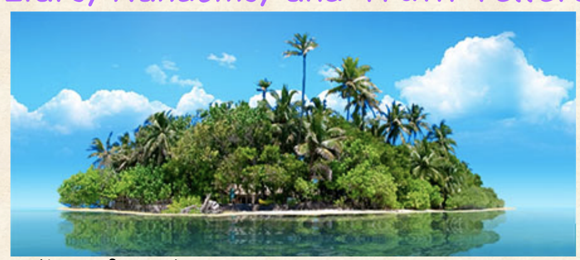




To handle f liars, must have f+1 truth tellers
Must have total of 2f+1 computers

Liars, *Randoms*, and Truth Tellers



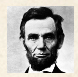
Assumptions of puzzle:

- 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

Puzzle with Random Info

You meet three people (A, B, C) from the island, one from each tribe

How can 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

Puzzle with Random Info

Hint: Which tribe gives the worst answers?

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…

Puzzle with Random Info

Hint: Which tribe gives the worst answers?

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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)

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

Puzzle with Random Info

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

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Determine answer for all 6 possibilities

- Red → Person answers no
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- RLT, RLT, RTL, RTL, TRL, TLR, LTR, LRT,

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?

Puzzle with Random Info: Solution

Yes: RLT, RTL, TLR, LTR

No: RLT, RTL, TRL, LRT

Imagine Answer is "Yes"; Which person ask next?

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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?

- 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

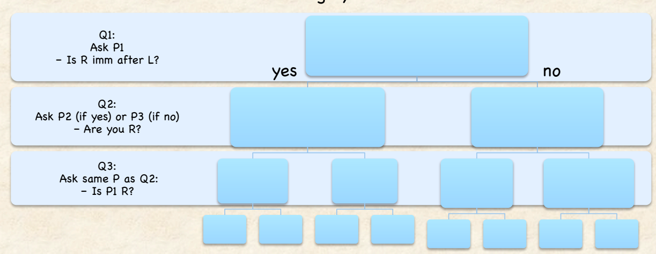
What is useful for 3rd question?

- 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



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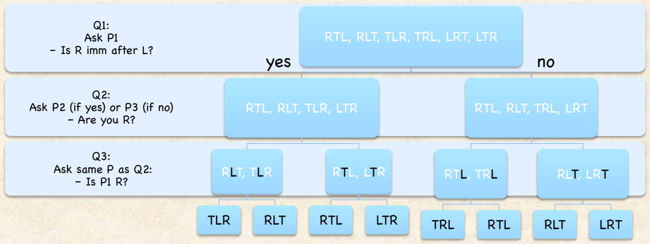
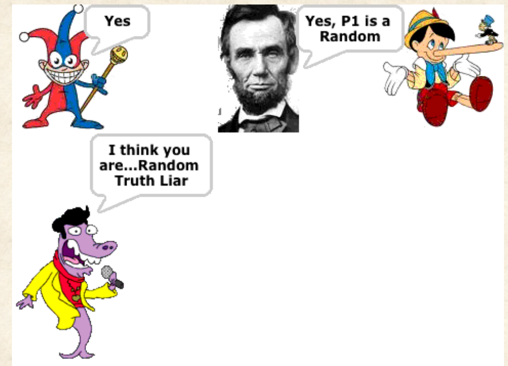


Insert Demo



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!