

CMSC 132: Object-Oriented Programming II



Problem Specification & Design

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Overview

- **Problem specification**
 - **Obstacles**
- **Program design**
 - **How to divide work**
 - **Interface & conditions**

Problem Specification

■ Goal

- Create complete, accurate, and unambiguous statement of problem to be solved

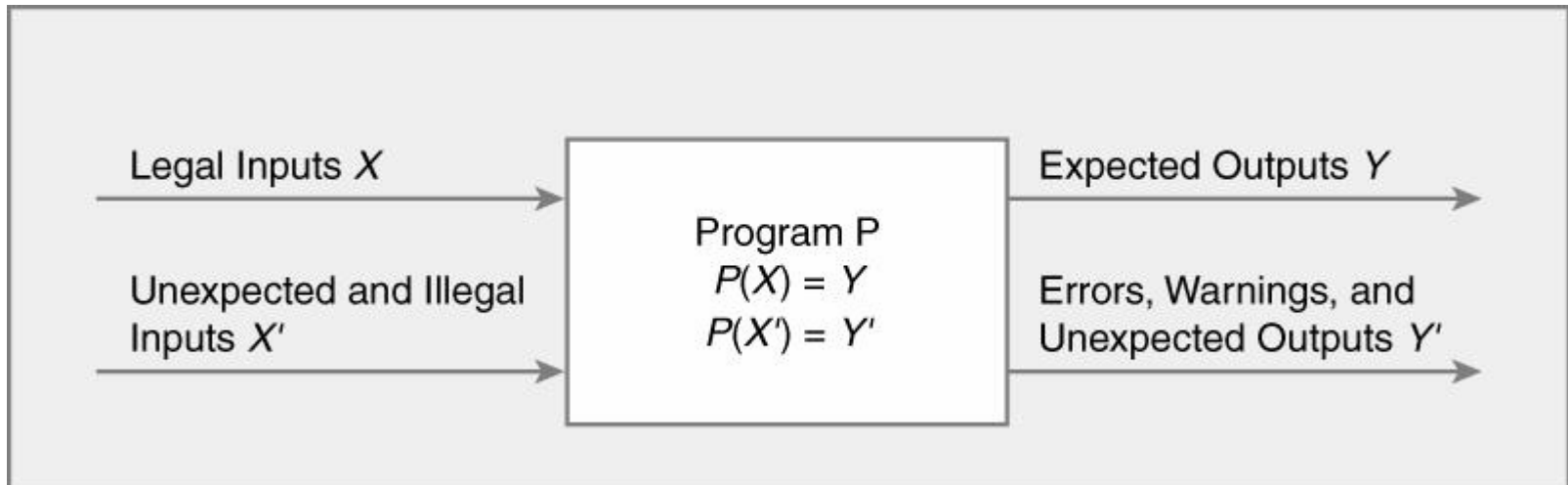
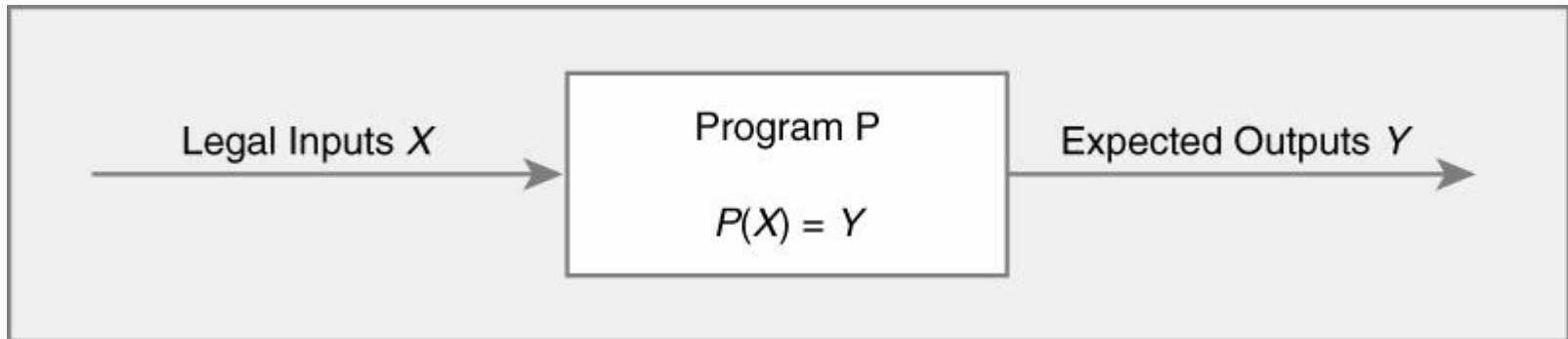
■ Problems

- Description may not be accurate
- Description may change over time
- Difficult to specify behavior for all inputs
- Natural language description is imprecise
- Formal specification languages limited and difficult to understand

Problem Specification

■ Example

■ Specification of input & output for program



Problem Specification Problems

- **Description may not be accurate**
 - **Problem not understood by customer**
- **Description may change over time**
 - **Customer changes their mind**
- **Difficult to specify behavior for all inputs**
 - **Usually only covers common cases**
 - **Hard to consider all inputs (may be impossible)**
 - **Example**
 - **Most UNIX utilities crash with random inputs**

Problem Specification Problems

■ Description may be ambiguous

■ Natural language description is imprecise

■ Why lawyers use legalese for contracts

■ Formal specification languages are limited and may be difficult to understand

■ Examples

■ Find sum of all values in N-element list L between 1 and 100

$$\sum_{i=0}^{N-1} L_i \ni (L_i \geq 1) \wedge (L_i \leq 100)$$

■ Difficult to write specifications that are both **readable** and **precise**

Program Design

■ Goal

- Break software into integrated set of **components** that work together to solve problem specification

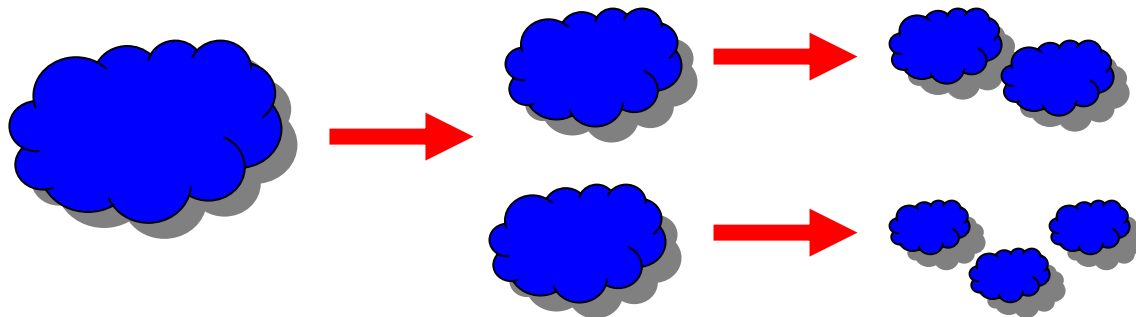
■ Problems

- Methods for decomposing problem
 - How to divide work
 - What work to divide
- How components work together

Design – How To Divide Work

■ Decomposing problem

- Break large problem into many smaller problems
 - Cannot solve large problems directly
- Divide and conquer
 1. Break problem up into simpler sub-problems
 2. Repeat for each sub-problem
 3. Stop when sub-problem can be solved easily



Design – How To Divide Work

■ Functional approach

- Treat problem as a collection of **functions**

■ Techniques

■ Top-down design

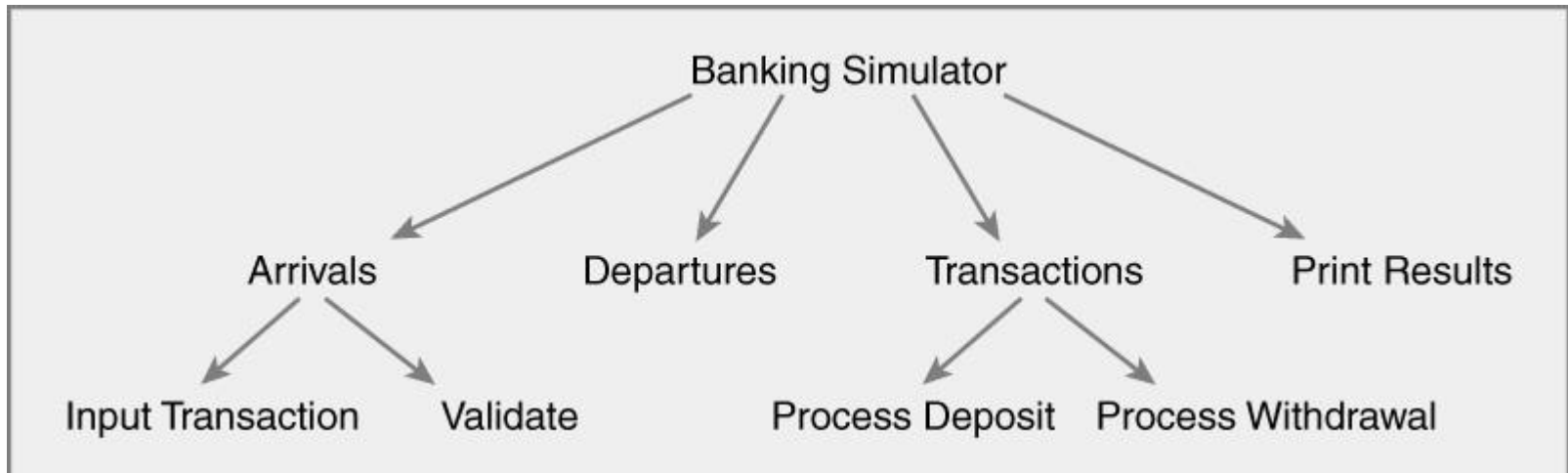
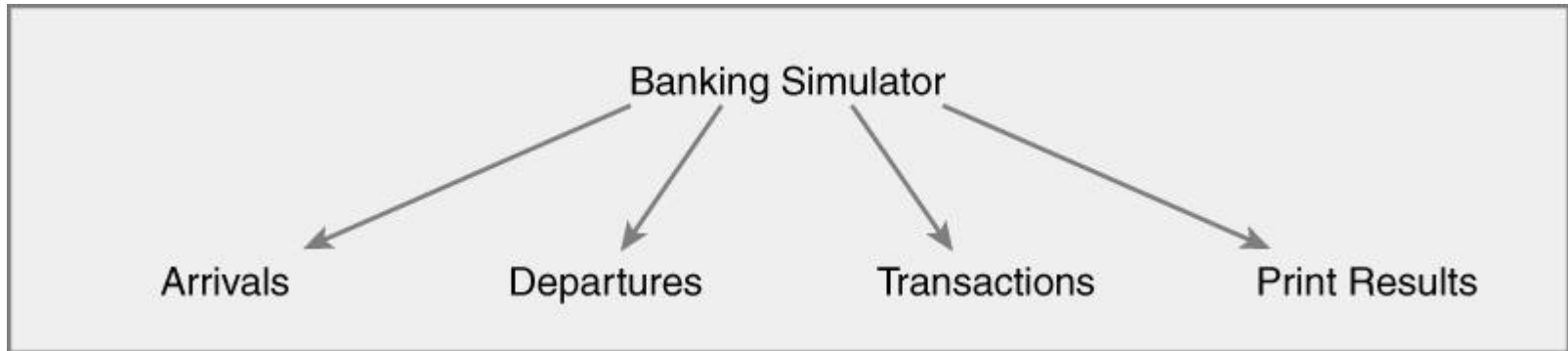
- Successively split problem into smaller problems

■ Bottom-up design

- Start from small tasks and combine

Design – Decomposition Example

■ Top-down design of banking simulator



Design – How To Divide Work

- **Object-oriented approach**
 - **Treat problem as a collection of data objects**
 - **Objects**
 - **Entities that exist in problem**
 - **Contain data**
 - **Perform actions associated with data**

Design – Comparison Example

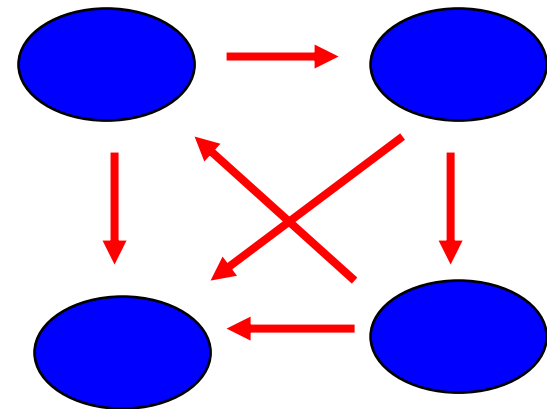
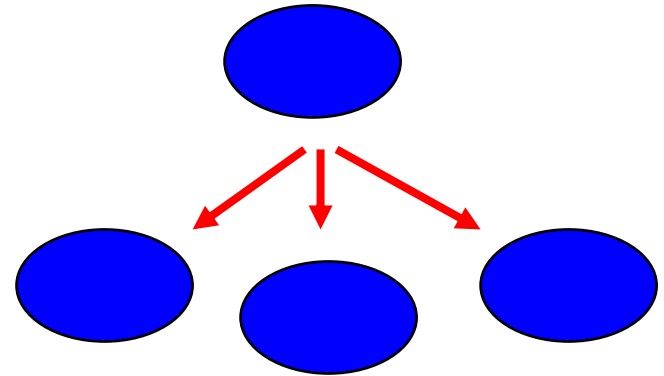
■ Bank simulation

■ Functional programming

- Arrivals, departures, transactions

■ Object-oriented programming

- Customers, lines, tellers, transactions



Design – Comparing Approaches

■ Functional approach

- Treat problem as a collection of **functions**
- Functions perform actions
- Think of functions as **verbs**

■ Object-oriented approach

- Treat problem as a collection of data **objects**
- Objects are entities that exist in problem
- Think of objects as **nouns**

Design – Comparing Approaches

- **Advantages to object-oriented approach**
 - Helps to **abstract** problem
 - Simpler high-level view
 - Helps to **encapsulate** data
 - Hides details of internals of objects
 - Centralizes and protects all accesses to data
 - Seems to scale better for larger projects
- **In practice**
 - Tend to use a combination of all approaches

Design – Components

- **Components must work together easily**
- **Each component requires**
 - **Interface**
 - Specifies **how** component is accessed & used
 - Specifies **what** functions (methods) are available
 - **Pre-conditions**
 - What conditions must be true **before** invocation
 - **Post-conditions**
 - What conditions will be true **after** invocation
- **Pre & post conditions represent a **contract** between designer & programmer**

Design – Interface & Conditions

■ Function `positivePower()`

- Calculate x^n for positive values of x & n

■ Interface

- `public static float positivePower(float x , int n)`

■ Pre-conditions

- x has positive floating point value > 0.0
- n has positive integer value ≥ 0

■ Post-conditions

- Returns x^n if preconditions are met
- Returns -1.0 otherwise