CS 351
Design of Large Programs
From Design To Code

Brooke Chenoweth

University of New Mexico

Spring 2025

Class Construct

Class is the fundamental programming concept in Java

- fields
- methods
- modifiers
  - `public` vs `private` vs `protected`
  - `static`
  - `final`
  - `abstract`

- Programs are structured in terms of classes
- Objects are instances of classes
- Execution entails the creation and manipulation of objects

Class Definition

A class can be defined in several ways:

- by defining the fields and methods it provides
- by implementing an existing interface
- by extending an existing class

If class C *extends* class S

- C is called a subclass, derived class, or child class
- S is called a superclass, base class, or parent class
- C inherits all the fields and methods associated with S
- C can add fields and methods
- C can override methods (and hide fields) but they can still be accessed by referring to super

Inheritance Illustrated

```
Manager jane = new Manager();
jane.setSalary(120000.0);
jane.setBonus(50000.0);
System.out.println(jane.getSalary());
```

What is the intended control flow?

Inheritance Illustrated

```
public class Employee {
  private double salary;
  public void setSalary(double salary) {
    this.salary = salary;
  }
  public double getSalary() {
    return salary;
  }
}
```

```
public class Manager extends Employee {
  private double bonus = 0;
  public void setBonus(double amount) {
    bonus = amount;
  }
  public double getSalary() {
    return salary + bonus;
  }
}
```

What is the error?

Inheritance Illustrated

```
public class Employee {
  private double salary;
  public void setSalary(double salary) {
    this.salary = salary;
  }
  public double getSalary() {
    return salary;
  }
}
```

```
public class Manager extends Employee {
  private double bonus = 0;
  public void setBonus(double amount) {
    bonus = amount;
  }
  public double getSalary() {
    return salary + bonus; salary field not visible
  }
}
```

What is the error?

Inheritance Illustrated

```
public class Employee {
  private double salary;
  public void setSalary(double salary) {
    this.salary = salary;
  }
  public double getSalary() {
    return salary;
  }
}
```

```
public class Manager extends Employee {
  private double bonus = 0;
  public void setBonus(double amount) {
    bonus = amount;
  }
  public double getSalary() {
    return getSalary() + bonus;
  }
}
```

What is the error?

Inheritance Illustrated

```
public class Employee {
  private double salary;
  public void setSalary(double salary) {
    this.salary = salary;
  }
  public double getSalary() {
    return salary;
  }
}
```

```
public class Manager extends Employee {
  private double bonus = 0;
  public void setBonus(double amount) {
    bonus = amount;
  }
  public double getSalary() {
    return getSalary() + bonus; Infinite recursion
  }
}
```

What is the error?

Inheritance Illustrated

```
public class Employee {
  private double salary;
  public void setSalary(double salary) {
    this.salary = salary;
  }
  public double getSalary() {
    return salary;
  }
}
```

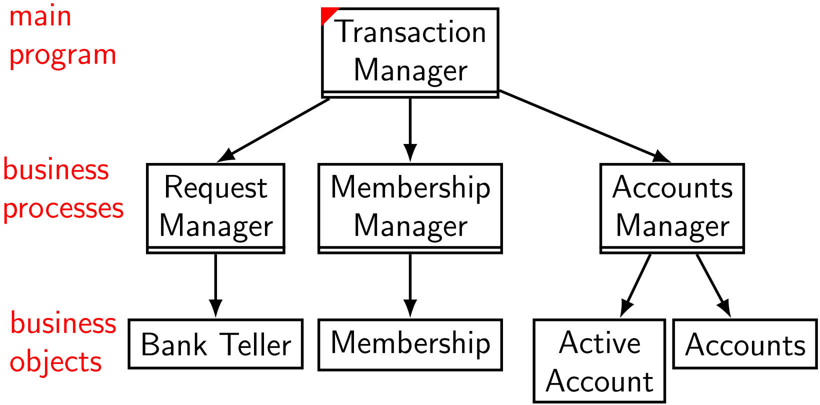
```
public class Manager extends Employee {
  private double bonus = 0;
  public void setBonus(double amount) {
    bonus = amount;
  }
  public double getSalary() {
    return super.getSalary() + bonus;
  }
}
```

Case Study: Credit Union

Consider a system that supports the basic operations of a Credit Union:

- manage membership in the credit union by adding and removing individual members
- manage accounts
  - account creation and closing
  - deposit and withdrawal of funds
  - fund transfers among accounts belonging to the same member
- accept and process transaction requests originating with the bank teller

Representative Design Solution



Coding Tasks

1. Define application-specific data types
   - tailored to the application
   - used consistently across the system
   - simplifying the programming task
2. Code procedures and limit access by controlling scope
3. Build classes required to manage the object portfolio

User-Defined Types

Basic application concepts are abstracted as user-defined data types

- ensure continuity with the requirements level
- simplify programming

Such types can vary in complexity

- class with multiple public fields
- class with multiple private fields and extractor methods
- class with private fields and public methods

User-Defined Types: AccountId & TransactionType

AccountId – member account identification

- last name (capitalized, single name)
- account number (9 digits)

```
public class AccountId {
  private String lastName;
  private double accountNumber;
}
```

TransactionType – transaction request type

- create, delete, deposit, withdraw, transfer

```
public enum TransactionType {
  CREATE, DELETE, DEPOSIT,
  WITHDRAW, TRANSFER
}
```

Main Program

For now: The main program defines the starting point for the entire application

- may or may not be terminating
- controls the sequencing of operations
- may employ local variables for temporary use
- retains little or no information

```java
public class TransactionManager {
  public static void main(String[] args) {
    // ...
  }
}
```

Functional Decomposition

Traditionally, modularity was achieved by means of top-down functional decomposition

- main program embodies the entire functionality of the system
- procedures at levels below decompose it into subfunctions or modules
- clean design enforces a policy of
  - process encapsulation
  - balanced levels of abstraction

In object-oriented design, functional decomposition is present

- at the top layers of the design
- in the design of complex methods

Functional Decomposition: Transaction Manager

```java
import managers.RequestManager;
import managers.MembershipManager;
import managers.AccountsManager;

public class TransactionManager {

  public static void main(String[] args) {
    RequestManager requestManager =
      new RequestManager();
    MembershipManager membershipManager =
      new MembershipManager();
    AccountsManager accountsManager =
      new AccountsManager();

    // ...
  }
```

Object Instantiation

A simple way to code an object:

- define the right class
- provide access to the class definition
- instantiate one or more objects as needed

Define class Account inside AccountsManager

- private fields:
  - AccountId (last name, account number–type defined earlier) and balance
- public methods:
  - deposit(amount), debit(amount), balance()
  - accountType() – the last two digits of the account number
- Create one or more instances within the body of the Accounts Manager

Inheritance & Specialization

Objects that relate to each other may still need to be different

Inheritance allows classes to extend a base class

- the latter captures all the common features
- the former adds capabilities specific to an object subtype

Inheritance & Specialization: Account

Accounts can be of two types:

- Checking – they receive a fixed dividend each month
- Savings – they are credited a fixed interest based on the average balance of each month with the daily balance being determined at midnight each day

Inheritance & Specialization: Account

Design changes:

- the Transaction Manager needs access to the system date and time

Subclassing implications:

- Checking requires a new method `payDividend`
- Savings requires
  - a new private field `balanceHistory`
  - a new public method `updateHistory`
  - a new public method `postInterest`

Specialization: Checking & Savings

```java
public class Savings extends Account {
  private float[] balanceHistory;
  private int day;

  public void updateHistory() {
    // ...
  }
  public void postInterest() {
    // ...
  }
}
```

```java
public class Checking extends Account {
  public void payDividend(float amount) {
    // ...
  }
}
```

Abstract Methods: Account Revisited

The class account may require a method `backup`

- the actual implementation is account type and system specific

The solution is to define backup as an `abstract` method

- force Checking and Savings to provide the details
- allow the two subclasses to have different backup approaches, if needed

```
public abstract class Account {
  public abstract void backup();
  // ...
}
```

No overall design changes required

Implementing Interfaces

An interface is a class that provides no implementation for its methods

- no code to execute

A derived class can extend a single base class

- for implementation reasons

A class may implement multiple interfaces

- `MyClass implements Interface1, Interface2`

Implementing Interfaces: Another Perspective on Account

Some of the requirements on the definition of Account:

- may be related to being a bank account
- may be related to being an insured account

Different requirements can be captured by different interfaces

Implementing Interfaces: Another Perspective on Account

```java
public interface BankAccount {
  // ...
}
```

```java
public interface InsuredAccount {
  void debitFee();
  // ...
}
```

```java
public abstract class Account
    implements BankAccount, InsuredAccount {
  public abstract void backup();
  // ...
}
```

Aggregation & Object Composition

Complex objects are constructed through *object composition*

- the methods of the composite object are coded using methods of nested objects
- these subordinate objects are private
- these subordinate objects should be independent of each other
- the relation between the composite and subordinate objects is called *aggregation*
- this relation between the objects is created by proper composition of classes

Hiding: Minor

One form of specialization entails hiding methods of the superclass

- method is overridden to generate exception if invoked

```
public class MinorSavings extends Savings {
  @Override
  public void withdraw(float amount)
      throws TransactionException {
    throw new TransactionException("Minors are "
                       + "not permitted to withdraw "
                       + "from savings accounts.");
  }
}
```

Designing with Classes

The philosophy of this course:

- focus on design
- exploit language features to realize the design
- keep the design language-independent

Implementation does not require an object-oriented language

A design strategy that is class-centered (often used in practice)

- limits implementation options
- may fail
    - to provide adequate encapsulation
    - to convey clarity of the design