Data Structures

OOP and Class Hierarchies

CS284

Objectives

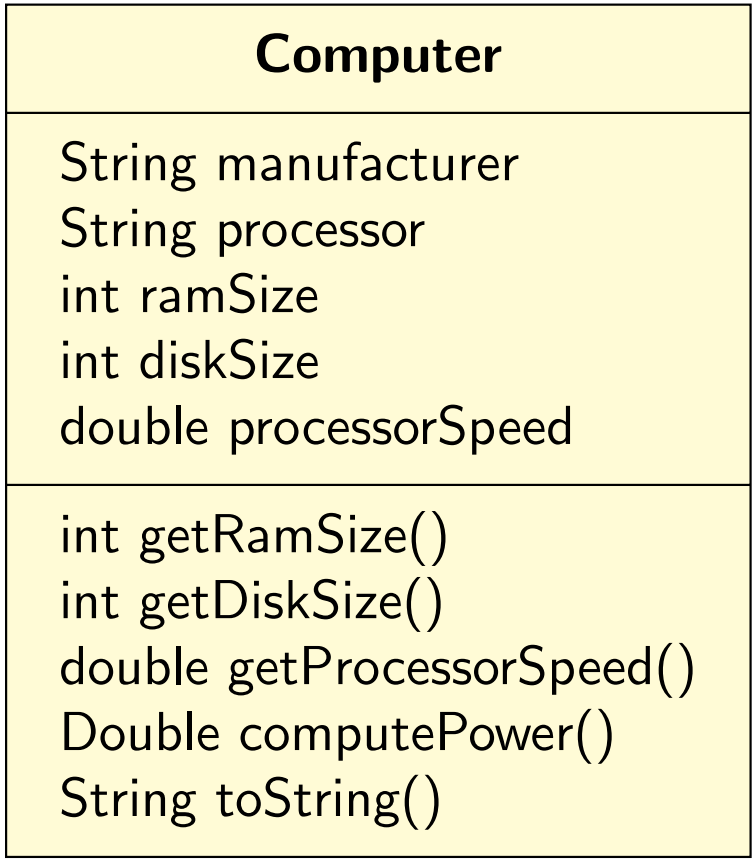
- Inheritance, class hierarchies and code reuse
- ADTs and Interfaces

Inheritance and Class Hierarchies

ADTs and Interfaces

Inheritance by Example

- A computer has
  - manufacturer
  - processor
  - RAM
  - disk



Inheritance by Example (cont.)

```
1  /** Class that represents a computers */
   public class Computer {
3    // Data fields
     private String manufacturer;
5    private String processor;
     private double ramSize;
7    private int diskSize;
     private double processorSpeed;
```

Inheritance by Example (cont.)

```
// Methods
 /** Initializes a Computer object with all properties specif
   @param man The computer manufacturer
   @param processor The processor type
   @param ram The RAM size
   @param disk The disk size
   @param procSpeed The processor speed
 */
 public Computer(String man, String processor, double ram, int
   manufacturer = man;
   this.processor = processor;
   ramSize = ram;
   diskSize = disk;
   processorSpeed = procSpeed;
 }
```

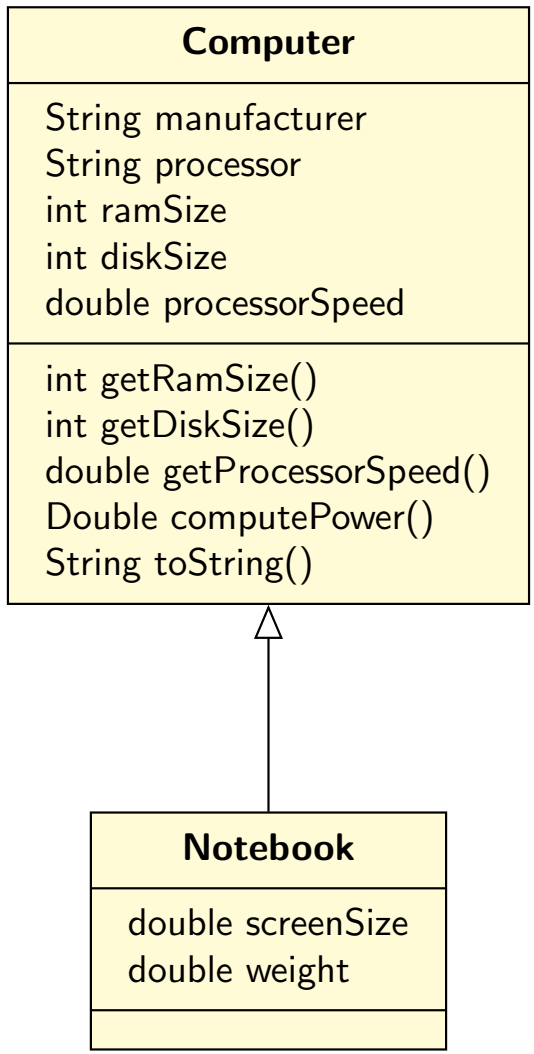
Inheritance by Example (cont.)

```
  public double computePower()
    { return ramSize * processorSpeed; }
  public double getRamSize() { return ramSize; }
  public double getProcessorSpeed()
    { return processorSpeed; }
  public int getDiskSize() { return diskSize; }
  // insert other accessor and modifier methods here

  public String toString() {
    String result = "Manufacturer: " + manufacturer +
        "\nCPU: " + processor +
        "\nRAM: " + ramSize + " megabytes" +
        "\nDisk: " + diskSize + " gigabytes" +
        "\nProcessor speed: " + processorSpeed +
            " gigahertz";
    return result;
  }
}
```

Inheritance by Example (cont.)

- A Notebook has all the properties of Computer,
  - manufacturer
  - processor
  - RAM
  - Disk
- plus,
  - screen size
  - weight



Inheritance by Example (cont.)

```
/** Class that represents a notebook computer */
public class Notebook extends Computer {
  // Data fields
  private double screenSize;
  private double weight;
     . . .
}
```

- The data fields declared in `Computer` are also available to `Notebook`: they are inherited
- The methods declared in `Computer` are also available to `Notebook`: they are inherited
  - But `Notebook` still needs its own constructor for initializing its notebook-specific data
  - Lets take a closer look at this

Constructors in a Subclass

- They begin by initializing the data fields inherited from the superclass(es)

```
super(man, proc, ram, disk, procSpeed);
```

  - This invokes the superclass constructor with the signature

```
Computer(String man, String processor, double ram, int
```

- They then initialize the data specific to their class, in this case to notebooks

```
        screenSize = screen;
2       weight = wei;
```

Constructors in a Subclass (cont.)

```
// methods
  //* Initializes a Notebook object with all properties specif
    @param man The computer manufacturer
    @param processor The processor type
    @param ram The RAM size
    @param disk The disk size
    @param procSpeed The processor speed
    @param screen The screen size
    @param wei The weight
   */
   public Notebook(String man, String processor, double ram, i
   {
      super(man, proc, ram, disk, procSpeed);
      screenSize = screen;
      weight = wei;
   }
```

The No-Parameter Constructor

- If the execution of any constructor in a subclass does not invoke a superclass constructor – an explicit call to super() – Java automatically invokes the no-parameter constructor for the superclass
- If no constructors are defined for a class, the no-parameter constructor for that class is provided by default
- However, if any constructors are defined, you must explicitly define a no-parameter constructor

Protected vs Private Data Fields

- Variables with private visibility cannot be accessed by a subclass
  - They are still there (they are inherited)
  - Just that to access them we have to use the methods defined in class `Computer`
  - An alternative is to declare them **`protected`** rather than **`private`**
- Variables with protected visibility (defined by the keyword protected) are accessible by any subclass or any class in the same package
- In general, it is better to use private visibility and to restrict access to variables to accessor methods

Is-a versus Has-a Relationships

- In an is-a or inheritance relationship, one class is a subclass of the other class
- In a has-a or aggregation relationship, one class has the other class as an attribute

Is-a versus Has-a Relationships

```
public class Computer {
  private Memory mem;
  ...
}

public class Memory {
  private int size;
  private int speed;
  private String kind;
  ...
}
```

- A Computer has only one Memory
- But a Computer is not a Memory (i.e. not an is-a relationship)
- If a Notebook extends Computer, then the Notebook is-a Computer

ADTs and Interfaces

Abstract Data Types

- An encapsulation of data and methods
- Allows for reusable code
- The user
  - need not know about the implementation of the ADT
  - interacts with the ADT using only public methods
- ADTs facilitate storage, organization, and processing of information
- The Java Collections Framework provides implementations of common ADTs

Interfaces

- A Java interface specifies or describes an ADT to the applications programmer:
  - the methods and the actions that they must perform
  - what arguments, if any, must be passed to each method
  - what result the method will return
- The interface can be viewed as a contract which guarantees how the ADT will function

Interfaces

- A class that implements the interface provides code for the ADT
- As long as the implementation satisfies the ADT contract, the programmer may implement it as he or she chooses
- In addition to implementing all data fields and methods in the interface, the programmer may add:
  - data fields not in the interface
  - methods not in the interface
  - constructors (an interface cannot contain constructors because it cannot be instantiated)

Example: ATM Interface

- An automated teller machine (ATM) enables a user to perform certain banking operations from a remote location.
- It must provide operations to:
  - verify a user's Personal Identification Number (PIN)
  - allow the user to choose a particular account
  - withdraw a specified amount of money
  - display the result of an operation
  - display an account balance
- A class that implements an ATM must provide a method for each operation

Example: ATM Interface

Interface:

- verify a user's PIN
- allow the user to choose a particular account
- withdraw a specified amount of money
- display the result of an operation
- display an account balance

Code:

```
1  public interface ATM {
2
3    /** Verifies a user's PIN.
4        @param pin The user's PIN
5    */
6    boolean verifyPIN(String pin);
7
8    /** Allows user to select account.
9        @return a String representing
10               the account selected
11   */
12   String selectAccount();
```

Example: ATM Interface

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Example: ATM Interface

Interface:

- verify a user's PIN
- allow the user to choose a particular account
- withdraw a specified amount of money
- display the result of an operation
- display an account balance

Code:

```
/** Withdraws a specified amount
      of money
      @param account The account
             from which the money
             comes
      @param amount The amount of
             money withdrawn
      @return whether or not the
             operation is
              successful
   */
 boolean withdraw(String account,
                  double amount);
```

Example: ATM Interface

Interface:

- verify a user's PIN
- allow the user to choose a particular account
- withdraw a specified amount of money
- display the result of an operation
- display an account balance

Code:

```
/** Displays the result of an
    operation
     @param account The account
            from which money was
           withdrawn
     @param amount The amount of
           money withdrawn
     @param success Whether or not
           the withdrawal took
            place
  */
void display(String account,
             double amount,
              boolean success);
```

Example: ATM Interface

Interface:

- verify a user's PIN
- allow the user to choose a particular account
- withdraw a specified amount of money
- display the result of an operation
- display an account balance

Code:

```
  /** Displays an account balance
      @param account The account
             selected
  */
  void showBalance(String account);
}
```

Note: Interfaces may include declaration of constants; these are accessible in classes that implement the interface

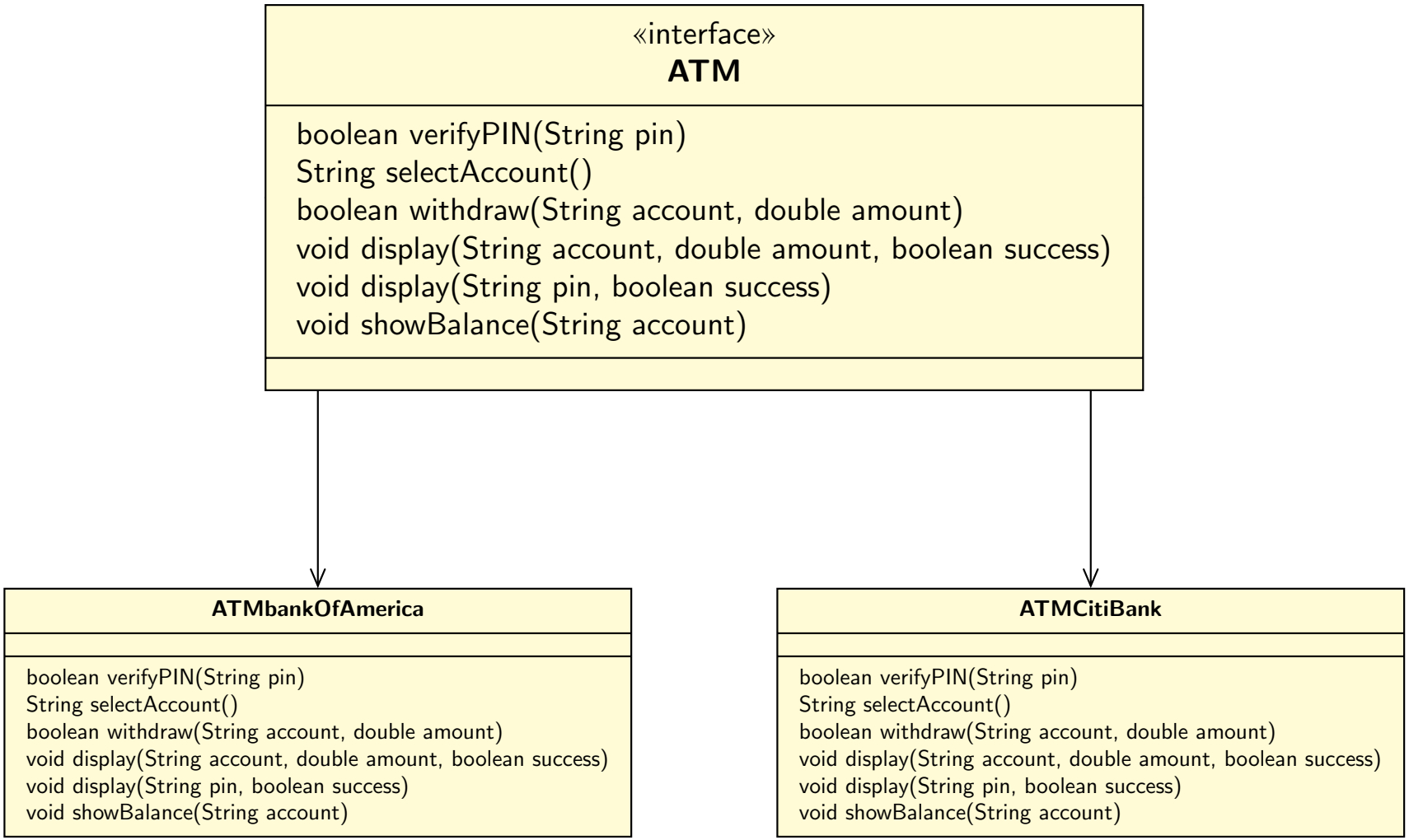
The `implements` clause

- For a class to implement an interface, it must end with the implements clause

```
public class ATMbankAmerica implements ATM
public class ATMbankCiti implements ATM
```

- A class may implement more than one interface—their names are separated by commas

UML Diagram of Interface & Implementers



The `implements` Clause: Pitfalls

- The Java compiler verifies that a class defines all the abstract methods in its interface(s)
  - A syntax error will occur if a method is not defined or is not defined correctly
- You cannot instantiate an interface; it will cause an error

```
ATM anATM = new ATM();     // invalid statement
```

Declaring a Variable of an Interface Type

While you cannot instantiate an interface, you can declare a variable that has an interface type

```
/* expected type */
ATMbankAmerica ATM0 = new ATMBankAmerica();

/* interface type */
ATM ATM1 = new ATMBankAmerica();
ATM ATM2 = new ATMCitiBank();
```

The reason for wanting to do this will become clear when we discuss polymorphism