Today’s topics

Networks and the Internet
Problem Solving

Upcoming
- Writing programs in pseudocode
- Programming language syntax

Reading
Great Ideas Chapters 12
Brooks, Chapter 4

The Internet

- Domain Name System: translates between names and IP addresses
- Properties of the Internet
  - Heterogeneity
  - Redundancy
  - Packet-switched
  - 604 million online (CIA World Factbook 2002)
- What country has the highest percentage of people online?
  1. Aruba
  2. Australia
  3. Denmark
  4. Hong Kong
  5. Iceland
  6. South Africa
  7. South Korea
  8. Sweden
  9. UK
  10. USA

Ethernet

- Invented by Dr. Robert Metcalfe in 1970 at Xerox Palo Alto Research Center
- Allows group of computers to communicate in Local Area Network

Figure 1
PC
PC
PC

Ethernet
An Internet

Network transfers

- A network transfer is the passage of a message from one network to another through a gateway machine.
- We wish to connect 100 machines having 2 network controllers each.
- Each network has at most 4 computers on it.
- How many computers can a message reach without leaving the 2 networks the originating computer is attached to?
- How many networks can a message reach in after 1 network transfer or 2 network transfers?
- How many network transfers are necessary to reach 100 computers or 1024 computers?

Number of networks needed?

Suppose you are dealing with Ethernets that can each only handle four computers. What is the number of networks, \( N \), that you would need to connect 100 such machines and tell how you would connect them. Assume that one machine can connect to no more than two networks simultaneously.

1. 100 networks
2. \( 50 < N < 100 \)
3. \( 25 < N < 50 \)
4. \( 10 < N < 25 \)
5. \( 0 < N < 10 \)

Problem Solving

Programming is a strenuous exercise in problem solving

- Understand the problem
  - What are its parts? unknown, data, condition
  - Does the problem make sense? Is it feasible?
  - Think about the problem, get a sense of what it needs

- Make a plan
  - Find the connection between givens and result
  - What kind of problem is it? Is it familiar?
  - Think about generalizations, specializations, variants

- Carry out the plan
  - Check each step

- Examine the result
  - Does it make sense?
Back of the envelope calculations

http://www.vendian.org/envelope/

- Engineering technique to approximate and check answers
  - Two answers are better than one
  - Quick checks
  - Rules of thumb
  - Practice
- Ad claims that salesperson drove 100,000 miles in a year. True?
- Newspaper article states that a United States quarter dollar coin has “an average life of 30 years.” How can you check that claim?

Why “back of the envelope” estimates?

- Often need to make rapid estimates
  - to eliminate candidate solutions
  - establish feasibility
  - sketch out potential trade-offs
- Most remember key numbers related to their field, not every detail
- Hence we need to estimate
  - which numbers are important
  - values of numbers needed
  - how to perform the calculation
- Emphasis is on “order of magnitude” estimates
  - to nearest factor of 10 (or 2)

Orders of Magnitude

- How far away is home? Is it more like 1, or 10, or 100 miles?
  - Probably do not know exactly
  - Is it approximately "a couple", or "a few", or "a lot"
  - Estimate based on powers rather than multiples of 10
- How tall is your dorm? More like 1, 10, 100, 1000 feet?
  - 1 foot tall is like a doll house, so that’s out
  - What do we know that is about 10 feet big? Hmm... People
  - If building is a couple of people high, 10 sounds good.
  - But that means 1000, would be 100 people high, so that’s out
  - So 10 or 100 depending on how many people tall the building is
- Use orders of magnitude as brackets to find reasonable range

Example: How many piano tuners in NYC

- Approximately how many people are in New York City?
  - 10,000,000
- Does every individual own a piano?
  - No
- Reasonable to assert “individuals do not own pianos; families do”?
  - Yes
- About how many families are there in a city of 10 million people?
  - Perhaps there are 2,000,000 families
- Does every family own a piano?
  - No
- Perhaps one out of every five does
  - That would mean there are about 400,000 pianos in NYC
Example: Piano Tuners continued

- How many piano tuners are needed for 400,000 pianos?
  - Some people never get around to tuning their piano
  - Some people tune their piano every month
  - Assume "on the average" every piano gets tuned once a year, then there are 400,000 every year
- How many piano tunings can one piano tuner do?
  - Assume that average piano tuner can tune four pianos a day
  - Assume that there are 200 working days per year
  - That means every tuner can tune about 800 pianos per year
- How many piano tuners are needed in NYC?
  - Number of tuners is approximately 400,000/800 or 500

Example: Piano Tuners summary

- “Back of the Envelope” estimates have
  - Formulas: provide roadmap to upcoming calculations
  - Estimates: brief justification of approximations in formula
  - Calculations: estimates and known facts are use in formula
- Piano Tuner example
  - Formula:
    \[
    \text{# tuners} = \frac{\text{# pianos} \times \text{# repairs}}{\text{# repairs per day} \times \text{# days}}
    \]
  - Estimates
    - # pianos \(\sim\) 400,000 (20% of 2,000,000 families own pianos)
    - # repairs \(\sim\) 1 per piano (some many, some none)
    - # repairs per day \(\sim\) 4
    - Working days \(\sim\) 200 (5 x 50 – vacation, sickness)
  - Calculation
    - # tuners \(\sim\) \(\frac{400,000 \times 1}{4 \times 200}\) = 500

Estimation General Principles

- Recall Einstein’s famous advice
  - Everything should be made as simple as possible, but no simpler
- Do not worry about constant factors of 2, \(\pi\), etc.
  - Round to “easy” number or nearest order of magnitude
- Guess numbers you do not know
  - Within bounds of common sense (accuracy increases with experience)
- Adjust geometry, etc., to suit you
  - Assume a cow is spherical if it helps
- Extrapolate from what you do know
  - Use ratios to assume unknown value is similar to known quantity
- Apply a ‘plausibility’ filter
  - If answer seems unbelievable, it probably is
  - Can usually set range of reasonable values that indicates major mistake (e.g., speed cannot be faster than light!)

Game

- 10 coins
  - You and a friend have a stack of 10 coins
  - On each person’s turn, they remove either 1 or 2 coins from the stack
  - The person who removes the last coin wins.
  - Can you win?
- 10 coins with a twist
  - 10 coins, can now ALSO place 1 or 2 coins back on the stack
  - Person who removes last coin wins
  - Should you go first or second, and what’s your strategy