Problem Solving

CS1A

- Why do we need Problem Solving
- 6 Approaches to Solving Problems
- Software Engineering Phases
- Vocabulary

Announcements

- Exam #1 after this section
- Lab #4 – Problem Solving

Why do we need Problem Solving Skills?

- Programming Computers effectively is largely dependent upon our ability to solve problems
- Programs essentially set out to resolve some problem
- Essentially we want to come up with a specific & efficient set of steps that can be repeated to solve our problem
  - This set of steps is called an **algorithm**
  - For example, if we want to find out the largest of 3 numbers → what is the process we employ to achieve this result
- Once we come up with our algorithms then we convert it to code so it can solve that problem repeatedly
  - Programs are usually consist of many algorithms

NOTE: We often have to solve problems that have not been solved before.

Problem Solving Process

1 – Analyze the problem

2 – Solve & Define the algorithm

3 – Test the algorithm

4 – Refine the algorithm

Problem Solving Process Explained

1- Analyze the problem
- Try to gain a greater understanding of it
- Break the problem down into smaller parts
  - AKA Divide and Conquer → big problems can be overwhelming!
- use one of the methods we'll discuss later

2 – Solve & Define the algorithm
- If can solve it once, then we can start to figure out what steps we employed.
- Define these so we can solve it again.

Problem Solving Process Explained (2)

3 – Test the algorithm
- Verify that it works
- Follow your steps and make sure they solve the problem

4 - Refine the steps
- Try to find a more efficient/effective way of solving the problem
- Make sure you verify again

This all takes practice → and some trial and error

The key to innovation is not giving up
If one approach doesn't work then you've still made progress
→ you can eliminate that approach

Analyzing and Initial Solution

- Determine what the problem is
  - Try to come up with one possible solution
- This is where we will start in this class
- We will use a variety of techniques to analyze and solve problems:
  - Build upon what you know
  - Analyzing the problem state
  - Thinking outside the box
  - Look for similarities in previously solved problems
  - Means-Ends Analysis
  - Divide and Conquer

Build upon what you know

- Often in software development you will have a seemingly disjoint set of requirements
- One approach is to
  Build upon your current knowledge
- Analyze each fact and determine if you can deduce anything based on those facts that will lead towards a solution
  - Try to solve in some systematic order
  - Take one requirement at a time

Favorite Television Show

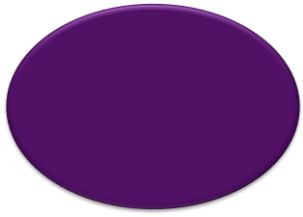
- Six friends are seated around a table discussing their favorite TV show
- The shows they are discussing are
  - The Walking Dead
  - Breaking Bad
  - Big Bang Theory
  - Criminal Minds
  - Parks & Recreation
  - Game of Thrones
- Based on the following information
  - Determine each person's favorite TV Show and where they are sitting

2 A) The boy who likes golf tournaments sits directly to the right of Sean
1 B) Scott sits between the two people, one watches "Game of Thrones" and the other one watches "Breaking Bad"
4 C) No one sits between Trish and Danielle
5 D) Danielle sits directly to the left of the boy who likes "The Walking Dead"
6 E) The boy who likes "Big Bang Theory" does not sit next to a girl
7 F) Danielle does not care for "Parks & Recreation"
8 G) Carlos does not sit next to a girl
3 H) Erik does not sit next to the girl who likes "Game of Thrones"

Name Scott

Fav Show _____

Think about what we know → Which of the clues build upon our current knowledge?



Summary → build upon what you know

- The purpose of this drill is to start with one clue
  - systematically address each requirement
- Most problems in CS consist of many requirements
- It is important to address each requirement without violating another requirment

Analyzing & Solving Techniques

- Build upon what you know
- Analyzing the problem state
- Thinking outside the box
- Look for similarities in previously solved problems
- Means-Ends Analysis
- Divide and Conquer

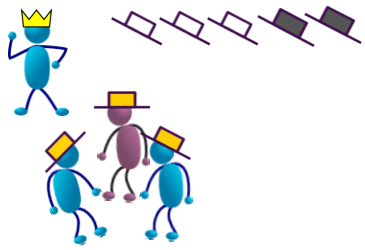
Analyzing the Problem State

- Sometimes we can list each possible state.
  - analyze each possibility individually.
- The problem can be solved through the process of elimination
  - In other words --- which possibilities can be eliminated and which ones can't

… or through a series of deductions

The Five Hats Problem

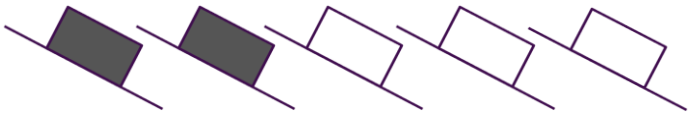
- Three men are condemned to die, one of whom is blind. The king decides he will offer them an opportunity to be set free.
- The three men are arranged in a circle facing one another.
- The king produces 5 hats: 3 white and 2 black.
- The men can't see the hats
- The king places a hat on the head of each person and then destroys the two remaining hats.



- The men have no idea which hats have been destroyed.
- The king instructs them, "The first one of you who can tell me the color of his hat will be set free."
- A period of time passes in silence and then finally the blind man tells the king the color of his hat and is set free.
- What color hat was the blind man wearing and how did he know?
- This does not have a "trick" answer – your answer should be very logical and well thought out. Be able to explain your answer from the viewpoint of each of the three prisoners.
- **Hint: Each sighted man can see the blind man's hat as well as that of the other sighted man. What does the pause in time infer?**

Five Hats Problem

- For problems like this we know each of the possible outcomes
- Write them down
- Then try to analyze each possibility
  - Eliminate possibilities if you can



Think about all the possibilities.

What are the potential arrangements of hats?

See1 See2 Bl

Analyzing & Solving Techniques

- Build upon what you know
- Analyzing the problem state (continued)
- Thinking outside the box
- Look for similarities in previously solved problems
- Means-Ends Analysis
- Divide and Conquer

Analyzing the Problem State

- The 5 hats / 3 prisoners problem is an example of analyzing the possible states
- Using this method
  - Identify that there is a limited number of choices
  - List out the choices and analyze them
  - Sometimes it is trial and error → this is okay for limited choices
- For the 5 hats → _____

  _____
- We examined all the possible states for all three prisoners (there were only 7)
- From these we deduced _____

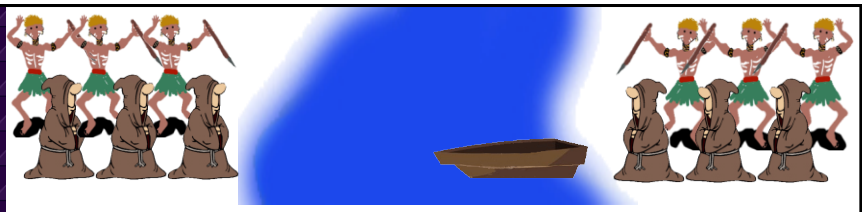
  _____

  → otherwise the seeing prisoners would have spoken up
- Let's expand upon this technique to solve the next problem

Missionary-Cannibal Problem

- There are 3 missionaries, 3 cannibals, and a boat.
- They want to cross the river.
- If there are more cannibals than missionaries on any side of the river the cannibals will eat the missionaries.
- Only 2 people fit in the boat at one time.
- How do the missionaries get the cannibals across the river without getting eaten. (both Missionaries and cannibals need to get to the other side)

Looking at the possibilities → just like the 5 hats
Make deductions at each step



Left River Right

Left River Right

Analyzing & Solving Techniques

- Build upon what you know
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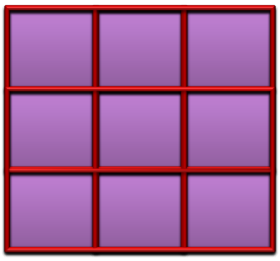
Thinking Outside the Box

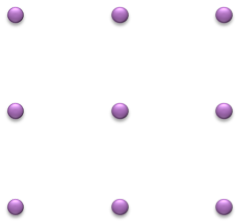
- How many boxes are there?



Sometimes we put constraints on problems
→We need to look at the constraints and determine if the problem dictates those constraints or if we do
→ If it is us then we need to think beyond our preconceptions

Thinking Out of the Box (2)

Draw four line segments through the 9 points without lifting your pencil or retracing a line.



Analyzing & Solving Techniques

- Build upon what you know
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Try to look for similarities

Look for similarities in other problems you have solved

For Example

Finding the heaviest & lightest weight

is really the same problem as

Finding the highest and lowest grades on a test

is really the same problem as

Finding the daily high and low temperatures

all 3 problems can be abstracted as being

_____

Analyzing & Solving Techniques

- Build upon what you know
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Means-Ends Analysis

- Beginning state and End state are often given
  - You need to define a set of actions that can be used to get from one to the other
  - Once you have a set of actions, you need to work out the details

Translated to computer programming

- Begin by writing down the inputs.
  - (Beginning state)
- What should the output be for those inputs?
  - (End state)
- What processing need to be performed to obtain the desired results?

Analyzing & Solving Techniques

- Build upon what you know
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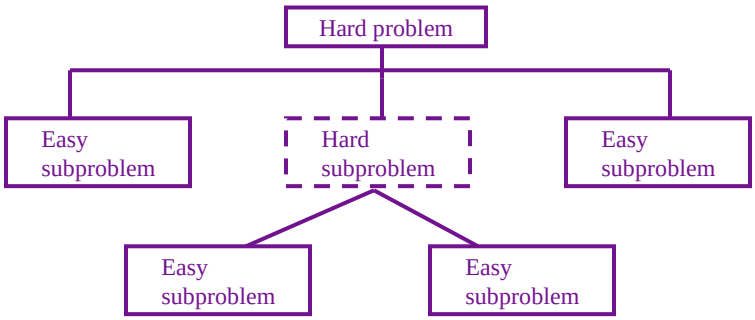
Divide & Conquer

- Break up large problems into smaller manageable problems



Divide & Conquer Example

Compute the area of a circle

Problem statement

- We need an interactive program (user will input data) that computes the area of a circle. Given the circle radius, the circle area should be displayed on the screen

Input/Output description

- Input → Circle radius
- Output → Circle area

Algorithm development (set of steps, decomposition outline)

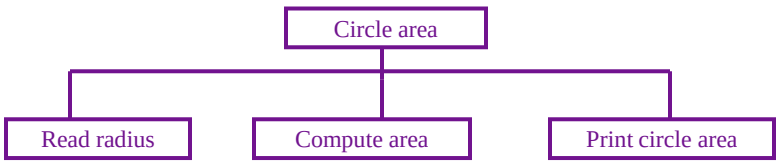
1. Read value of circle radius (r)
2. Compute circle area as $\pi^* r^2$
3. Print the value of circle area

How do we represent more complex algorithms

- Pseudocode, flowcharts

Divide & Conquer Example (2)

A divide and conquer block diagram of our problem



Pseudocode

BEGIN

PROMPT the user for the circle radius

READ radius

CALCULATE Circle area (π^* radius^2)

OUTPUT Circle area

END

5 Basic Software Development Phases

1. Requirements Phase
   - →Analyze and specify the problem
   - →Define the problem → inputs and outputs
2. Design Phase
   - →Determine how the problem will be approache and solved (Problem Solving)
   - →Verify your solution solves the problem specified

In this class we will mostly focus on small scale Design and Implementation Phases

Software Development Phases (2)

3. Implementation Phase
   - →Code & document the program (Concrete solution)
   - →Basic testing
4. Testing
   - →More formalize testing → make sure it meets the specifications
5. Maintenance
   - →Use the Program
   - →Modify (meet changing requirements)
   - →Fix bugs missed in implementation

Going from Problem Solving to Programming - Vocabulary

- Algorithm
  - → a step by step process for solving a problem.
- Top-Down Design (design methodology)
  - → break a larger problem into small parts progressing from the general to the specific
  - → The smaller parts are more manageable and easier to understand
  - → AKA "divide & conquer"
- Hierarchical Input/Output "HIPO" Chart
  - → A diagram of the top down design
  - → Provides a hierarchical perspective of the systems input, output, and processing modules
- Module
  - → One small part of the solution

Vocabulary (2)

- Flowchart
  - → A diagram of an algorithm using specific symbols that represent programming constructs
- Pseudocode
  - → A terse, English-like description of an algorithm
  - → Used to understand the basic program flow without worrying about the correct syntax
- Desk Check
  - → Walking through the algorithm manually – step by step
  - → Draw each memory location and check the algorithm as though you were the computer
- Documentation
  - → Anything that provides information about a program
  - → Comments in the code, data tables that describe the data used in the code & external documents (flow charts, user's manual, the design, &etc)