

Object-Oriented Design & Programming



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Overview

- **Object-oriented design**
 - **Goals**
 - **Techniques**
 - **Object-oriented view**
 - **Examples**

Goals

- **Improve software design**
 - Reduce implementation effort
 - Scalable to large software projects
- **Try to take advantage of two techniques**
 - Abstraction
 - Encapsulation

Techniques – Abstraction

- **Abstraction**
 - Provide simple high-level model of
 - Physical entity
 - Activity
- **Helpful for managing complexity**
- **Enables information hiding**
 - Can change implementation & representation
 - Will not affect other software components

Types of Abstraction

- **Procedural abstraction**
 - Specify what actions should be performed
 - Hide algorithms
- **Data abstraction**
 - Specify data objects for problem
 - Hide representation

Abstraction Example

■ Abstraction of a **Student Roster**

- **Data**
 - List of student names
- **Actions**
 - Create roster
 - Add student
 - Remove student
 - Print roster

STUDENT ROSTER
List of names
Create() AddStudent() RemoveStudent() Print()

Techniques – Encapsulation

- **Encapsulation**
 - Confine information so it is only visible / accessible through an associated external interface
- **Approach**
 - For some entity **X** in program
 - Abstract data in **X**
 - Abstract actions on data in **X**
 - Collect data & actions on **X** in same location
 - Protects and hides **X**

Encapsulation

- **Extension of abstraction**
 - Always abstract data & function together
 - Encapsulated entity ⇒ Abstract Data Type (ADT)
- **Examples**
 - List ADT
 - May be implemented as array, linked list, etc...
 - Java collections library

Benefits of Encapsulation

- **Easier to make code modifications**
 - Due to information hiding
- **Promotes code reuse**
 - Interface to data structure clearly defined
 - Easier to reuse code
- **Code reuse increases productivity**

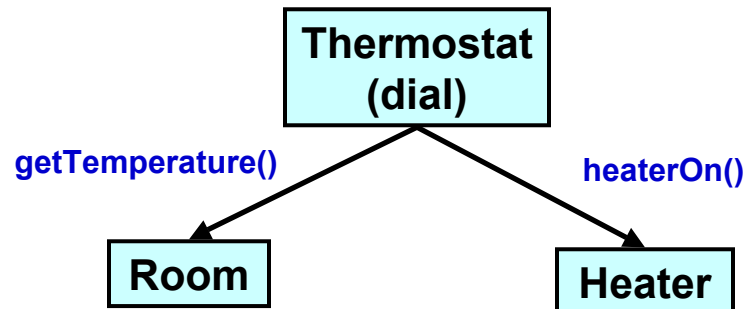
Object-Oriented Design

- **View software as**
 - A collection of entities (objects)
 - Functions associated with each object
 - Communication between objects
- **Exploits abstraction & encapsulation**
- **Can rely on programming language support**

Object-Oriented View

■ Example problem description

- Thermostat uses dial setting to control a heater to maintain constant temperature in room



History of Object-Oriented Design

■ Preceded by **procedure-oriented** view

- Earliest approach to programming
- Uses procedure abstraction
- Similar to actual machine instructions
- Focus on control flow, program scope
- Examples: Fortran, Cobol, Pascal, Basic

■ Example

- Thermostat()
 1. Get room temperature
 2. If (temperature < setting) turn heater on
 3. Else turn heater off
 4. Goto step 1

OO Programming Languages

- **Development history**
 - **Simula (Dahl & Nygaard, 1962)**
 - Modeling discrete event simulation
 - **Smalltalk (Kay, 1972)**
 - General programming
 - **C++ (Stroustrup, 1979)**
 - Manage complexity in huge software projects
 - **Java (Gosling, 1991)**
 - Designed for embedded processors

Factors in Success of OO Design

- **Growing demand**
 - More experience with large software projects
- **Improvements in language design**
 - Made OO programming easier
- **Improvements compiler technology**
 - Support more language features efficiently
- **Improvements in hardware**
 - Handled inefficiencies in OO programming
 - Made performance less critical

Elements of Object-Oriented Design

- **Objects**
 - Entities in program
- **Methods**
 - Functions associated with objects
- **Classes**
 - Groups of objects with similar properties
- **Inheritance**
 - Relationship between classes

Objects

- **Definition**
 - Entity that has state, behavior, and identity
 - State (data)
 - Properties possessed by object
 - Current values of those properties
 - Behavior (methods)
 - How objects react to changes in state
 - How objects interact with each other
 - Identity (references)
 - Mechanism to distinguish between objects

Object Example

■ Thermostat

■ State

- DesiredTemp
- CurrentTemp
- HeaterState

■ Behavior

- SetDesiredTemp()
- TurnHeaterOn()
- TurnHeaterOff()

■ Identity

- this

Object Example

■ Thermostat

■ State

	Property	Value
■ DesiredTemp	integer	78°
■ CurrentTemp	integer	72°
■ HeaterState	boolean	ON

Object State

- **Properties**
 - Static, unchanging
 - May view as types
- **Values**
 - Dynamic, changes
 - Within bounds set by properties

Methods

- **Definition**
 - Procedures associated with object
- Specify **behavior** of objects
- **Invocation** ⇒ sending message to object
- **Example**
 - `myThermostat.setDesiredTemp(78)`
 - `myThermostat.turnHeaterOn()`
 - `myThermostat.turnHeaterOff()`

Method Types

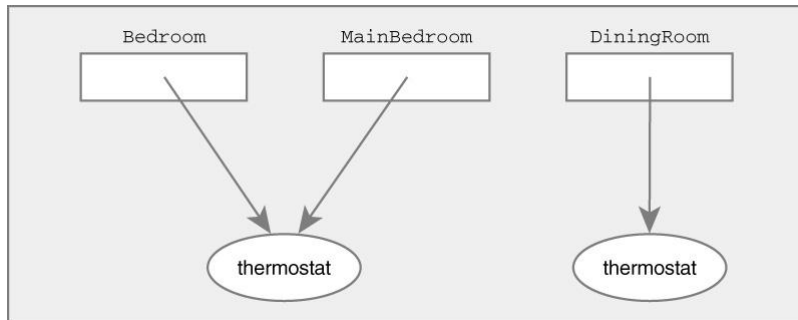
- **Accessor**
 - Return state information
- **Mutator**
 - Modify state information
- **Constructor**
 - Create & initialize new object
- **Destructor**
 - Remove object & free up resources

Identity

- How to distinguish between objects
- **Reference variables**
 - Used in object-oriented programming languages
 - Points to objects
 - Multiple variables may point to same object

Reference Variables

■ Example



Identity

■ Equivalence

- Whether two objects are equal

■ Name equivalence

- Reference variables point to same object

■ Content equivalence

- Objects from same class
- State in each object are identical

Equivalence

■ Example

Name Equivalent

Content Equivalent

