5. Defining Classes and Methods

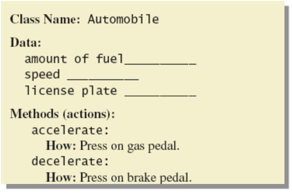
Harald Gall, Prof. Dr.
Institut für Informatik
Universität Zürich
http://seal.ifi.uzh.ch/info1

Objectives

- Describe and define concepts of class and object
- Describe use of parameters in a method
- Use modifiers `public`, `private`
- Define *accessor*, *mutator* class methods
- Describe purpose of `javadoc`
- Describe references, variables, parameters of a class type

Example: Automobile

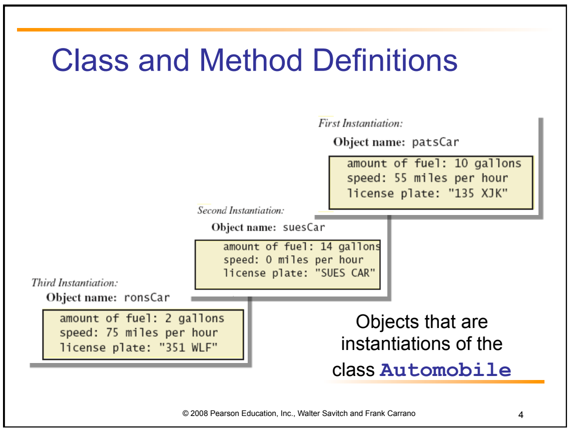
- A class `Automobile` as a blueprint



Class Name: Automobile

Data:
```
  amount of fuel__________
  speed __________
  license plate __________
```

Methods (actions):
```
   accelerate:
      How: Press on gas pedal.
   decelerate:
      How: Press on brake pedal.
```



Class and Method Definitions

First Instantiation:
Object name: patsCar

```
amount of fuel: 10 gallons
speed: 55 miles per hour
license plate: "135 XJK"
```

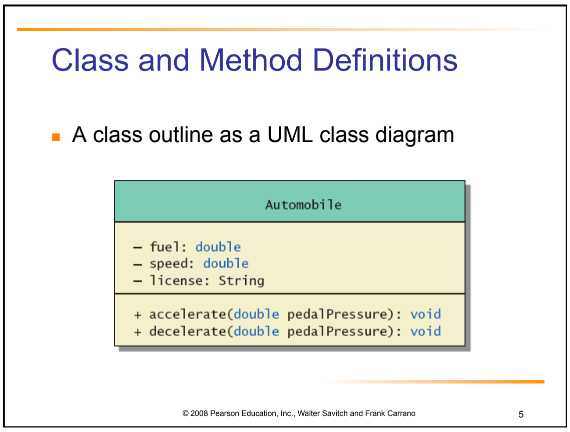
Second Instantiation:
Object name: suesCar

```
amount of fuel: 14 gallons
speed: 0 miles per hour
license plate: "SUES CAR"
```

Third Instantiation:
Object name: ronsCar

```
amount of fuel: 2 gallons
speed: 75 miles per hour
license plate: "351 WLF"
```

Objects that are instantiations of the class **`Automobile`**



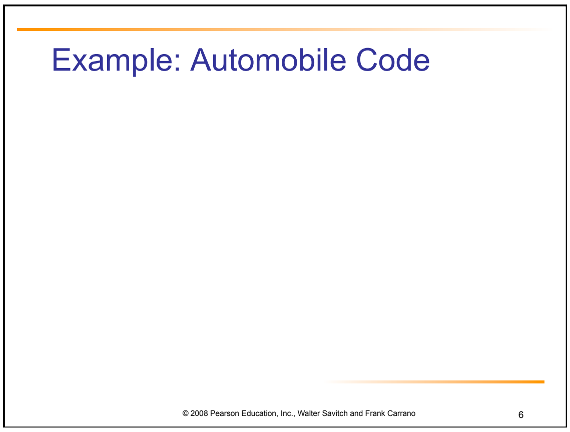
Class and Method Definitions

- A class outline as a UML class diagram

```
Automobile

– fuel: double
– speed: double
– license: String

+ accelerate(double pedalPressure): void
+ decelerate(double pedalPressure): void
```



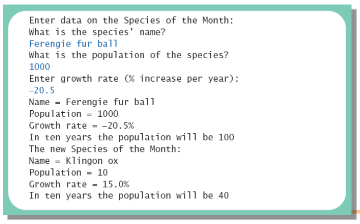
Example: Automobile Code

Example: Species

- A class `Species` shall hold records of endangered species.
  - Each object has three pieces of data: a *name*, a *population size*, and a *growth rate*.
  - The objects have 3 behaviors: *readInput*, *writeOutput*, *predictPopulation*.
- Sample program `class SpeciesFirstTry`

Using a Class and Its Methods

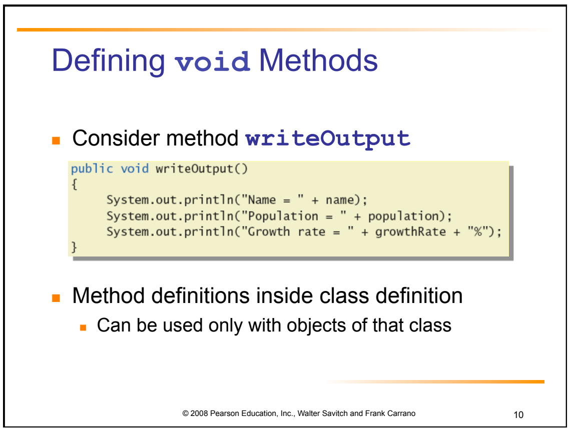
- `class SpeciesFirstTryDemo`



```
Enter data on the Species of the Month:
What is the species' name?
Ferengie fur ball
What is the population of the species?
1000
Enter growth rate (% increase per year):
-20.5
Name = Ferengie fur ball
Population = 1000
Growth rate = -20.5%
In ten years the population will be 100
The new Species of the Month:
Name = Klingon ox
Population = 10
Growth rate = 15.0%
In ten years the population will be 40
```

Methods

- Two kinds of Java methods
  - Return a single item, i.e. `return type`
  - No return type: a `void` method
- The method `main` is a `void` method
  - Invoked by the system
  - Not by the program



Defining `void` Methods

- Consider method `writeOutput`

```
public void writeOutput()
{
     System.out.println("Name = " + name);
     System.out.println("Population = " + population);
     System.out.println("Growth rate = " + growthRate + "%");
}
```

- Method definitions inside class definition
  - Can be used only with objects of that class

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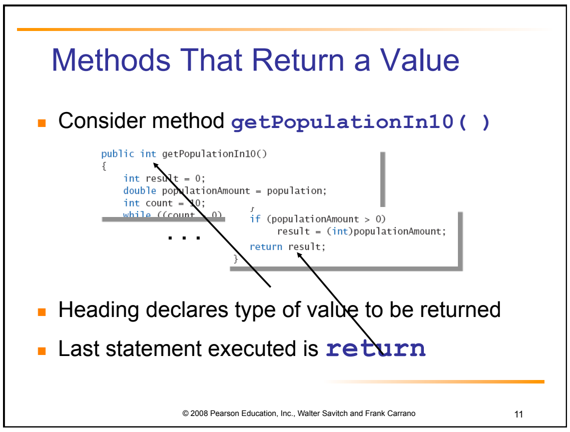

Methods That Return a Value

- Consider method `getPopulationIn10( )`

```
public int getPopulationIn10()
{
    int result = 0;
    double populationAmount = population;
    int count = 10;
    while ((count > 0)
          . . .
        if (populationAmount > 0)
            result = (int)populationAmount;
        return result;
}
```

- Heading declares type of value to be returned
- Last statement executed is `return`

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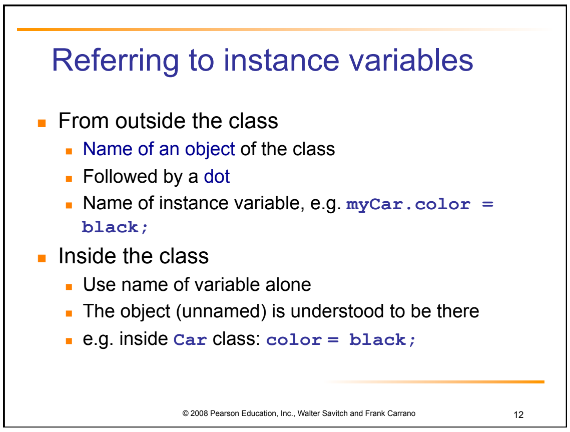

Referring to instance variables

- From outside the class
  - Name of an object of the class
  - Followed by a dot
  - Name of instance variable, e.g. `myCar.color = black;`
- Inside the class
  - Use name of variable alone
  - The object (unnamed) is understood to be there
  - e.g. inside `Car` class: `color = black;`

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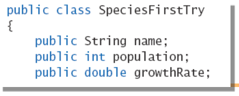
The Keyword `this`

- Inside the class the unnamed object can be referred to with the name **`this`**
- Example
  `this.name = keyboard.nextLine();`
- The keyword **`this`** stands for the receiving object

Local Variables

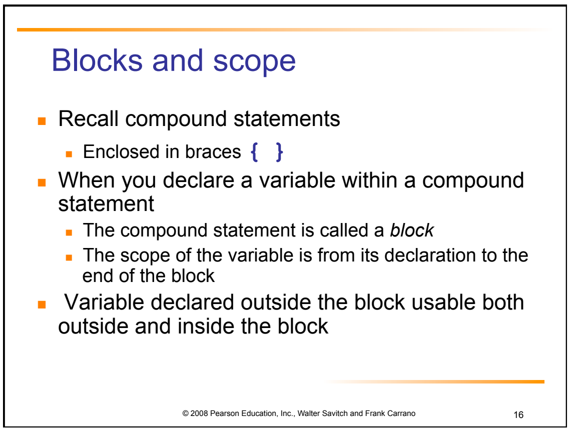
- Variables declared inside a class are considered *local* variables
  - May be used only inside this class
- Variable with same name inside a different class is considered a different variable
- All variables declared in method **`main`** are local to **`main`**



```
public class SpeciesFirstTry
{
    public String name;
    public int population;
    public double growthRate;
```

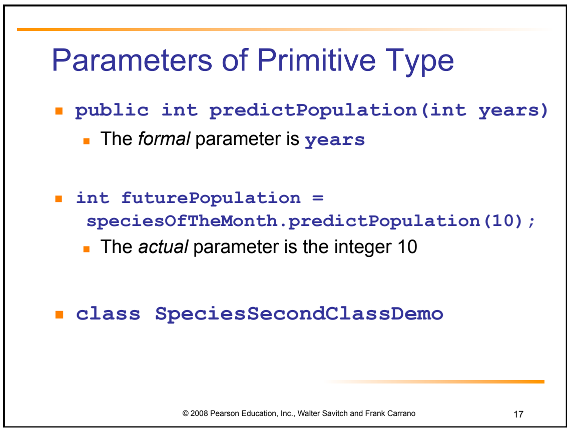
Local Variables

- **`class BankAccount`**
- **`class LocalVariablesDemoProgram`**
- Note two different variables **`newAmount`**
  - Note different values output



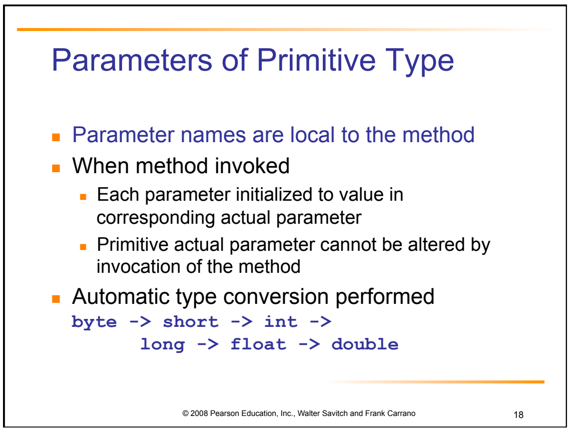
Blocks and scope

- Recall compound statements
  - Enclosed in braces `{ }`
- When you declare a variable within a compound statement
  - The compound statement is called a *block*
  - The scope of the variable is from its declaration to the end of the block
- Variable declared outside the block usable both outside and inside the block



Parameters of Primitive Type

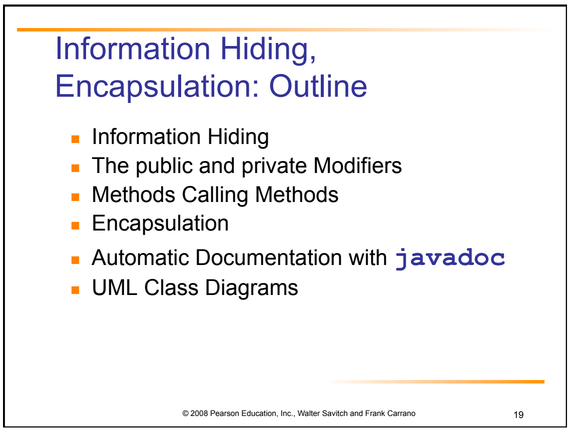
- `public int predictPopulation(int years)`
  - The *formal* parameter is `years`
- `int futurePopulation =`
  `speciesOfTheMonth.predictPopulation(10);`
  - The *actual* parameter is the integer 10
- `class SpeciesSecondClassDemo`



Parameters of Primitive Type

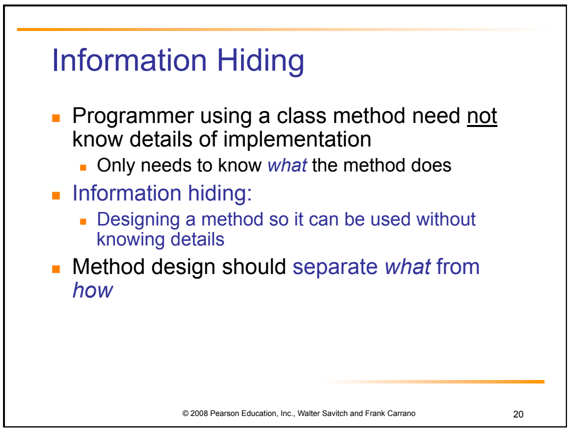
- Parameter names are local to the method
- When method invoked
  - Each parameter initialized to value in corresponding actual parameter
  - Primitive actual parameter cannot be altered by invocation of the method
- Automatic type conversion performed

```
byte -> short -> int ->
      long -> float -> double
```



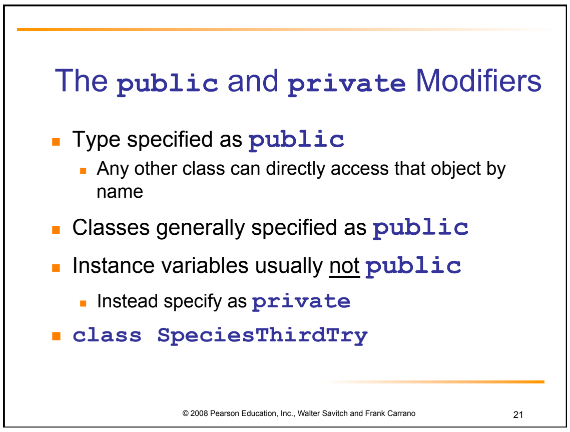
Information Hiding, Encapsulation: Outline

- Information Hiding
- The public and private Modifiers
- Methods Calling Methods
- Encapsulation
- Automatic Documentation with `javadoc`
- UML Class Diagrams



Information Hiding

- Programmer using a class method need not know details of implementation
  - Only needs to know *what* the method does
- Information hiding:
  - Designing a method so it can be used without knowing details
- Method design should separate *what* from *how*



The `public` and `private` Modifiers

- Type specified as `public`
  - Any other class can directly access that object by name
- Classes generally specified as `public`
- Instance variables usually not `public`
  - Instead specify as `private`
- `class SpeciesThirdTry`

Accessor and Mutator Methods

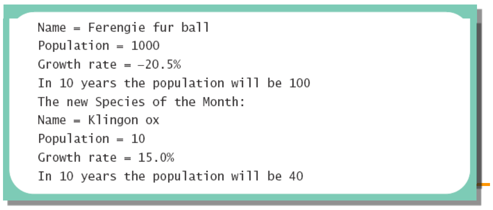
- When instance variables are private one must provide methods to access values stored there
  - Typically named **get*SomeValue***
  - Referred to as an accessor method (getter)
- Must also provide methods to change the values of the private instance variable
  - Typically named **set*SomeValue***
  - Referred to as a mutator method (setter)

Accessor and Mutator Methods

- Consider an example class with accessor and mutator methods
- Sample code **`class SpeciesFourthTry`**
- Note the mutator method
  - **`setSpecies`**
- Note accessor methods
  - **`getName`**, **`getPopulation`**, **`getGrowthRate`**

Accessor and Mutator Methods

- Using a mutator method
- **`classSpeciesFourthTryDemo`**

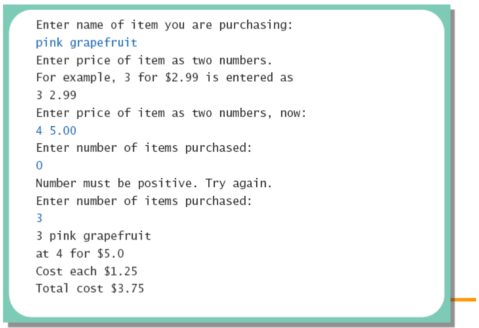


```
Name = Ferengie fur ball
Population = 1000
Growth rate = -20.5%
In 10 years the population will be 100
The new Species of the Month:
Name = Klingon ox
Population = 10
Growth rate = 15.0%
In 10 years the population will be 40
```

Programming Example

- A Purchase class
- Sample code **`class Purchase`**
  - Note use of private instance variables
  - Note also how mutator methods check for invalid values
- Sample code **`class purchaseDemo`**

Programming Example

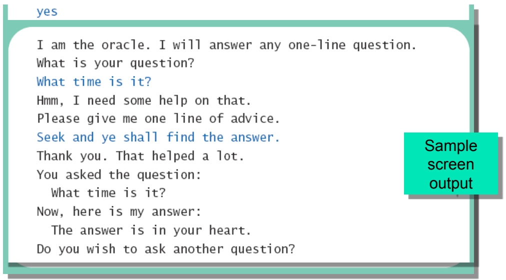


```
Enter name of item you are purchasing:
pink grapefruit
Enter price of item as two numbers.
For example, 3 for $2.99 is entered as
3 2.99
Enter price of item as two numbers, now:
4 5.00
Enter number of items purchased:
0
Number must be positive. Try again.
Enter number of items purchased:
3
3 pink grapefruit
at 4 for $5.0
Cost each $1.25
Total cost $3.75
```

Methods Calling Methods

- A method body may call any other method
- If the invoked method is within the same class
  - Need not use prefix of receiving object
- View sample code, listing 5.13
  class Oracle
- View demo program, listing 5.14
  class OracleDemo

Methods Calling Methods



```
yes
I am the oracle. I will answer any one-line question.
What is your question?
What time is it?
Hmm, I need some help on that.
Please give me one line of advice.
Seek and ye shall find the answer.
Thank you. That helped a lot.
You asked the question:
  What time is it?
Now, here is my answer:
  The answer is in your heart.
Do you wish to ask another question?
```

Sample screen output

Encapsulation

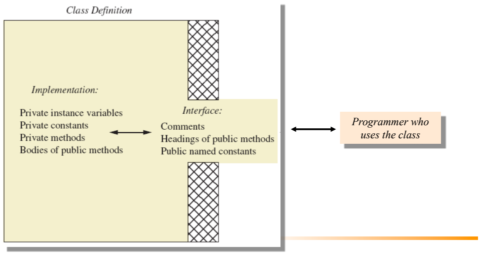
- Consider example of driving a car
  - We see and use break pedal, accelerator pedal, steering wheel – know what they do
  - We do not see mechanical details of how they do their jobs
- Encapsulation divides class definition into
  - Class interface
  - Class implementation

Encapsulation

- A *class interface*
  - Tells what the class does
  - Gives headings for public methods and comments about them
- A *class implementation*
  - Contains private variables
  - Includes definitions of public and private methods

Encapsulation

- Figure 5.3 A well encapsulated class definition



Encapsulation

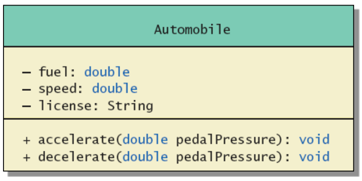
- Preface class definition with comment on how to use class
- Declare all instance variables in the class as private
- Provide public accessor methods to retrieve data
- Provide public methods manipulating data
    - Place a comment before each public method heading that fully specifies how to use method.
- Make any helping methods private.
- Write comments within class definition to describe implementation details.

Automatic Documentation `javadoc`

- Generates documentation for class interface
- Comments in source code must be enclosed in `/**  */`
- Utility `javadoc` will include
    - These comments
    - Headings of public methods
- Output of `javadoc` is HTML format

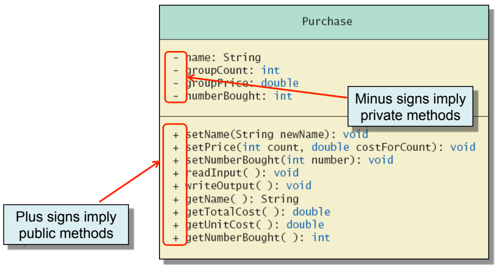
UML Class Diagram

- Recall



```
Automobile
– fuel: double
– speed: double
– license: String
+ accelerate(double pedalPressure): void
+ decelerate(double pedalPressure): void
```

UML Class Diagram



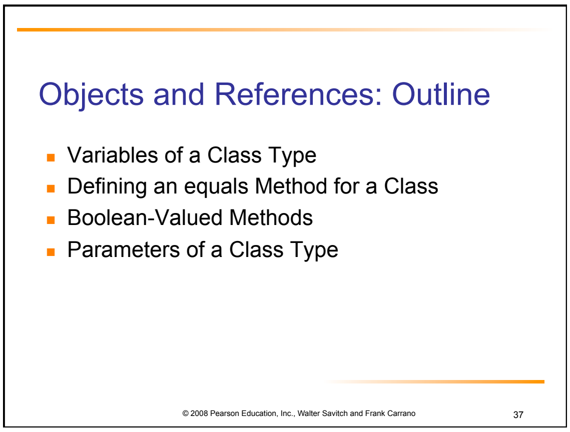
```
Purchase
- name: String
- groupCount: int
- groupPrice: double
- numberBought: int
+ setName(String newName): void
+ setPrice(int count, double costForCount): void
+ setNumberBought(int number): void
+ readInput( ): void
+ writeOutput( ): void
+ getName( ): String
+ getTotalCost( ): double
+ getUnitCost( ): double
+ getNumberBought( ): int
```

Minus signs imply private methods

Plus signs imply public methods

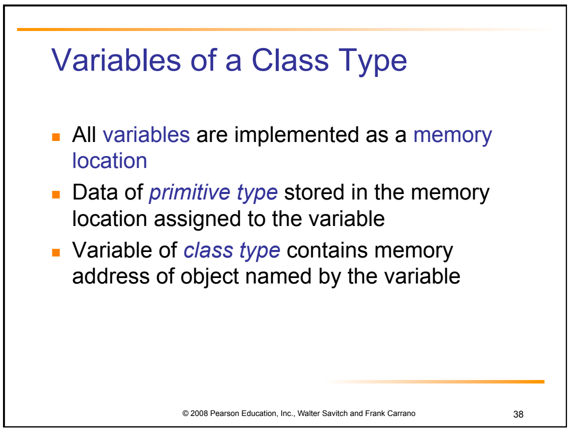
UML Class Diagram

- Contains more than interface, less than full implementation
- Usually written *before* class is defined
- Used by the programmer defining the class
  - Contrast with the interface used by programmer who uses the class



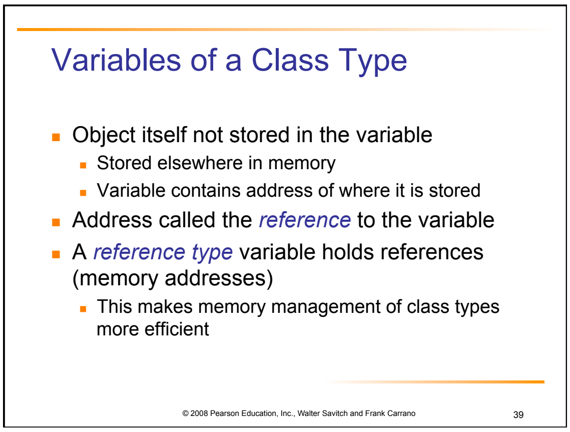
Objects and References: Outline

- Variables of a Class Type
- Defining an equals Method for a Class
- Boolean-Valued Methods
- Parameters of a Class Type



Variables of a Class Type

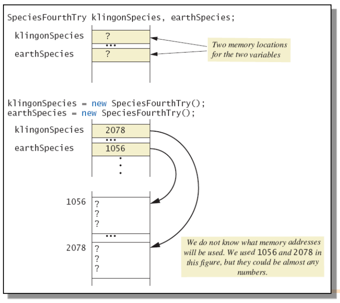
- All variables are implemented as a memory location
- Data of *primitive type* stored in the memory location assigned to the variable
- Variable of *class type* contains memory address of object named by the variable



Variables of a Class Type

- Object itself not stored in the variable
  - Stored elsewhere in memory
  - Variable contains address of where it is stored
- Address called the *reference* to the variable
- A *reference type* variable holds references (memory addresses)
  - This makes memory management of class types more efficient

Variables of a Class Type



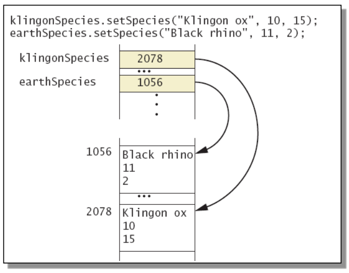
```
SpeciesFourthTry klingonSpecies, earthSpecies;
```

Two memory locations for the two variables

```
klingonSpecies = new SpeciesFourthTry();
earthSpecies = new SpeciesFourthTry();
```

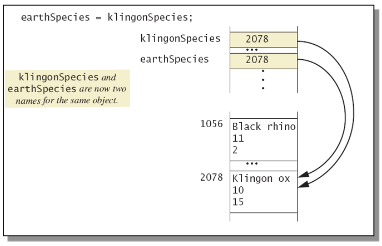
We do not know what memory addresses will be used. We used 1056 and 2078 in this figure, but they could be almost any numbers.

Variables of a Class Type



```
klingonSpecies.setSpecies("Klingon ox", 10, 15);
earthSpecies.setSpecies("Black rhino", 11, 2);
```

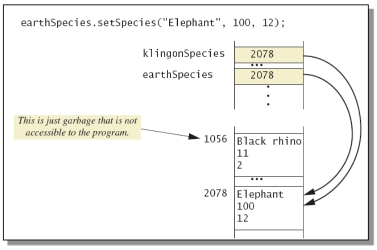
Variables of a Class Type



```
earthSpecies = klingonSpecies;
```

klingonSpecies *and* earthSpecies *are now two names for the same object.*

Variables of a Class Type

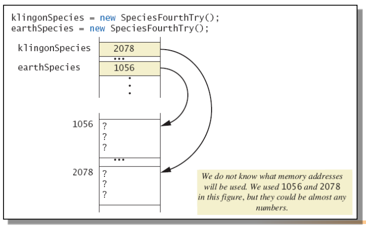


```
earthSpecies.setSpecies("Elephant", 100, 12);
```

This is just garbage that is not accessible to the program.

Variables of a Class Type

- Danger of using == with objects!

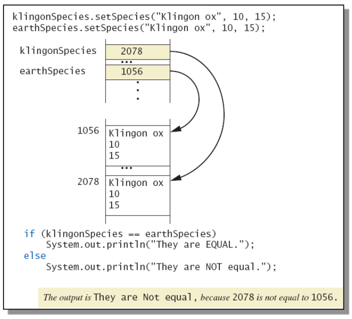


```
klingonSpecies = new SpeciesFourthTry();
earthSpecies = new SpeciesFourthTry();
```

We do not know what memory addresses will be used. We used 1056 and 2078 in this figure, but they could be almost any numbers.

Variables of a Class Type

- Dangers of using == with objects



```
klingonSpecies.setSpecies("Klingon ox", 10, 15);
earthSpecies.setSpecies("Klingon ox", 10, 15);
```

```
if (klingonSpecies == earthSpecies)
    System.out.println("They are EQUAL.");
else
    System.out.println("They are NOT equal.");
```

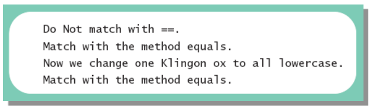
The output is They are Not equal, *because* 2078 *is not equal to* 1056.

Defining an equals Method

- As demonstrated by previous figures
  - We cannot use == to compare two objects
  - We must write a method for a given class which will make the comparison as needed
- View class Species
- The equals for this class method used same way as equals method for String

Demonstrating an equals Method

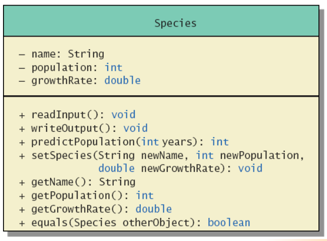
- View sample program class SpeciesEqualsDemo
- Note difference in the two comparison methods == versus .equals( )



```
Do Not match with ==.
Match with the method equals.
Now we change one Klingon ox to all lowercase.
Match with the method equals.
```

Programming Example

- View class Species



```
Species

– name: String
– population: int
– growthRate: double

+ readInput(): void
+ writeOutput(): void
+ predictPopulation(int years): int
+ setSpecies(String newName, int newPopulation,
            double newGrowthRate): void
+ getName(): String
+ getPopulation(): int
+ getGrowthRate(): double
+ equals(Species otherObject): boolean
```

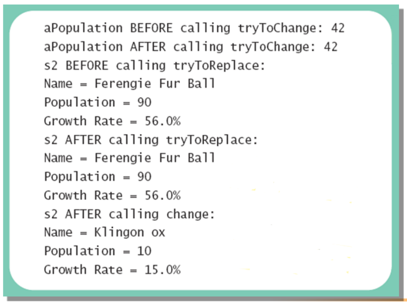
Parameters of a Class Type

- Assignment operator used with objects of class type
  - Only memory address is copied
- Parameter of class type
  - Memory address of actual parameter passed to formal parameter
  - Formal parameter may access public elements of the class
  - Actual parameter thus can be changed by class methods

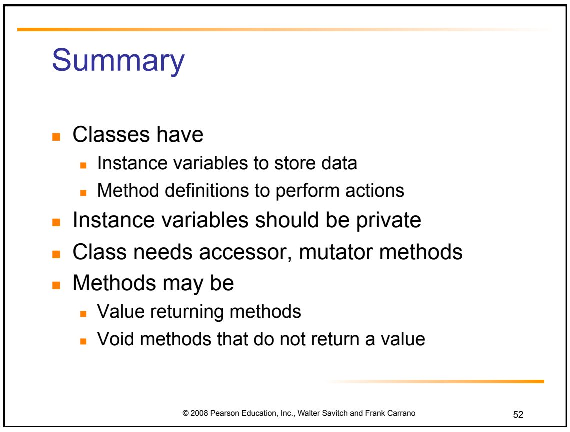
Programming Example

- View `class DemoSpecies`
  - Note different parameter types and results
- View `class ParametersDemo`
  - Parameters of a class type versus parameters of a primitive type

Programming Example



```
aPopulation BEFORE calling tryToChange: 42
aPopulation AFTER calling tryToChange: 42
s2 BEFORE calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling change:
Name = Klingon ox
Population = 10
Growth Rate = 15.0%
```



Summary

- Classes have
  - Instance variables to store data
  - Method definitions to perform actions
- Instance variables should be private
- Class needs accessor, mutator methods
- Methods may be
  - Value returning methods
  - Void methods that do not return a value

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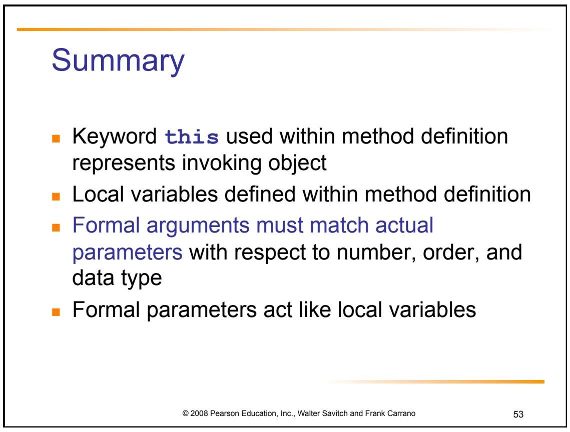

Summary

- Keyword **`this`** used within method definition represents invoking object
- Local variables defined within method definition
- Formal arguments must match actual parameters with respect to number, order, and data type
- Formal parameters act like local variables

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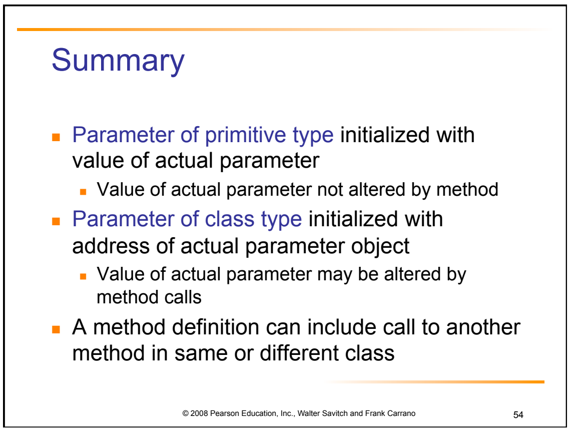

Summary

- Parameter of primitive type initialized with value of actual parameter
  - Value of actual parameter not altered by method
- Parameter of class type initialized with address of actual parameter object
  - Value of actual parameter may be altered by method calls
- A method definition can include call to another method in same or different class

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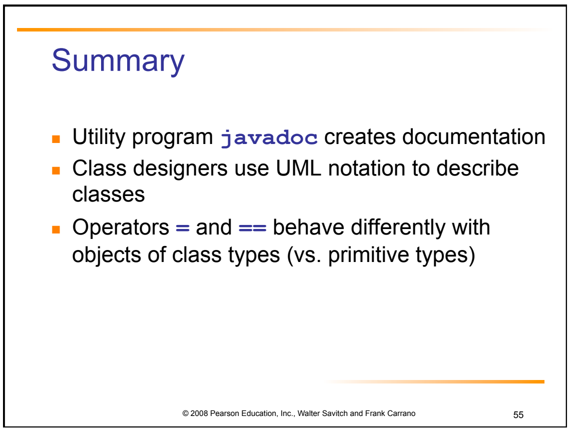

Summary

- Utility program `javadoc` creates documentation
- Class designers use UML notation to describe classes
- Operators `=` and `==` behave differently with objects of class types (vs. primitive types)