Today's topics

Networks and the Internet
Problem Solving
Pseudocode

Upcoming
- Programming language syntax
- Python

Reading
Brookshead, 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

Ethernet

An Internet

Ethernet Ace

Ethernet 2
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?

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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?

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Are problem solving skills primarily domain-specific?

- You’re first told:
  A fortress surrounded by a moat is connected to land by numerous narrow bridges. An attacking army successfully captures the fortress by sending only a few soldiers across each bridge, converging upon it simultaneously.
- Then you’re asked:
  A patient has a cancerous tumor. Beams of radiation will destroy the tumor, but in high doses will also destroy healthy tissue surrounding the tumor. How can you use radiation to safely eradicate the tumor?
- Do the skills transfer between subjects? Is a good math problem solver a good computer science problem solver? How about English to Physics?

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Programming and Problem Solving

- Latin school movement in the 1600s
  - Teach proper habits of the mind
  - Thorndike’s classic “transfer of training” studies found that learning Latin did not produce strong transfer to other domains
- Programming teaches problem solving movement of late 1900s
  - Seymour Papert, 1980, *In learning to program, “powerful intellectual skills are learned in the process*
  - *The activity of programming computers is fundamentally an exercise in problem solving. The program represents the solution to some problem and the execution behavior of that program becomes a means to judge, unemotionally, the success of the problem solution.*
  - Programming is a strenuous exercise in problem solving

*post hoc, ergo propter hoc.*
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

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!)

What’s wrong with this algorithm?

(From back of shampoo bottle)

Directions:
- Wet Hair
- Apply a small amount of shampoo
- Lather
- Rinse
- Repeat

Properties of good algorithms

- Good algorithms must be
  - Correct
  - Complete
  - Precise
  - Unambiguous

- And should be
  - Efficient
  - Simple
  - Contain levels of abstraction

An algorithm is an ordered set of unambiguous, executable steps, defining a terminating process.
Algorithms

- Hand-waving not allowed!
- Specifying algorithms requires you to say what is really involved in making it work.
- Example:
  - How does a computer work?
  - Hand-wave: zeros & ones
  - Real answer: see later part of class.
- You learn to know when you don’t know
  - “I know nothing except the fact of my ignorance.”
  - Socrates, from Diogenes Laertius, Lives of Eminent Philosophers

Describing Algorithms

- Pictures
- Natural language (English)
- Pseudo-code
- Specific high-level programming language

Pseudocode

- A shorthand for specifying algorithms
- Leaves out the implementation details
- Leaves in the essence of the algorithm

```
procedure Greetings
Count ← 3;
while (Count < 0) do
  (print the message "Hello" and Count ← Count +1)
```

- What does this algorithm do?
- How many times does it print Hello?

Sequential search

```
procedure Search (List, TargetValue)
if (List empty)
  then (Declare search a failure)
else
  (Select the first entry in List to be TestEntry;)
  while (TargetValue > TestEntry and there remain entries to be considered)
    do (Select the next entry in List as TestEntry.);
  if (TargetValue = TestEntry)
    then (Declare search a success.)
  else (Declare search a failure.)
end if
```
Picking courses

1. Make a list of courses you want to register for, in order of priority
2. Start with empty schedule. Number of courses = 0.
3. Choose highest priority class on list.
   1. Add the class to the schedule
   2. Increment the number of classes scheduled
4. If the chosen class is not full and its class time does not conflict with classes already scheduled, then register for the class (2 steps):
   1. Add the class to the schedule
   2. Increment the number of classes scheduled
5. Cross that class off of your list.
6. Repeat steps 3 through 5 until the number of classes scheduled is \( \geq 4 \), or until all classes have been crossed out.
7. Stop.

Flowcharts

Make list of classes you want to take

Choose highest priority class on list

Is this class full?

Is there a time conflict?

Add the class to your schedule. Increment Num Classes.

Cross the class off your list.

Num Classes \( \geq 4 \)?

More classes on list?

End

Components of Computing Algorithms

Any computing algorithm will have AT MOST five kinds of components:

- Data structures to hold data
- Instructions change data values
- Conditional expressions to make decisions
- Control structures to act on decisions
- Modules to make the algorithm manageable by abstraction, i.e., grouping related components

Programming Primitive Operations

- Assign a value to a variable
- Call a method
- Arithmetic operation
- Comparing two numbers
- Indexing into an array
- Following an object reference
- Returning from a method