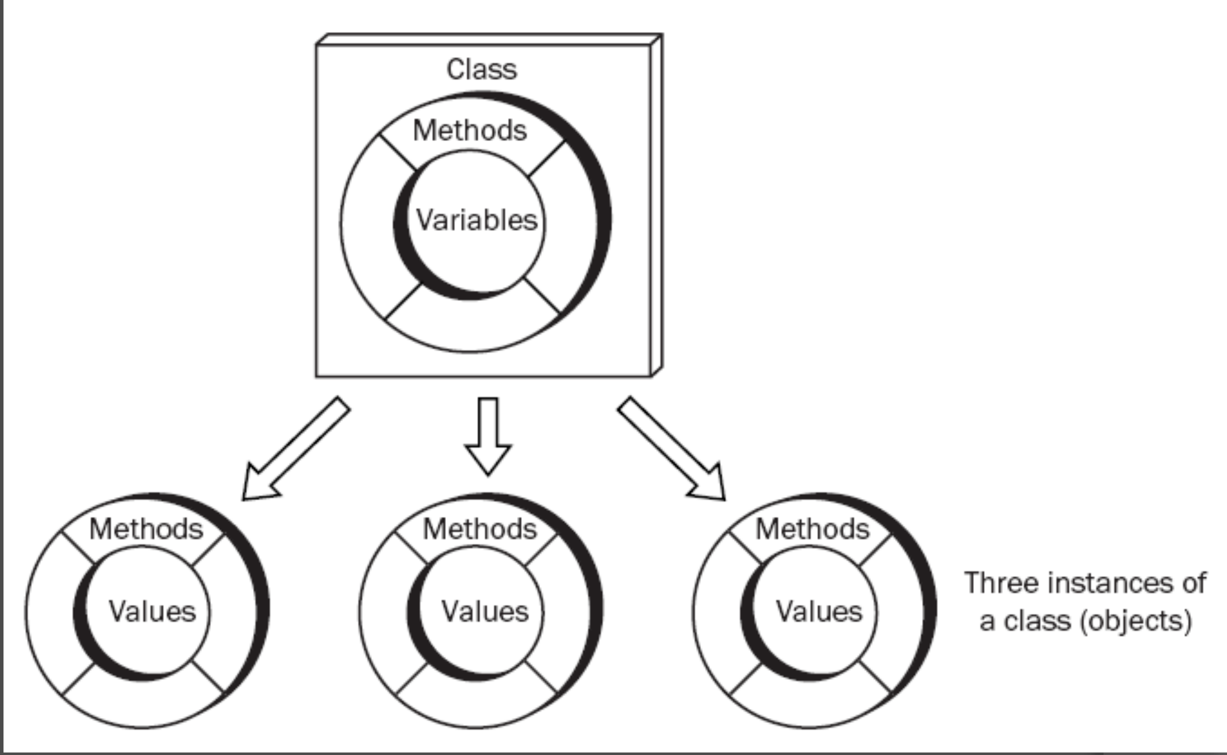
Chapter 9: Classes with Instance Variables

or Classes=Methods+Variables

Asserting Java

One class constructing three different objects, each with its own set of values (state)

Classes



Computing Fundamentals, Rick Mercer Franklin, Beedle and Associates, 2003

- Classes are
  - a collection of methods and data
  - a blueprint used to construct many objects
  - a great way to partition a software system
  - A way to implement any type
    - A **type** defines a set of values, and the allowable operations on those values

Putting it All Together in a Class

- Even though quite different in specific methods and state, virtually all classes have these things in common:
  - variables store the state of the objects
  - constructors initialize the state of an object
  - some messages modify the state of objects
  - some messages provide access to the state of objects

General form of a Java class

```
public class class-name {
   //--instance variables
   private class-name  identifier ;
   private primitive-type identifier ;

   // Constructor
   public class-name ( parameters ) {
   }

   //--Methods
   public return-type method-name-1 ( parameters ) {
   }

   public return- type method-name-N ( parameters )  {
   }
}
```

An Example class BankAccount

```
public class BankAccount {
  //--instance variables
  private String ID;
  private double balance;

  // Constructor to initialize the state
  public BankAccount(String initID, double initBalance) {
    ID = initID;
    balance = initBalance;
  }

  // Credit this account by depositAmount
  public void deposit(double depositAmount) {
     balance = balance + depositAmount;
  }

  // Debit this account by withdrawalAmount
  public void withdraw(double withdrawalAmount) {
    balance = balance - withdrawalAmount;
 }
```

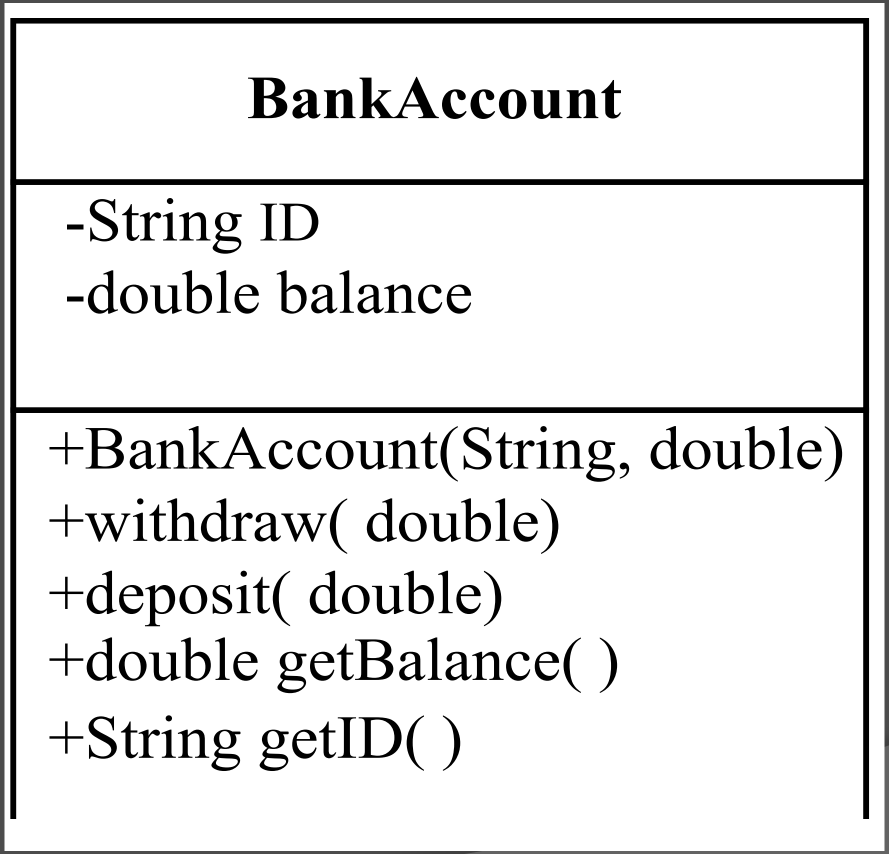
3 modify, now 3 access, state

```
 public String getID() {
   return ID;
 }

 public double getBalance() {
   return balance;
 }

 public String toString( ) {
   return ID + " $" + balance;
 }

} // End class BankAccount
```

Objects are a lot about Operations and State

- The methods declared `public` are the messages that may be sent to any instance of the class *the objects*
- The instance variables declared `private` store the state of the objects
  - no direct access from outside the class
- Every instance of a class has it own separate state
  - If you have 5,234 BankAccount objects, you'll have 5,234 IDs and 5, 234 balances

The Unified Modeling Language (UML) class diagram -- another view of a class methods and state



Sample Messages

```
BankAccount anAcct = new BankAccount("Moss", 500.00);
anAcct.withdraw(60);
anAcct.deposit(147.35);
// These assertions should pass
assertEquals("Moss", anAcct.getID());
assertEquals(500.0, anAcct.getBalance(), 0.001);
```

Instance Variables

- State of objects stored as instance variables
  - these are the variables that are declared inside the class, but outside of the method bodies
  - each instance of the class (object) has its own values stores in its own instance variables *with 954 objects you have 954 sets of instance variables*
  - all methods in the class can access instance variables
    - and most methods will reference at least one of the instance variables *the data and methods are related*
  - when declared private, no one else can access the instance variables *the state is encapsulated, nice and safe behind methods*

Constructors

- Constructor
  - a special method that initializes the state of objects
  - gets invoked when you construct an object
  - has the same name as the class
  - does not have a return type
    - a constructor returns a reference to the instance of the class
- Assigning object references to reference variables

```
String aString = new String("Initial state");
BankAccount anAcct = new BankAccount("Katey", 10.00);
JFrame window = new JFrame("My Application");
```

Constructors

- General form: calling a constructor to construct and initialize an object

class-name object-name **= new** *class-name* **(***initial-state***) ;**

  - *class-name:* name of the class
  - *object-name:* any valid Java identifier
  - *initial-state:* zero or more arguments supplied during instance creation.

Constructors

- A constructor uses the arguments *initial-state* to help initialize the private instance variable

```
public BankAccount(String initID, double initBalance)
{
   ID = initID;
   balance = initBalance;
}


BankAccount anAcct
               = new BankAccount("Kellen", 123.45);
```

Methods that Access State

- Other methods return the current value of an object's data member, or return some information related to the state of an object

```
anAccount.getBalance()   // return current balance
aString.substring(0, 3) // Get part of a string
```

- Some accessing methods simply return values of instance variables, others require some processing

return in non-void methods

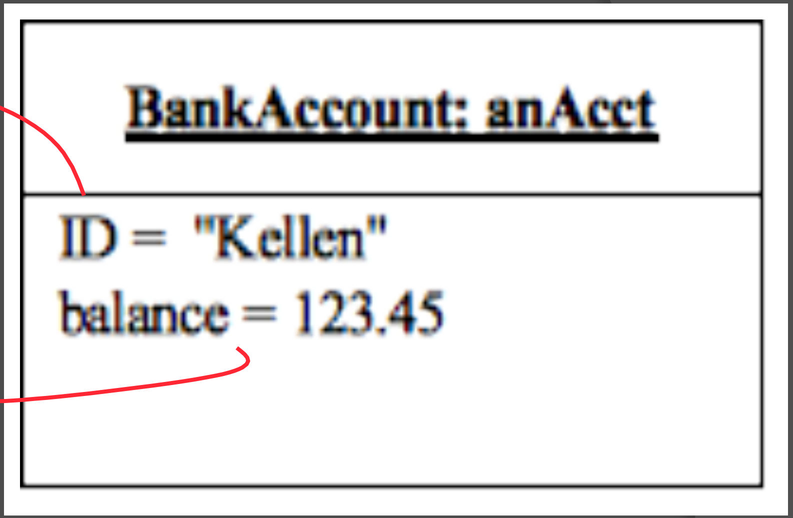
- Java's return statement provide the means to return information, General form

```
    return expression ;
```

- When return executes, the value of *expression* replaces the message *control returns to the message*
- *expression* must match the return type of method heading
  - String return type means you must return a String
  - double return type? Return a double
- You can not return an value from a void method

Returning state

An instance of BankAccount



BankAccount: anAcct

ID = "Kellen"
balance = 123.45

```
public String getID() {
   return ID;
}

public double getBalance() {
   return balance;
}


System.out.println( + anAcct.getID() + ": "
                        + anAcct.getBalance());
```

Output: `Kellen 123.45`

Methods that Modify State

- Some methods modify (change) the state of an object:

```
anAccount.withdraw(120.00)
  // Account balance has been reduced by 120.00

  // Modify the state of any BankAccount object
  public void withdraw(double amount) {
    // balance is an instance variable
    balance = balance + amount;
  }
```

Naming Conventions

- Rules #1, 2, and 3:
  - 1: Always use meaningful names
  - 2: Always use meaningful names
  - 3: Always use meaningful names
- Rule #4
  - Constructors: Same name as the class

public or private?

- When designing a class, do this *at least for now*
  - declare constructors and methods **`public`**
  - declare instance variables **`private`**
- Public messages can be sent from wherever the object is in scope
- Private state can not be messed up

```
BankAccount myAcct = new BankAccount("Me", 10.00);
myAcct.balance = myAcct.balance + 99999999.99;
```

Protecting an Object's State

- Access modes make operations available to clients and also protect the state
- Instance variables and methods are known as follows

Access Mode	*Where is the symbol known?*
`public`	From all methods of the class and in the scope (where it is known) of the object
`private`	Known only in the class

Some Guidelines

- Recommendations for writing your first classes:
  - declare instance variables `private` *after class definition*
  - declare constructors `public` *no return type, no static!*
  - declare most methods `public` *no static!*
    - however, private helper methods are often useful
  - look at examples in Book and on the Code Demos page as patterns
  - use one file to store the class (no main method)
  - use a unit test to test instances of the class

Object-Oriented Design Guidelines

- Object-oriented design guideline
  - a rule of thumb intended to help produce good object-oriented software
- Example: When deciding what access users of a class should have to methods and instance variables
- OOD Guideline

All data should be hidden within its class

- Translation: make instance variables private

Why private?

- If `balance` were public, what is it after this?

```
myAcct.balance = myAcct.balance - myAcct.balance;
```

- With `balance` private, compiletime error occurs
- You want programmers to use the methods
  - imagine the other things that occur during a real withdraw
    - write a transaction to a file
    - check for trying to withdraw more than balance
- Also, you can later change the class
- Also, programmers only need to know the methods

Cohesion within a class

- The methods of a class should be strongly related
  - don't put a **`blastOff`** method in BankAccount
- The instance variables should be strongly related
  - don't put **`double acceleration`** in BankAccount
- Cohesion means solidarity, hanging together
- Classes with high cohesion are a better design
  - the methods and data are related
- OOD Guideline

Keep related data and behavior in one place