Java Program Structure

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Where's the Source Code?

In Java, all source code is contained in classes.

A class defines a *kind of object*.

and the object's attributes and behavior.

You create objects from a class.

Creating Objects

Use "new" to create an instance (object) of a class.

```
new Date( )
```

To refer to the object again later, you usually want to assign a *reference* to it:

```
Date d = new Date( );
```

What does "new Date( )" mean? How about this:

```
Date d = new Date(112, 2, 20);
```

Answer: it depends on the **source code**.

Defining your own class

To define a new kind of object, you write a Java *class.*

For example, in the coin purse project, we want to have "coins" that remember their value, so we define a Coin class.

Class Structure

```
import java.util.Scanner;
/**
 * Describe this class.
 * @author Bill Gates
 */
public class Coin {
   constants
   attributes
   constructors
   methods
}
// No code allowed here!
```

import other classes

Javadoc comment describes this class.

Start of the class

End of the class

Attributes

Attributes are what an object knows.

An ttribute is represented as a variable.

```
import java.time.LocalDate;

public class Person {
    private String name;
    private LocalDate bday;

    // methods go here
}
```

attributes of a Person:

a Person has a name and a birthdate.

Declaring Attributes

```
public class Person {
   /** person's name */
   private String name;
```

Javadoc for attribute

Visibility

public

protected

(package)

private

Data Type

primitive

class name

interface

array

Variable Name

name of attribute

should start with **lowercase**

Common Java Data Types

Some data types used in Java are:

Data Type	Examples
int	-100 ... -1 0 1 2 ... 2147483647
double	0.5 -3.70 2.98E+8
boolean	true false
String	"Hello" "I'm hungry" "turn left"
List ArrayList	Collection of things. List list = new ArrayList( ); list.add("apple"); list.add("orange");

Initialize All Your Attributes!

```
public class Person {
   private String name;
   private LocalDate birthday;

   /** initialize a new person object */
   public Person(String name) {
      this.name = name ;
   }
```

Two ways to initialize attributes:

1. assign a value as part of declaration, or

2. (better) initialize in a constructor

3 Kinds of Comments

```
/**
 * Javadoc comment describes this class.
 */
public class Greeter {
   /*
    A multi-line comment can be
    very long.
    */
    public static void method1( ) {
        // a single line comment
        System.out.print("This is method1");
        int n = 0;  // end-of-line comment
    }
}
```

The compiler ignores comments.

Javadoc comments create online documentation for your code.

Constructor Initializes a New Object

```
Coin ten = new Coin( 10 );
```

```
/** initialize a new coin */
public Coin( double value ) {
   this.value = value ;
}
```

Constructor has the same name as the class.

Constructor does **not** have a return value. Not even "void".

"this" means "this object". "this" is used to *distinguish* between the parameter value and attribute value.

How Objects are Created

```
new Coin( 10 )
```

Java creates object in memory

initialize state of object
by invoking *constructor*

```
// constructor's job is to
// initialize a new object
public Coin(double value ) {
  this.value = value
```

Correct this Code

```
public class Coin {
    private double value;
   public void Coin(double value) {
        this.value = value;
   }
```

This code has legal syntax, but it is not a constructor.

More than One Constructor

```
public class Coin {
   /** default constructor */
   public Coin( ) {
      this.value = 0;
      this.currency = "THB";
   }
   public Coin(double value) {
      this.value = value;
      this.currency = "THB";
   }
   public Coin(double value,
               String currency) {
      ...
```

A class can have *many constructors*,

if they have different parameters.

Default Constructor

```
public class Coin {
   private double value;
   public Coin( ) {
      this.value = 0 ;
      this.currency = "THB";
   }
```

```
Coin zero = new Coin( );
```

A constructor with no parameters is called the default constructor.

Avoid Duplicate Code

```
public class Coin {
   /** default constructor */
   public Coin( ) {
      this.value = 0;
      this.currency = "THB";
   }
   public Coin(double value) {
      this.value = value;
      this.currency = "THB";
   }
   public Coin(double value,String currency)
{
      this.value = value;
      this.currency = currency;
```

These 3 constructors all do the same thing.

Constructor calls Constructor

A constructor can call another constructor using "this()", but it must be the first statement in constructor.

```
public Coin( ) {
    this( 0, "THB");
 }
 public Coin(double value) {
    this( value, "THB");
 }
 public Coin(double value, String curr) {
    if (value < 0)
        throw new IllegalArgumentException(...);
    this.value = value;
    this.currency = curr;
 }
```

Methods

- The behavior of objects is defined in methods.
- Methods contain the program's logic.

name of method

```
String makeHint(int guess) {
    if guess == this.secret
        return "You're right!"
    else if guess < this.secret
        return "too small"
    ...
}
```

instructions for this method

Method in Java

return value (nothing)

name of the method

start of method body

```
public void makeHint(int guess) {

        .
        .
        .
        .
}
```

instructions

of the method ("body")

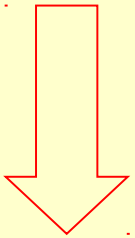
end of this method

The Body of a Method

The body of a method is a **list of instructions**.

Instructions are executed from top to bottom.

```
public void act( ) {
   move( );
   turn( 30 );
   move( );
}
```



list of instructions

You can use a { block } anywhere

You can use { } for "else" or "while" or ...

```
if ( guess > this.secret ) {
        block of statements for
        "then" case
}
else {
        block of statements for
        "else" case
}
```

else block

Writing a Method that Returns Result

this method returns an "`int`" value

```
public class Coin {
   private int value;
   /** compare 2 coins by value */
   public int compareTo(Coin other) {
      int diff = this.value - other.value;
      return diff;
   }
}
```

Method with a Parameter

We use *parameters* to give information to a method.

Behavior in English with *parameter*	Method in Java with *parameter*
turn ***left***	`turn( -90 )`
turn ***15 degrees***	`turn( 15 )`
can see ***a Worm*** *?*	`canSee( Worm.class )`
move to ***x , y***	`setLocation( x, y )`

Writing a Method with Parameter

specify the *data type* of the parameter value

the parameter name

```
/* Create some Coins */
void makeCoins( int howMany, int value ) {
   int count = 0;
   while ( count < howMany ) {
      list.add( new Coin(value) );
      count = count + 1;
   }
}
```

Attributes for Knowing Things

An object has to remember information.

A class defines the attributes of a kind of object.

Attributes are what an object knows

Attributes -

what a Purse knows

Methods -

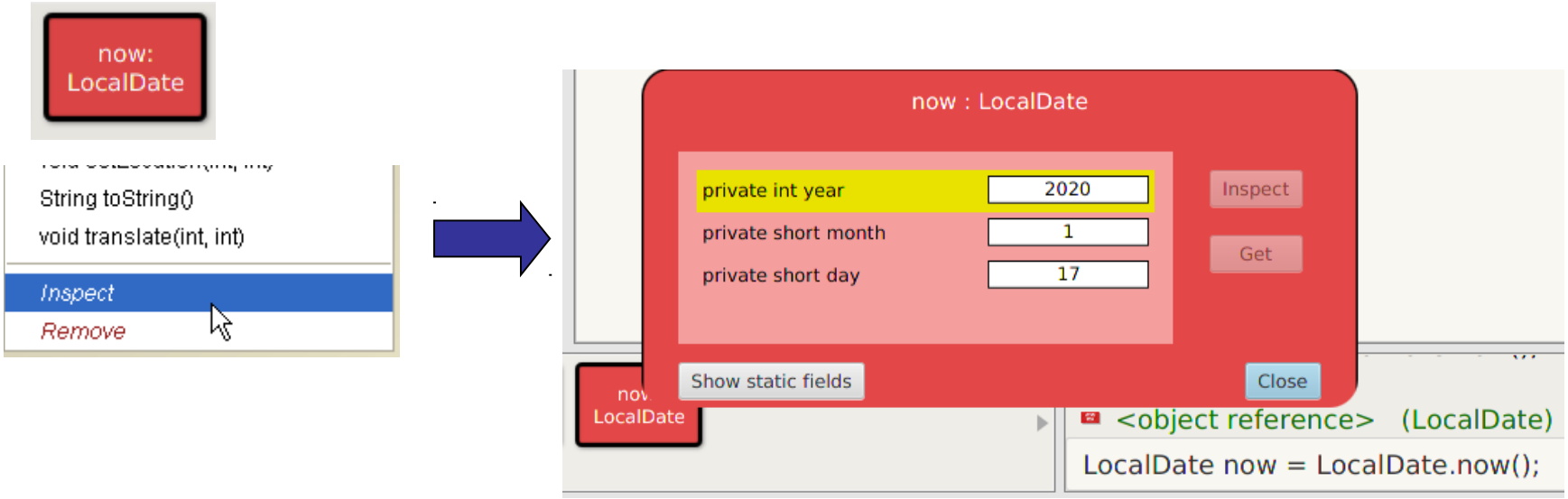
what a Purse can do

Purse
capacity: int coins: Coin[*]
getBalance( ) getCapacity insert(Coin) isFull( ) withdraw(amount)

See *attributes* of an Object

In BlueJ, you can "inspect" attributes of an object.

1. Create an object: `now` = java.time.LocalDate.now();
2. Type `now` on a line by itself, then drag to object workbench.
3. Right click and choose "*Inspect*". What are attributes?



Defining an Attribute

Attributes of an object are also called "fields" or "properties".

Attributes should be defined near top of class.

Attribute has a visibility, data type, and name.

You can optionally initialize its value.

Memory

0

```
class Coin {

    private int value = 0;
```

private:

Only this class can see **value**.

The type of data we want to store.

The name of this attribute

Assigning and Changing a Value

We can change the value of a variable as often as we like. To assign a value use:

```
variableName = some expression;
```

variable = *assign to* *expression*

```
count = 0;

count = count + 1;
```

Memory

0
1

Values and References

- A variable of a primitive type like "int" contains a value of the primitive.
- A variable of an object type like Coin is a reference.

Variables as *References*

A variable can be used to *reference* an object.

- A reference (variable) is how one object sends a message to another object.

Example:

A mobile phone contact is a *reference* to another object, such as a mobile phone number ...

Variables as References (2)

A variable is a reference to another object.

Example:

A Purse contains a *reference* to a List of coins.

The List contains *references* to Coin objects.

A Purse has a capacity which is just a value (int).

Variables as References (3)

Use a reference to ask as object some questions, using the object's methods.

```
void describe(Purse purse) {
   int balance = purse.getBalance();
   if ( purse.isFull() ) ...
```

Local Variables

Variables defined inside a method are local variables.

(1) can only be used *inside the method*

(2) deleted when the method returns

```
public class Purse {

  public int getBalance( ) {
    int balance = 0;
    for(int k=0; k<coins.size(); k++) {
        // add coins.get(k) to balance
    }
```

Local variables are defined inside a method.

3 Types of Variables

An object has access to 3 kinds of variables:

Attributes of the object

Static attributes of the class

Local variables and parameters - inside one method

Local Variables vs. Attributes

An **attribute** is something an object *remembers* for its whole life.

A **local variable** is for temporary data. It is deleted when execution leaves the method.

```
public class Purse {
  private int capacity;
  private List coins;
  public int getBalance( ) {
    int balance = ...;
    return balance;
  }
```

A purse must *remember* its capacity and coins

balance is a local variable. getBalance() recomputes it each time.

Don't need to remember it.

Static Method as Service

Some classes provide a "service".

A service is something that the class does, but is not associated with any object.

Services are defined by *static methods*.

Get the current system time in milliseconds:

```
System.getTimeMillis(  );
```

Name of Class

static method name

Service: method without an object

Some other service (static) methods:

Square root:

```
double r = Math.sqrt( 2 );
```

Convert a String to an integer:

```
int value = Integer.parseInt("123");
```

Play a sound in Greenfoot:

```
Greenfoot.playSound("starwars.wav");
```

These methods are performed by a class, not an object:

Service methods are static

A method that doesn't belong to an object is called static.

`Math.sqrt(2)` - static method in the **Math** class

`Integer.parseInt("1")` static method in **Integer**

To create a static method, add the word "**`static`**":

```
/** distance between points (x1,y1) and (x2,y2) */
public static double distance( x1, y1, x2, y2 ) {
   // hypot computes hypothenous of a triangle
   double d = Math.hypot( x1 - x2, y1 - y2 );
   return d;
}
```

Java Naming Convention

class name begins with Uppercase: `Coffee, String`

method name uses camelCase: `getMoreCoffee( )`

variable name also uses camelCase: `myCoffee`

constants use UPPER_CASE and _: `MAX_VALUE`

package names are all lowercase (but not always):

`java.lang  java.io  java.util  org.junit`

primitive type names are all lowercase:

`boolean, char, int, double, float, long`

What are these?

Date

System

System.nanoTime( )

System.out

System.out.println( )

double

Double

"Hello nerd".length( )

java.lang.Double.MAX_VALUE

Comparable

java.util

java.util.ArrayList

java.util.*List*

Is it a ...

package

class

primitive type

attribute ("field")

method

(static or instance)

constant

(static final attribute)

interface *(more advanced)*

???

Packages

- Java uses packages to organize classes.
- Packages reduce size of *name space* and avoid *name conflicts (two classes with same name)*

Example: there are 2 `Date` classes.

`java.util.Date` "`Date`" class in `java.util`

`java.sql.Date` "`Date`" class in `java.sql`

To use the Date from java.utll package, write:

```
import java.util.Date;
```

Core Packages

`java.lang`	Java language core classes. `Object, String, System, Integer, Double, Math, Thread` java compiler always imports this package, so you don't need to.
`java.io` **`(java.nio)`**	Classes for input and output `InputStream, BufferedReader, File, OutputStream`
`java.util`	collections, utilities, old Date/Time classes `Calendar, Date, List, ArrayList, Set, Arrays, Formatter, Scanner`
`java.time`	`LocalDate LocalTime Period ...`

Importing classes

Write "import" statements at top of file, **after** the "package" statement (if you have one).

```
package coinpurse;
import java.util.Scanner;
import java.util.List;
/**
 * User interface for coin purse.
 */
public class ConsoleDialog {
   Scanner console = new Scanner( System.in );
   ...
```

imports come after `package` statement and before class Javadoc comment.

What is "import"?

`import` tells the compiler *where* to find classes.

It does not actually "import" any <u>code</u>!

```
package guessinggame;
import java.util.Random;
/**
 * User interface for guessing game.
 */
public class GameDialog {
   private Random rand = new Random( );
   ...
```

tell the compiler where to find the Random class

Why `import`?

The reason for "import" to to resolve ambiguity.

Many classes can have the *same name*.

Java API has 2 classes named "`Date`".

5 classes & interfaces named "`Element`".

3 classes named "`Timer`".

If your program uses a `Date`, you need import to specify <u>which</u> `Date` you want:

```
import java.util.Date;
class Appointment {
   private Date startDate;
```

Import Everything

You can import everything from a package. Use *

```
package lazyimport;
import java.util.*;
import java.io.InputStream;

class Person {
   private static Scanner console = ...;
   private Date birthday;
   private List<Person> friends;
   ...
```

Ambiguity in `import`

If a class matches more than one wildcard "*", Java requires you to <u>resolve</u> the ambiguity using an import without the wildcard.

Example: There are 2 Date classes: `java.util.Date` and `java.sql.Date`. These imports are *ambiguous:*

```
import java.util.*;
import java.sql.*;
/** a class using a Date */
class Ambiguous {
   private Date today;
```

which **Date** class should Java use?

Resolving Ambiguity

There are two ways to resolve ambiguity.

1. import a specific class (no wildcard)
2. use the fully qualified name in Java code

```
import java.util.*;
import java.sql.*;
import java.util.Date; // Solution #1
class Ambiguous {
   private Date today = new Date( );
      // Solution #2: include full path
   private java.sql.Date mdate
         = new java.sql.Date( );
```

Packaging and Commenting Code

```
package coinpurse;
/**
 * Coin represents money with an integer value.
 * @author Bill Gates
 */
public class Coin {
   private int value;
  /**
   * Initialize a new coin object.
   * @param value is the value of the coin
   */
   public Coin( int value ) {
      this.value = value;
   }
```

Summary (1)

- ✓ A compiler translates Java source code into a form that can be run.
- ✓ An object-oriented program consists of classes.
- ✓ Classes can contain:

  attributes of objects -- things an object knows

  methods -- behavior of objects

  constructor -- initializes data of a new object

  static methods -- services provided by the class

  static variables -- things known by the class

Summary (2)

- In Java, all code must be part of a class.
- A class begins with the declaration:

  `public class SomeClassName`

  followed by the class definition inside { ... }
- "public" means that this class is visible to other classes.
- Inside a class, code is contained in *methods*.
- This main method is where program execution begins. The main method must have this header line:

```
public static void main( String [ ] args )
```

Summary (3)

- A class defines a kind of object, like Actor or Crab.
- The methods of a class contain the logic for how an object behaves (written in Java).
- A method can call other methods in the same object, e.g. `act( )` calls `move( )`.
- A method can call methods of other objects, e.g. `atWorldEdge()` calls `world.getWidth( )`.

General Class Structure

```
package greeting;
import java.util.Scanner;
import java.time.LocalTime;
/** Print an impersonal greeting message
 *  @author James Brucker
 */
public class Greeting  {
    public static final Strng GREET = "Hello";
    private static int counter = 0;
    /** instance variable */
    private String name;
    /** constructor for new objects
     * @param name is person to greet
     */
    public Greeting ( String name )  {
        this.name = name;
    }
    public void greet( ) {
        System.out.println(GREET + name);
```

1. package name (optional)
2. import statement(s) - may have many.
3. Javadoc comment for class
4. Start of the class

Contents of Class:

1. define constants first
2. static variables
3. instance variables
4. constructor(s) - optional
5. methods
6. private methods

method names: camelCase

Question: why { ... } ?

Why do we have to write **{** and **}** around the method instructions?

Why?

```
public void sayHello(String who) {
   System.out.println( "Hello "+who );
}
```

Why?

How to convert number to String?

How to convert a number n to a String?

```
int n = 100;

String s = n;  // error: must convert to string


// At least 4 possible solutions:

String s1 =

String s2 =

String s3 =

String s4 =
```

How to convert a number to String?

How to convert a number n to a String?

```
int n = 100;

String s = n;  // ERROR: must convert to string


// At least 4 solutions:

String s1 = Integer.toString( n );

String s2 = "" + n;

String s3 = String.valueOf( n );

String s4 = String.format( "%d", n );
```