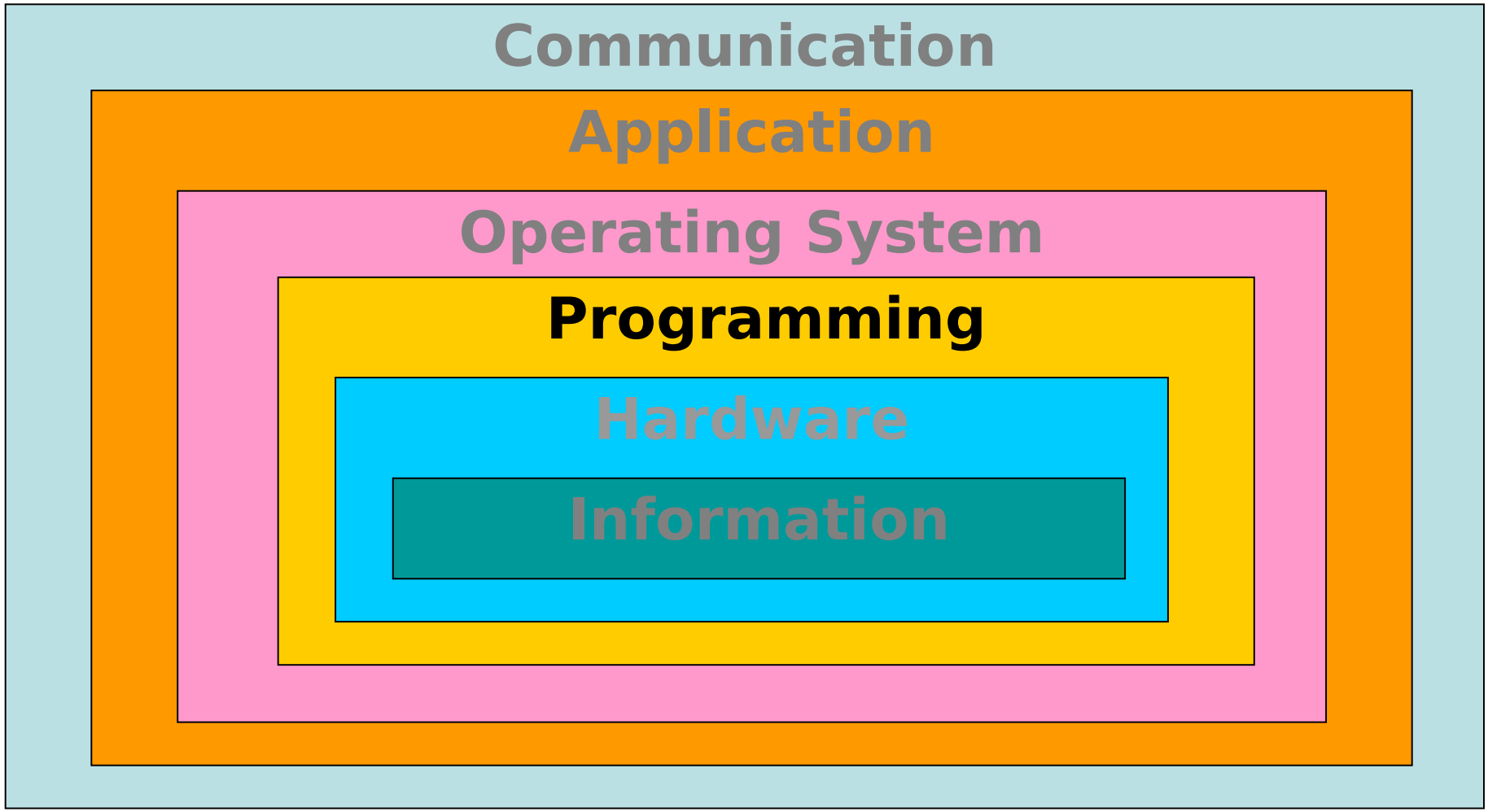
Chapter 6

Problem Solving and Algorithm Design

Layers of a Computing System



Chapter Goals

- Determine whether a problem is suitable for a computer solution
- Describe the computer problem-solving process and relate it to Polya's How to Solve It list
- Distinguish between following an algorithm and developing one
- Apply top-down design methodology to develop an algorithm to solve a problem

Chapter Goals

- Define the key terms in object-oriented design
- Apply object-oriented design methodology to develop a collection of interacting objects to solve a problem
- Discuss the following threads as they relate to problem solving: information hiding, abstraction, naming things, and testing

Problem Solving

- **Problem solving** The act of finding a solution to a perplexing, distressing, vexing, or unsettled question

Ask Questions...

- ...to understand the problem
  - *What do I know about the problem?*
  - *What is the information that I have to process in order the find the solution?*
  - *What does the solution look like?*
  - *What sort of special cases exist?*
  - *How will I recognize that I have found the solution?*

Look for Familiar Things

- You should never reinvent the wheel
- In computing, you see certain problems again and again in different guises
- A good programmer sees a task, or perhaps part of a task (a subtask), that has been solved before and plugs in the solution

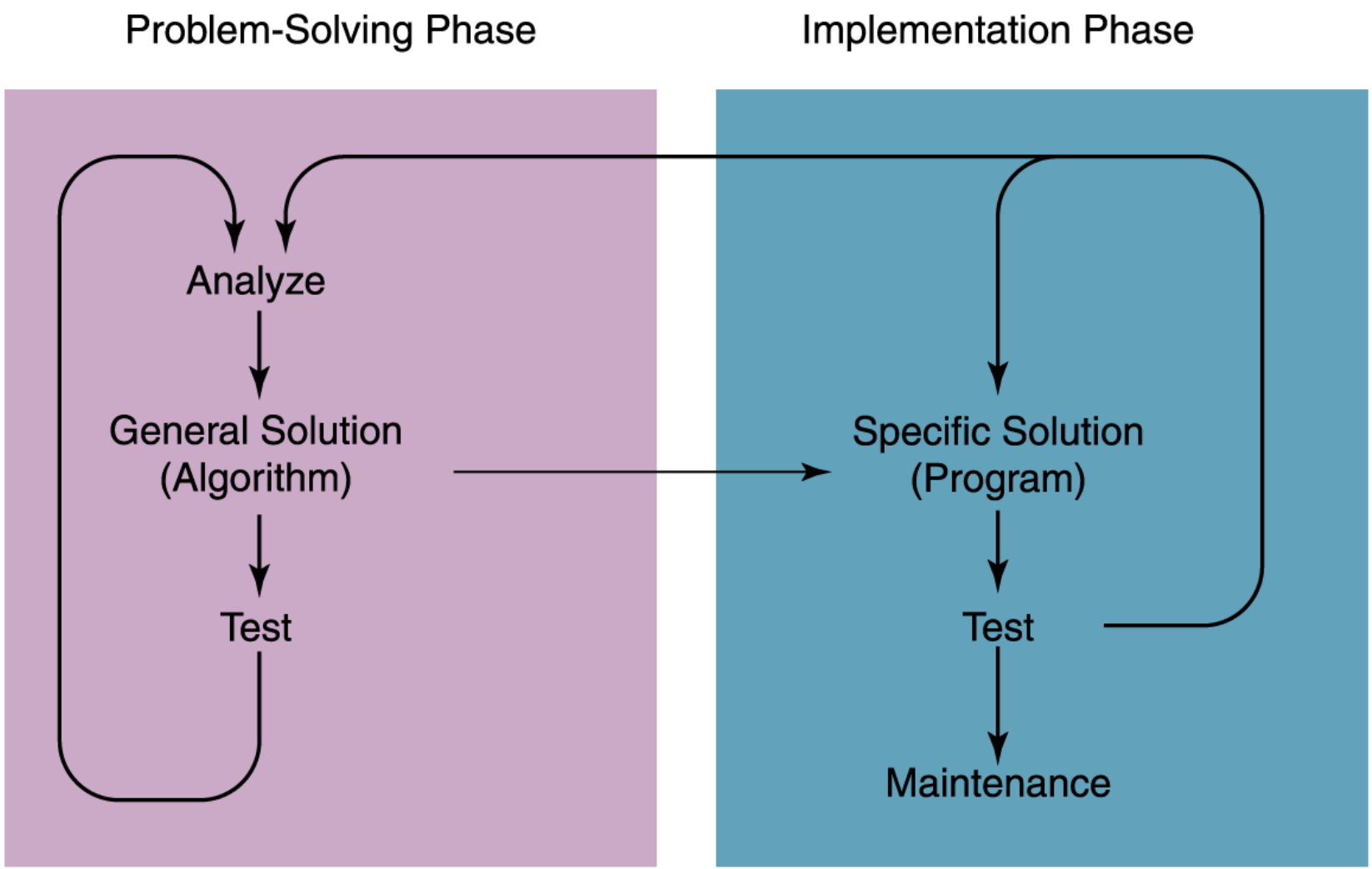
Divide and Conquer

- Break up a large problem into smaller units that we can handle
  - Applies the concept of abstraction
  - The divide-and-conquer approach can be applied over and over again until each subtask is manageable

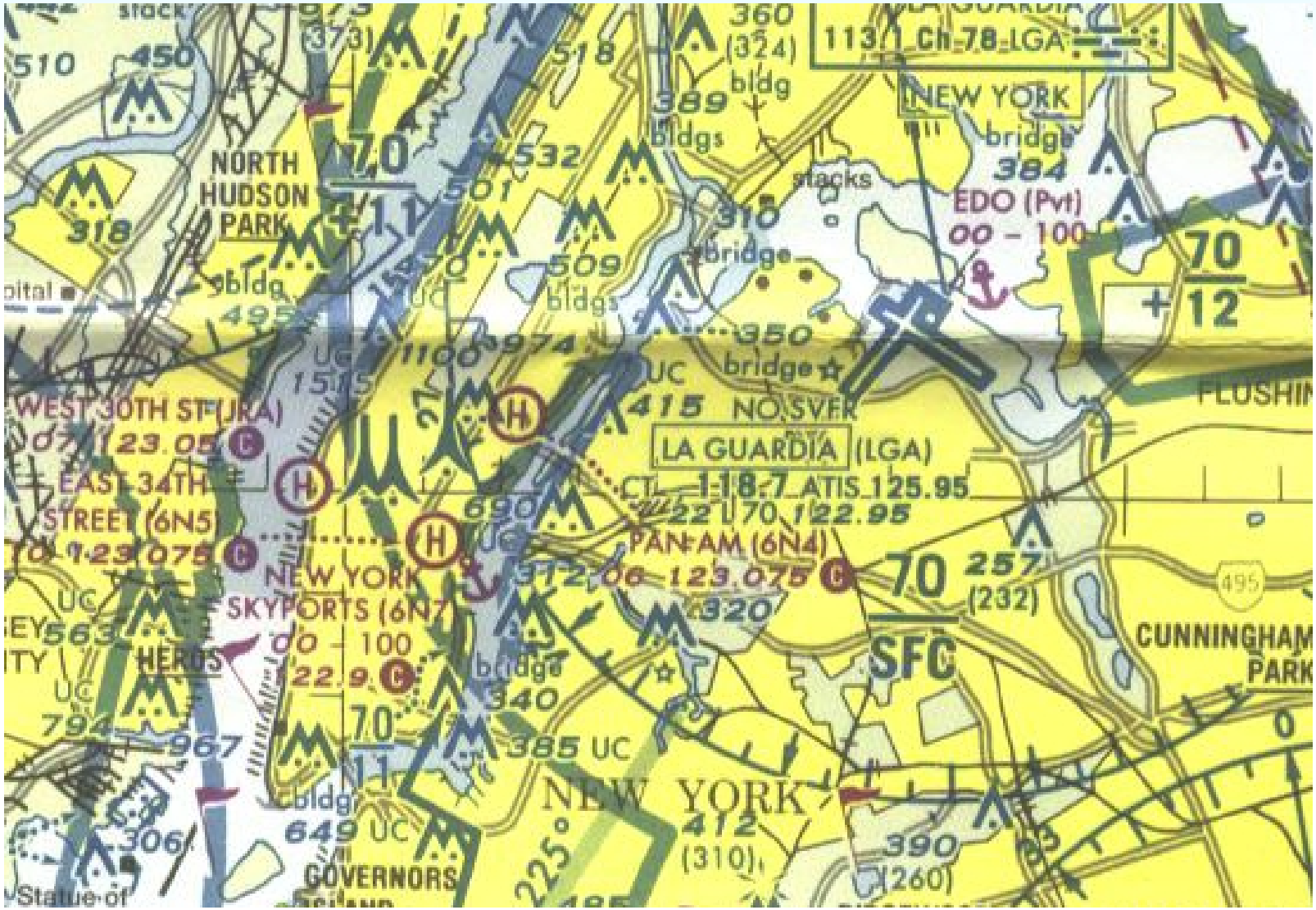
Algorithms

- **Algorithm** A set of instructions for solving a problem or subproblem in a finite amount of time using a finite amount of data
- The instructions must be unambiguous

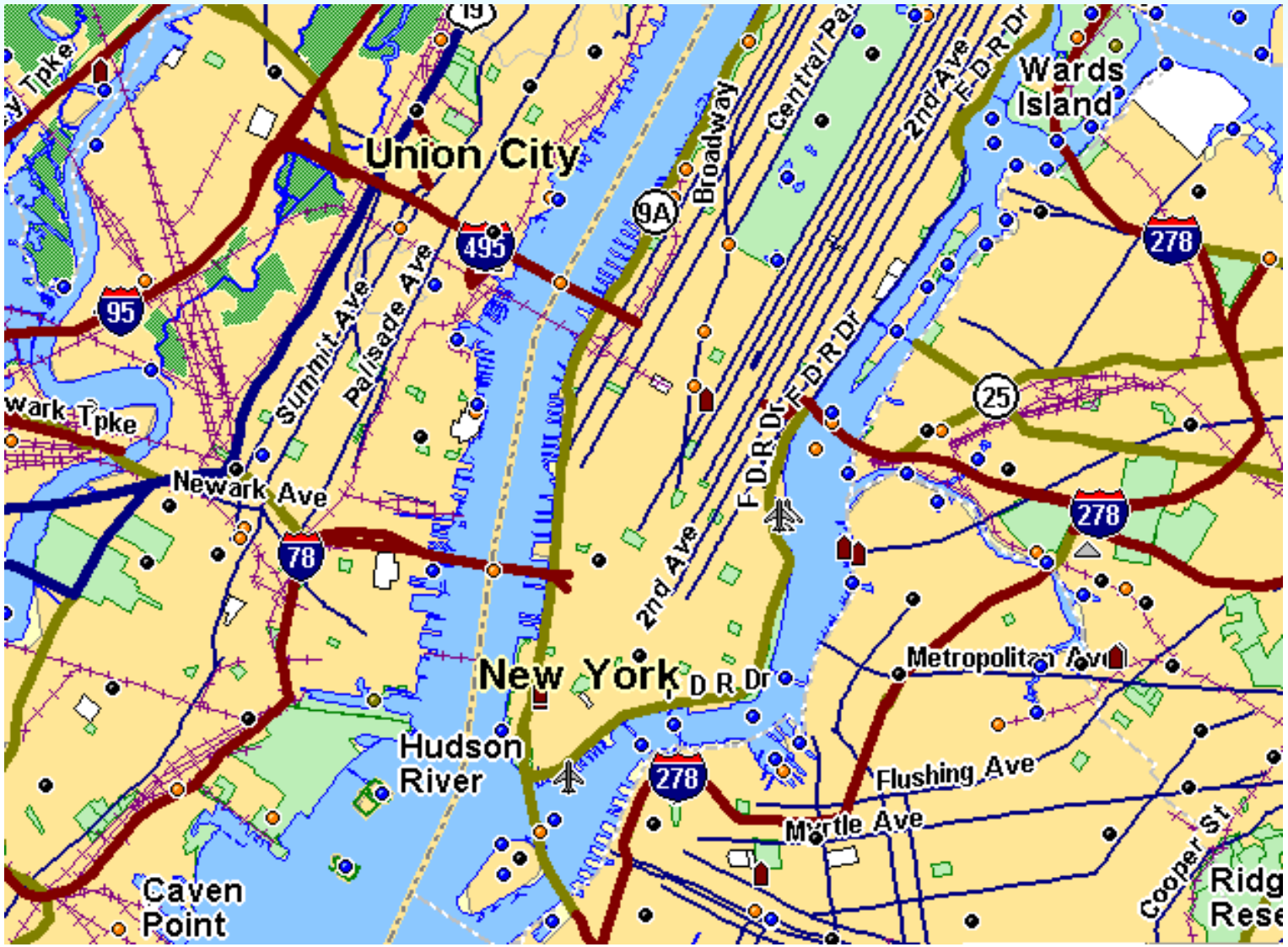
The Interactions Between Problem-Solving Phases



Problem Solving



Problem Solving

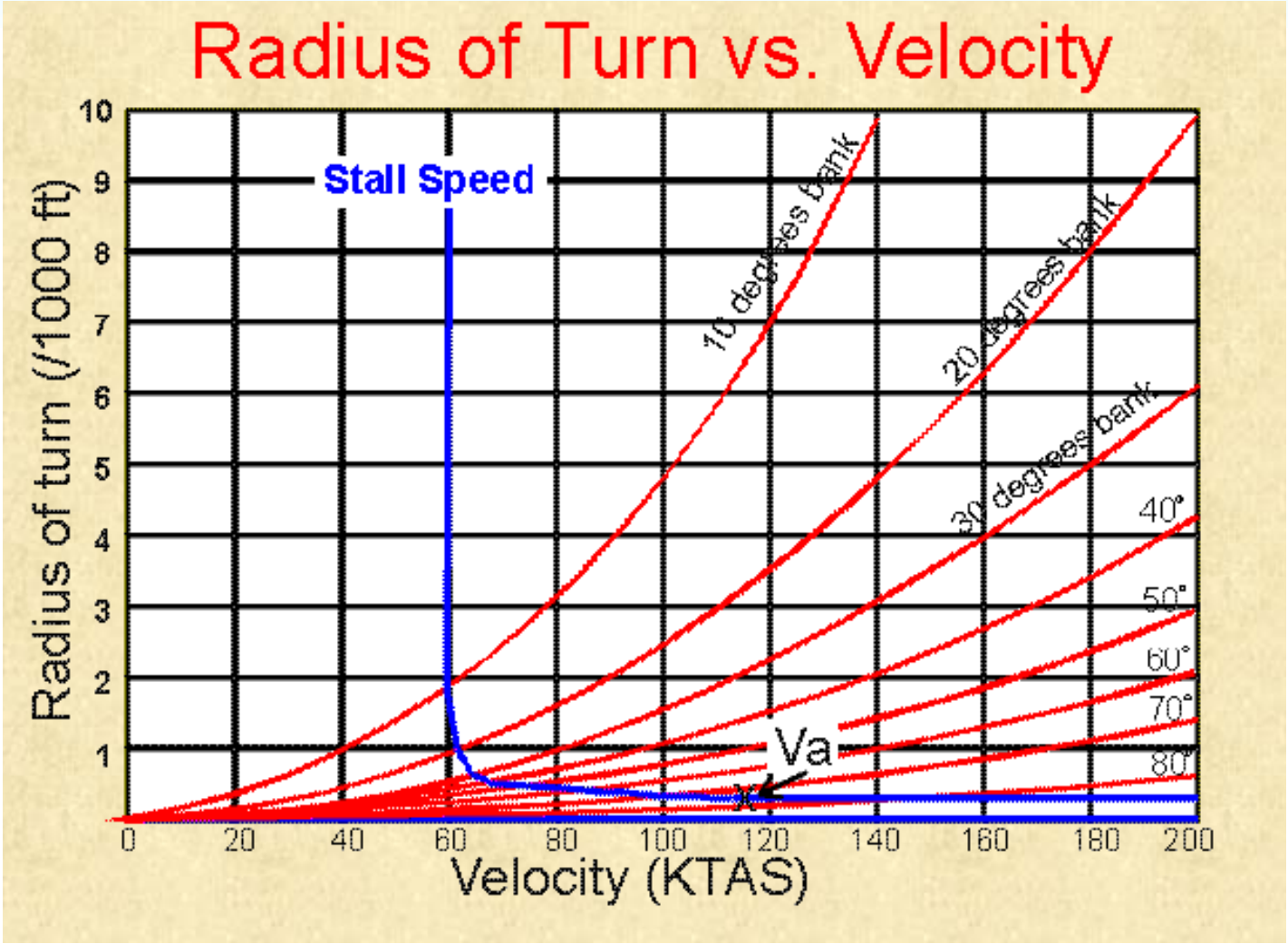


Problem Solving

$$r = \frac{V^2}{g \tan(b)}$$

- How wide is your turn?
- Slow down to the lowest possible speed
- What about bank?

Problem Solving



Top-Down Design

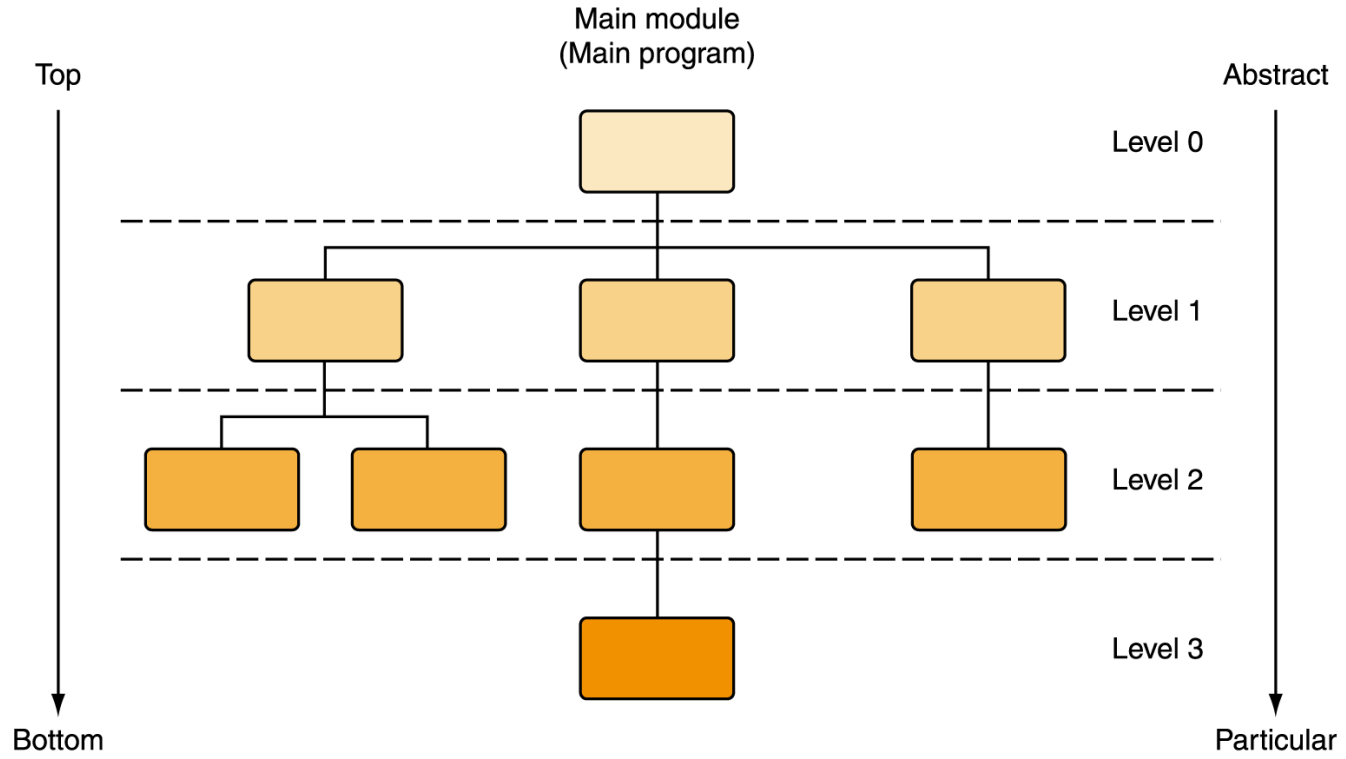
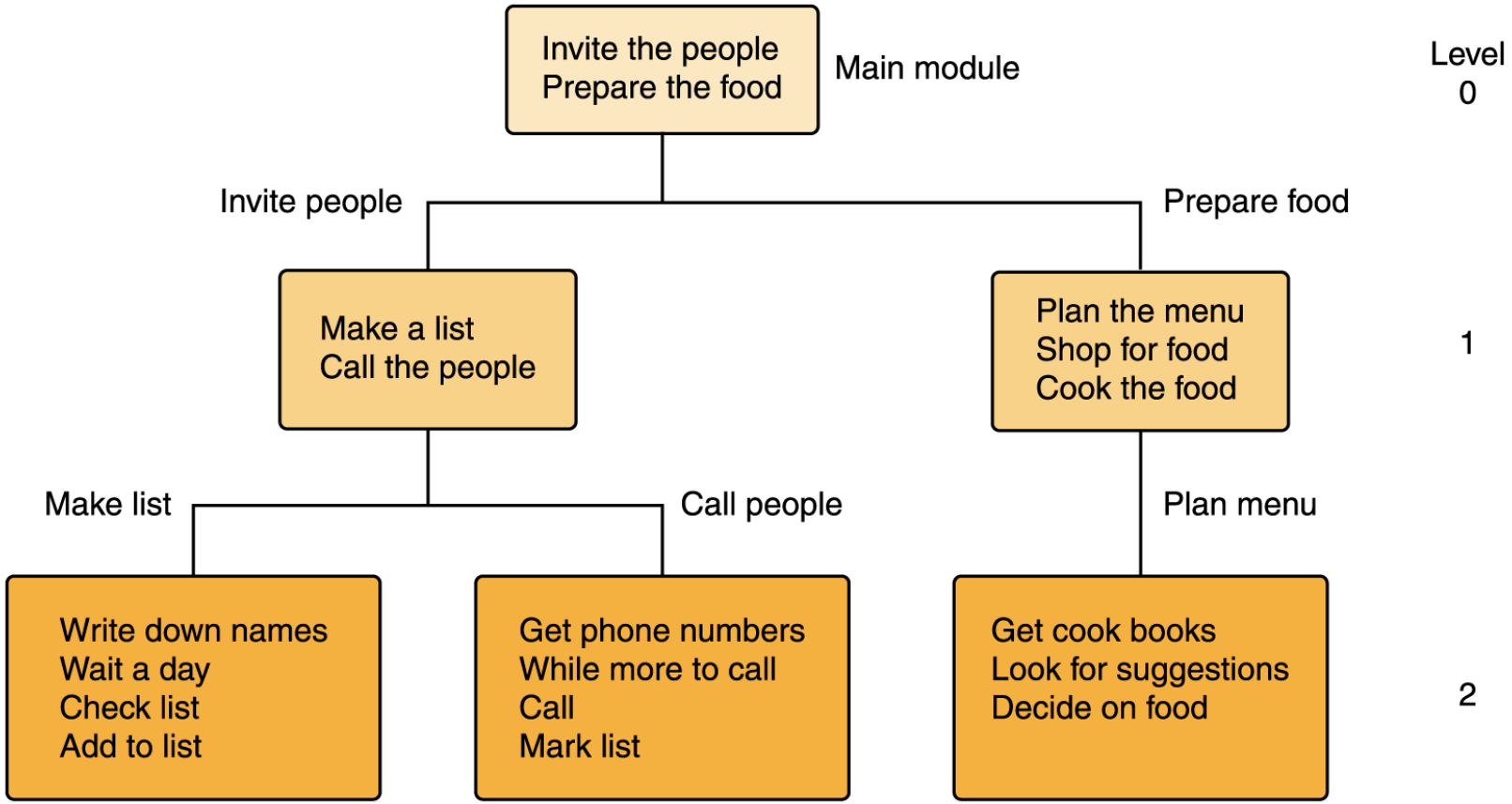


Figure 6.5
An example of top-down design

- This process continues for as many levels as it takes to expand every task to the smallest details
- A step that needs to be expanded is an abstract step

A General Example

- Planning a large party



Object-Oriented Design

- A problem-solving methodology that produces a solution to a problem in terms of self-contained entities called *objects*
- **Object** A thing or entity that makes sense within the context of the problem

  For example, a student

Object-Oriented Design

- A group of similar objects is described by an **object class**, or **class**
- A class contains fields that represent the properties and behaviors of the class
  - A **field** can contain data value(s) and/or methods (subprograms)
  - A **method** is a named algorithm that manipulates the data values in the object

Relationships Between Classes

- Containment
  - “part-of”
  - An address class may be part of the definition of a student class
- Inheritance
  - Classes can inherit data and behavior from other classes
  - “is-a”

Object-Oriented Design Methodology

- Four stages to the decomposition process
  - **Brainstorming**
  - **Filtering**
  - **Scenarios**
  - **Responsibility algorithms**

CRC Cards

Class Name:	Superclass:	Subclasses:
Responsibilities	Collaborations	

Page 165

Brainstorming

- A group problem-solving technique that involves the spontaneous contribution of ideas from all members of the group
  - All ideas are potential good ideas
  - Think fast and furiously first, and ponder later
  - A little humor can be a powerful force
- Brainstorming is designed to produce a list of candidate classes

Filtering

- Determine which are the core classes in the problem solution
- There may be two classes in the list that have many common attributes and behaviors
- There may be classes that really don't belong in the problem solution

Scenarios

- Assign responsibilities to each class
- There are two types of responsibilities
  - What a class must know about itself (knowledge responsibilities)
  - What a class must be able to do (behavior responsibilities)

Scenarios

- Each class **encapsulates** its data but shares their values through knowledge responsibilities.
- **Encapsulation** is the bundling of data and actions in such a way that the logical properties of the data and actions are *separated from the implementation details*

Responsibility Algorithms

- The algorithms must be written for the responsibilities
  - Knowledge responsibilities usually just return the contents of one of an object's variables
  - Action responsibilities are a little more complicated, often involving calculations

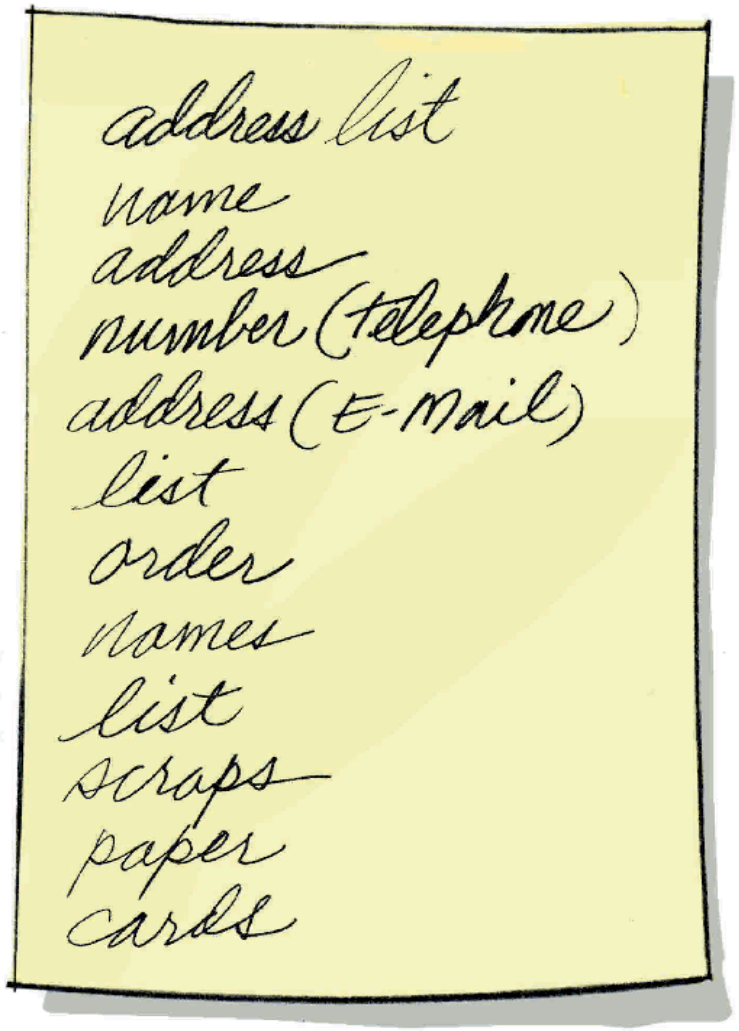
Computer Example

- Let's repeat the problem-solving process for creating an address list
- Brainstorming and filtering
  - Circling the nouns and underlining the verbs

Create an address list that includes each person's name, address, telephone number, and e-mail address. This list should then be printed in alphabetical order. The names to be included in the list are on scraps of paper and business cards.

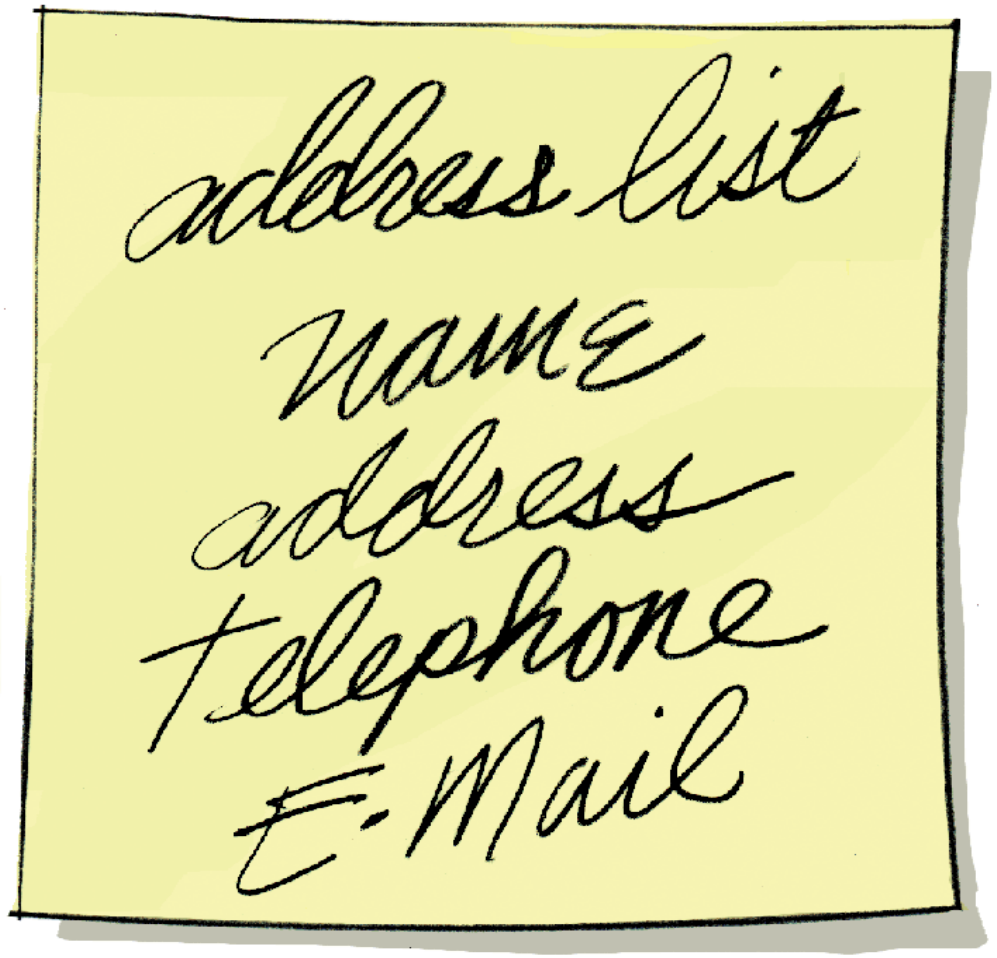
Computer Example

- First pass at a list of classes



Computer Example

- Filtered list



CRC Cards

Class Name: Person	Superclass:	Subclasses:
Responsibilities	**Collaborations**	
Initialize itself (name, address, telephone, e-mail)	Name, Address, Telephone, E-mail	
Print	Name, Address, Telephone, E-mail	

Class Name: Name	Superclass:	Subclasses:
Responsibilities	**Collaborations**	
Initialize itself (name)	String	
Print itself	String	

Responsibility Algorithms

Initialize

name.Initialize()

address.Initialize()

telephone.Initialize()

email.Initialize()

Print

name.Print()

address.Print()

telephone.Print()

email.Print()

Information Hiding/Abstraction

- **Information Hiding** and **Abstraction** are two sides of the same coin.
  - **Information Hiding** The practice of hiding the details of a module with the goal of controlling access to the details of the module.
  - **Abstraction** A model of a complex system that includes only the details essential to the viewer.

Information Hiding/Abstraction

- Abstraction is the result with the details hidden
  - **Data abstraction** Separation of the logical view of data from their implementation.
  - **Procedural abstraction** Separation of the logical view of actions from their implementation.
  - **Control abstraction** Separation of the logical view of a control structure from its implementation.

Programming Languages

- Instructions written in a **programming language** can be *translated* into the instructions that a computer can execute directly
- **Program** A meaningful sequence of instructions for a computer
  - **Syntax** The part that says how the instructions of the language can be put together
  - **Semantics** The part that says what the instructions mean

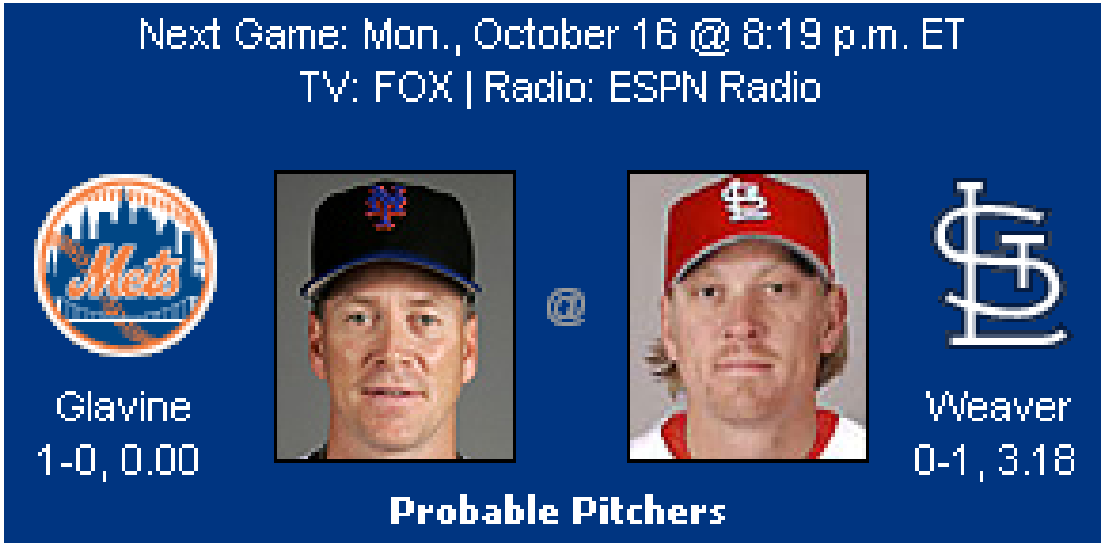
Homework

- **Read Chapter Six, Sections 6.3 & 6.4**

Mid-Term

- **Take Home** Exam – Non-Trivial (think!)
- Cover Chapters 1-5 & 16 & Anything Covered In Class
- Given Out: Oct 16
- Due Back: Oct 23
- No Lateness!!!

Good Night



...Unbiased Opinion!