11. Completing the Program

Increment 4: Completing the game

In this final increment we will complete the GCU adventure game. This means we have to meet the following requirements that were not met in the previous increments:

- *The sequence of turns should repeat until a command is given to quit*
- *At each turn, the player can type a command to specify the action which he or she wants to take during that turn*
- *The player should be able to ask for help during any turn instead of navigating*

Meeting these requirements will give a program that behaves like a game and allows the player to engage and interact with the game. It is worth noting that although the game is a very simple one which is not really fun to play, the model we have built, using sound object oriented principles and practices, would provide a solid basis for the development of a more complex and interesting version of the game.

Introducing interactivity - handling commands

Up to this point the adventure game is lacking in interactivity. There is no way for someone who is playing the game to control what happens. In a text-based adventure game, players interact with the game by typing **commands**. There is usually a limited set of commands that the game understands and which may cause some change in the game state. The user can type anything at all, but only valid commands will be understood.

An example of a command might be:

```
go west
```

The result of this command would be that the `Player` object would *go* to another room, using the exit from the current room marked *west*. The first command word (go) indicates the type of action to take, while the second command word (west) gives additional information about how to perform the action.

Some commands may have only one command word, for example:

`help`

This command would simply list the valid (first) command words in the game.

The design of the Player class will change now so that instead of simply using the objects in the current room, the `takeTurn` method will have a wider range of possible actions. This will be achieved by having the `takeTurn` method **process a command**.

The Command class

A command is fairly simple –just one, or possibly two, strings. It will be useful, though, to have a class that represents a command. The `Player` object will then process a `Command` object within its `takeTurn` method, and perform the requested action. It will be easier to write the new code in `Player` to do this if it can get a command as a single object rather than two separate strings.

We can also put some additional methods into `Command` to make it more convenient to use. A method `hasSecondWord` will provide an easy way to check whether a one-word or two-word command has been entered. Another method `isUnknown` will provide an easy way to check whether a command with an invalid first word has been entered.

Here is the code for the `Command` class:

```
public class Command
{
    private String commandWord;
    private String secondWord;

    public Command(String commandWord, String secondWord)
    {
        this.commandWord = commandWord;
        this.secondWord = secondWord;
    }

    public String getCommandWord()
    {
        return commandWord;
    }

    public String getSecondWord()
    {
        return secondWord;
    }

    public boolean isUnknown()
    {
        return (commandWord.equals("?"));
    }



    public boolean hasSecondWord()
    {
        return (secondWord != null);
    }
}
```

Relationship between Player and Command

There needs to be a relationship between `Player` and `Command` because a `Player` object will need to be able to send messages to a `Command` object to, for example, get the command words.

The `Player` object does not need to own the `Command`, it simply **uses** it in order to get information about what action to perform. This is another example of the "uses-a" pattern.

CODE PATTERN: ***"USES-A"***

Problem: how do you implement a "uses-a" relationship, where an object needs to send a message to another object

Solution: the class which needs to send the message has a method parameter or local variable whose type is the name of the other class.

There is an interesting difference between the `Player`-`Item` relationship that you saw previously and the `Player`-`Command` relationship. An `Item` exists as part of the game world - it belongs to a `Room` and stays there ready to be used by any `Player` who enters the `Room`. However, a `Command` object **only needs to exist while it is being processed**. As soon as it has been processed, and the player's turn in complete, that `Command` object is no longer needed and ceases to exist. The next turn will create a completely new `Command` object to be processed. `Command` objects are **temporary** objects.

The code pattern is similar, though. The revised version of the `takeTurn` method of `Player` now has a **local variable of type** `Command`.

```
    public boolean takeTurn()
    {
        Command command = ??
        return processCommand(command);
    }
```

`processCommand` will be a new method in `Player` which will contain the code which performs the action indicated by the `Command`. Note that we haven't yet decided how the `Command` will be created (hence the ?? which needs to be replaced at some point with some actual code), so this method is still not complete.

Note that the `takeTurn` method now returns a boolean value, which will be used in the game loop to decide whether to exit the loop after this turn.

Turning user input into a Command

There is something missing here. We need something that will do the job of taking the players' keyboard input and turning it into commands that can be processed. The player could potentially type anything at all – one word, two words or more; valid or invalid commands; complete or partial commands.

This "something" needs to:

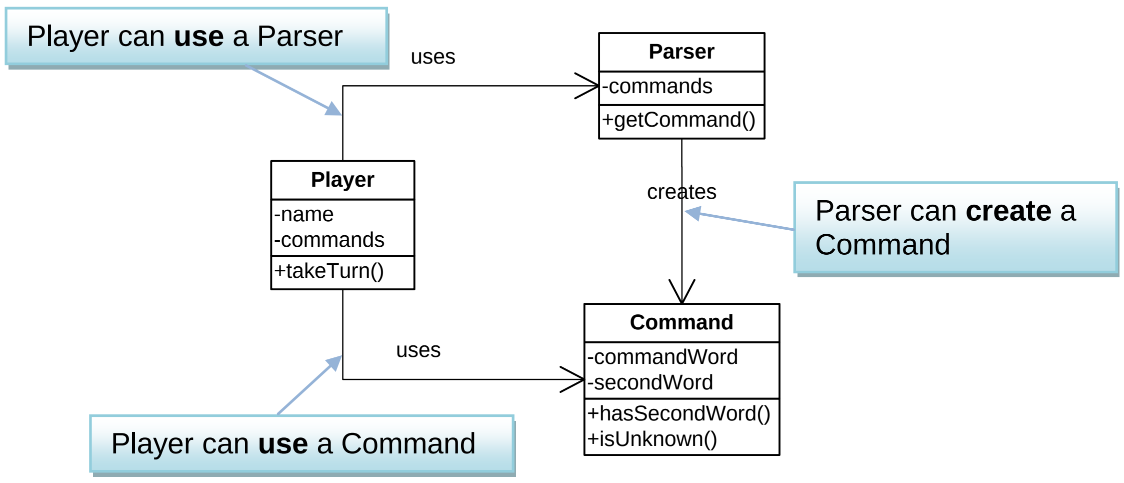
- Read in a line of text typed at the command prompt
- Split the input text into individual words
- Check that the first word is a valid command word
- Construct a `Command` object using the first word and the second word (if there is one), ignoring any additional words

The Parser class

In an object-oriented program, "something" is usually an object. We will need an object or objects that can do this job, and so we will need a class to allow these objects to be created. We didn't identify this class at the start of the development process – the need for it has only become clear when looking in more detail at the implementation of one of the requirements.

The class will be called `Parser`. A `Parser` object will **not** represent **an entity or concept** in the game. Instead, `Parser` is class that **performs a specific role** in the program.

`Parser` is related to both `Player` and `Command`. Here is the class diagram for these classes:



The relationship between `Player` and `Parser` is very similar to that between `Player` and `Command` – a `Player` object uses a `Parser` object. The `Parser` only needs to exist while it is doing its job.

Relationship between Parser and Command

A key part of the job of a `Parser` object is to create a new `Command`. The relationship between `Parser` and `Command` is an example of a new pattern:

CODE PATTERN: *"CREATES-A"*

Problem: how do you implement a "creates" relationship, where an object creates an instance of another class?

Solution: the class which creates the instance has a method which returns a value whose type is the name of the other class. The instance is newly constructed within this method.

Note that these **three classes work together** as follows:

- A `Player` uses a `Parser` to read input and create a `Command`
- The `Player` then uses that `Command` to decide what action to perform

The following listing shows some key features of the code for the `Parser` class. You can download the full code from GCULearn if you want to look at the details of the compete class.

```
public class Parser
{
    private String[] commands;  // holds all valid command words
    private Scanner reader;      // source of command input

    public Parser(String[] commands)
    {
        this.commands = commands;
        reader = new Scanner(System.in);
    }

    public Command getCommand()
    {
        String inputLine;   // will hold the full input line
        String word1 = null;
        String word2 = null;

        System.out.print("> ");     // print prompt
        inputLine = reader.nextLine();

        // Find up to two words on the line
        ...

        // replace any invalid command word with ?
        if(!isValidCommand(word1))
        {
            word1 = "?";
        }

        // construct and returns Command
        return new Command(word1, word2);
    }
    private boolean isValidCommand(String commandWord)
    {
       // checks whether commandWord is in array of valid commands
      ...
    }

    public String showCommands()
    {
      // returns a list of valid commands
      ...
    }
}
```

We can now fill in the rest of the `takeTurn` method in `Player`:

```
    public boolean takeTurn()
    {
        Parser parser = new Parser(commands);
        Command command = parser.getCommand();
        return processCommand(command);
    }
```

The variable `commands` is an array of type `String` which contains a list of all the valid command words which the `Player` can process. The command list is defined as a field in `Player`, which is then passed into the constructor of `Parser`.

```
    // valid command words
    private String[] commands = {"go","quit","help"};
```

The `Parser` and `Command` classes have no knowledge in advance of the actual list of valid commands, and will work with any list supplied by `Player` (or indeed by any other class which may use them). If we decide to add more commands later, then the only class that needs to be changed is the `Player` class.

Note that we are giving the `Player` class the **responsibility of knowing what commands are valid**. As you will see shortly this makes sense as we also give the `Player` class the **responsibility for processing the command**, so it will have to know what commands it can process. It is not completely obvious that these responsibilities belong to `Player` – we could probably have come up with an equally satisfactory design where these are the responsibilities of the `Game` itself. In object oriented programming there is not always just one possible way to solve a problem.

Processing a Command

The `Player` class has a method `processCommand` that uses the command word of a `Command` to decide what action to take. It can do one of the following:

- print a message if the command word is “?” (the value set if the user input is not recognised)
- print a help message if the command word is “help”
- go to another room if the command word is “go”

- return *true* if the command word is “quit” – this will act as a flag to stop the game loop

This method is private – it is not intended to be used by a call from another object. The method will only be called from methods within the `Player` class. In fact, it will only be called when the `takeTurn` method runs. It is defined as a separate method to make the code in the `Player` class more readable and cohesive.

In the case of a “go” command, the `Command` object will be passed to another private method, `goRoom`, which will use the second word of the command to decide which exit to go through. In the case of a “help” command, another private method `printHelp` will be called. In the case of a “quit” command, this method will return *true*, and will return *false* otherwise – the return value will be used to decide whether to end to game after this turn.

The code for `processCommand` is listed here.

```
private boolean processCommand(Command command)
{
    boolean quit = false;

    // get command word and use to select option
    String commandWord = command.getCommandWord();

    if(commandWord.equals("?")) {
        System.out.println("I don't know what you mean...");
    }
    else if (commandWord.equals("help")) {
        printHelp();
    }
    else if (commandWord.equals("go")) {
        goRoom(command);
    }
    else if (commandWord.equals("quit")) {
        System.out.println("the game will
              finish at the end of this round");
        quit = true;
    }
    return quit;
}
```

The switch statement

The sequence of **if** and **else** statements in the above code is a rather clumsy way of selecting from a list of choices based on the value of a variable. The **switch statement** is a statement that can make this arguably more elegant and readable. In a switch statement a variable is input as a **condition** that will determine the choice to be made. For each choice there is a **case**, or an action to be carried out. Each case is defined as a sequence of statements, which should end in a break statement.

The selection statement above can be replaced with the following switch statement. The condition variable in a switch statement can be an integer, character or string (note that in older versions of Java, prior to Java 7, strings were *not* allowed).

```
// get command word and use to select option
        String commandWord = command.getCommandWord();

        switch(commandWord)
        {
            case "?":
                System.out.println("I don't know what you mean...");
                break;
            case "help":
                printHelp();
                break;
            case "go":
                goRoom(command);
                break;
            case "quit":
                System.out.println("the game will finish
                       at the end of this round");
                quit = true;
                break;
        }
```

The goRoom method

The `goRoom` method is called if the command word is “go”. Here is part of the code for this method, giving an outline of how this works.

```
public void goRoom(Command command)
{
    if(!command.hasSecondWord()) {
            System.out.println("Go where?");
    }
    else
    {
        String direction = command.getSecondWord();

        Room nextRoom = this.getCurrentRoom().getExit(direction);

        if (nextRoom == null) {
            System.out.println("There is no door!");
        }
        else
        {
            this.setCurrentRoom(nextRoom);
            System.out.println(this.getCurrentRoom().
                 getDescription());
            // use the items in the room
            ...
        }
    }
}
```

The first part of the code checks whether the command has a second word – the player can’t move unless a direction is specified.

If the command has a second word, then we ask the current room for an exit with a label matching the second word, using the getExit method. If there is an exit with this label, we change the current room of the player to the room which that exit refers to.

The complete version of this method also loops through the items in the new room and calls the use method of each one. The code here is based on the code that we used in the takeTurn method of Player in previous increments before refactoring that method to process commands. You can download the full code from GCULearn if you want to look at the compete method.

The modified game loop

We are nearly finished the game. The last thing we will have to do is to modify the game loop, which is in the play method of Game. The last time we looked at this it simply gave the player one turn, then stopped. Now, we can make it continue looping until the player enters a quit command.

Note that the processCommand method returns true if the command is "quit". The takeTurn method in turn returns *true* to the code which calls it, which is the game loop. The game loop can then use the value returned by takeTurn to set the value of finished, the boolean variable it uses as a flag to stop the loop executing:

```
public void play()
{
    printWelcome();

    // Enter the main command loop.
    // Here we repeatedly read commands and execute them until game
    // is over
    boolean finished = false;
    do
    {
        System.out.println("Player: " + player.getName());
        finished = player.takeTurn();
    } while (! finished);
    System.out.println("Thank you for playing.  Good bye.");
}
```

Interfaces

The game is now complete, but before we run it let's look at an alternative (thought not necessarily better) approach we could have taken to meet one of the requirements, and in doing so introduce an object oriented concept that you will find increasingly useful as you go on to learn more about object oriented programming.

In lecture 9 you saw how to use inheritance to meet the requirement to have different kinds of items. We could have met this requirement another way, using an interface. Essentially, inheritance is concerned with **types of objects** while interfaces are concerned with **what objects can do**.

So what does an Item object actually have to do? It needs to be able to be **used** – a Player object calls the use method of an item object. The Player doesn't really care what type of object it is as long as this use method is available. As far as the Player is concerned, an item is simply **any object which has a method called use** which takes no parameters and a void return type. As long as an object can **guarantee** to have this method, then the `Player` will be happy to use it.

How does an object give this guarantee? In Java we can define a type that actually represents the guarantee. This is called an **interface**. An interface contains a list of **methods that are guaranteed to be available**. The guarantee that the `Player` is looking for can be written as an interface, which we will call `Usable`:

```
public interface Usable
{
     void use();
}
```

An interface is not a class – you can't use it to create objects. Therefore an interface doesn't have instance variables or constructors. It states what can be done, but not how this can be done, so the methods (only one in this case) don't have code blocks to implement the action that is performed.

Implementing an interface
A guarantee is not much use unless someone agrees to honour that guarantee. Similarly, an interface is only useful if a class agrees to implement that interface. Implementing an interface means providing all of the methods listed in the interface – and actually providing code to allow the methods to perform actions. The class can implement those methods any way it likes – as long as the method is there then the guarantee is honoured and the `Player` can use an object of that type. Here is the `Item` class (with some details missed out here for brevity) rewritten to implement `Usable`:

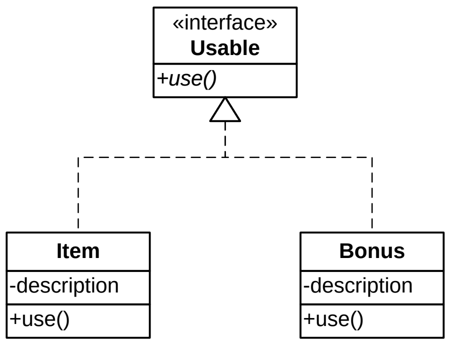
```
public class Item implements Usable
{
    private String description;

    public Item(String description)
    {
        this.description = description;
    }

    public void use()
    {
        System.out.format("You are using item: %s\n",
             description);
    }
}
```

And here is another class, `Bonus`, which also implements `Usable`, but provides a different implementation of the `use` method:

```
public class Bonus implements Usable
{
    private String description;
    private String codeWord;

    public Bonus(String description, String codeWord)
    {
        this.description = description;
        this.codeWord = codeWord;
    }

    public void use()
    {
        System.out.format("You are using bonus: %s\n",
             description);
        System.out.format("The secret code word is %s\n",
             codeWord);
    }
}
```

These two classes are different in the way they work, but both, by implementing the interface, guarantee to provide a `use` method, so can be used in the same way.

This is **different from inheritance**, as each class provides all of its own fields and methods, but they are linked by the fact that they implement a common interface. The class diagram looks like this:



Interface polymorphism
Interfaces allow us to take advantage of polymorphism rather like inheritance does. We can use the **name of an interface** as **the type of a variable**.

A variable of type `Usable` can refer to an object whose type implements `Usable`, for example the new version of `Item` shown in this section.

This means we can do this:

reference type

```
Usable myItem;
myItem = new Item(“my item”);
```

run-time type

or

```
Usable myBonus;
myBonus = new Bonus(“my bonus item”);
```

To apply this in the game, we can change the design of `Room` slightly so that its `items` collection contains `Usable` references:

```
private ArrayList<Usable> items;
```

and you can add any object of a type which implements `Usable`.

```
    public void addItem(Usable newItem)
    {
        items.add(newItem);
    }
```

Therefore the `Room` can contain any combination of `Item` and `Bonus` objects, and we can be sure because they implement the interface that a `Player` can use them. This needs a small modification to the code in `Player` that uses the items in a room (in the completed game version this is now in the goRoom method), so that it now has `Usable` as the reference type for `items`. `Room` has been modified to return its items as an array of type `Usable[]`.

```
        Usable[] items = currentRoom.getItems();
        for(Usable it : items)
        {
            if(it!=null)
                it.use();
        }
```

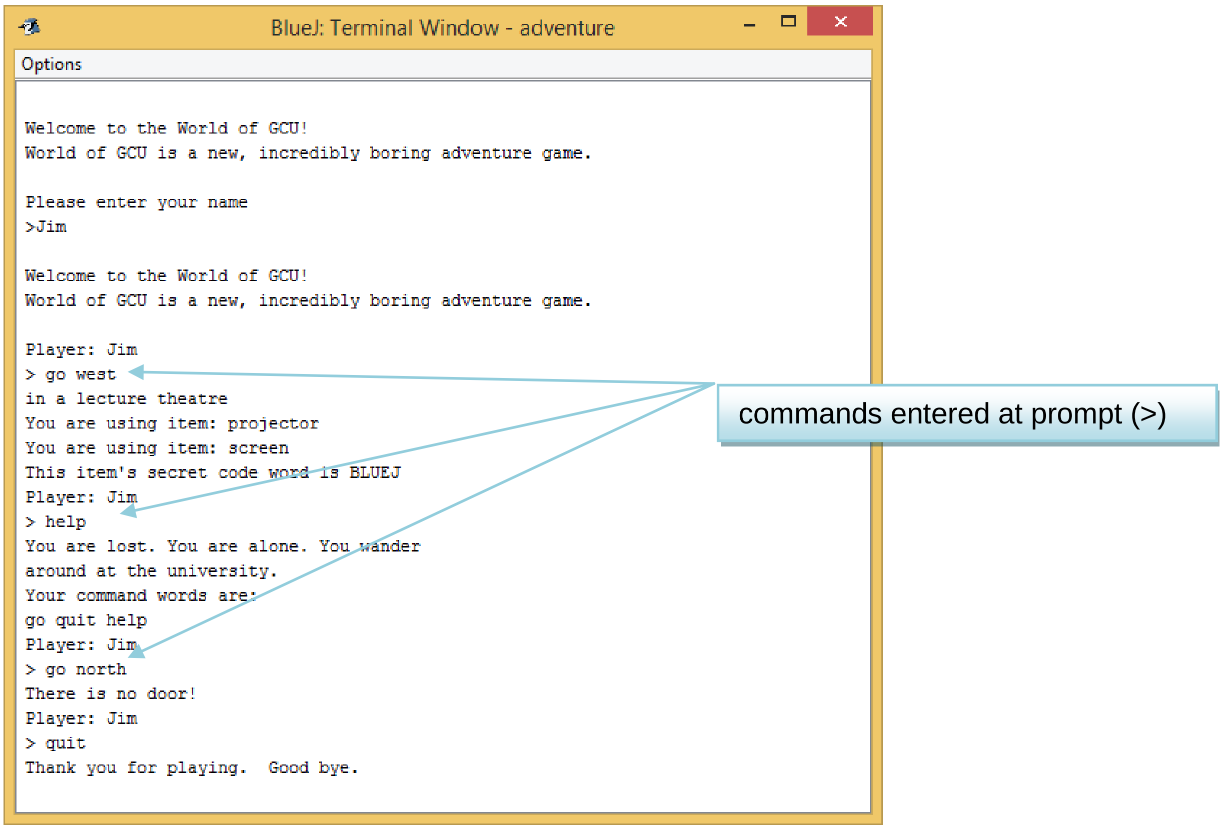
can do this as any object which implements *Usable* guarantees to have method *use*

Interfaces are very useful when you want one type of object to be able to collaborate with another, but you don't actually know what kind of object that will be. By programming with interfaces you can rely on the guarantee provided by the interface that as long as that object is of a type that implements the appropriate interface then it can be used successfully. This idea is widely used within the Java API classes.

Running the game

We can run the game simply by right-clicking on the `Game` class in the BlueJ class diagram and selecting the `main` method. The output appears in the terminal window.

Here is an example of game play

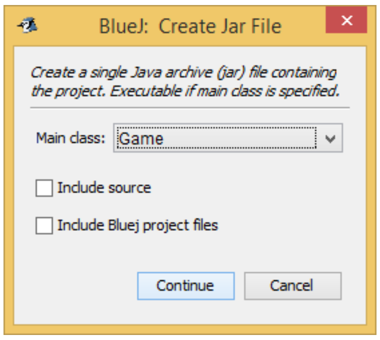

BlueJ: Terminal Window - adventure
Options
commands entered at prompt (>)

```
Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Please enter your name
>Jim

Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Player: Jim
> go west
in a lecture theatre
You are using item: projector
You are using item: screen
This item's secret code word is BLUEJ
Player: Jim
> help
You are lost. You are alone. You wander
around at the university.
Your command words are:
go quit help
Player: Jim
> go north
There is no door!
Player: Jim
> quit
Thank you for playing.  Good bye.
```

However, you do not expect users of your application to run it in BlueJ. Applications are usually run by **clicking on an icon** (for applications with a graphical user interface) or **typing a command at a command prompt**. BlueJ can package the game project so that it can be run at a system command prompt.

We select the Project > Create Jar File... menu option in BlueJ. This will package the contents of the project into a single, executable file, called a **Jar**. This is similar to a Windows .exe file.

The `main` method, which is the entry point which the operating system needs to launch the application, is in the `Game` class, so you need to specify that this is the main class in the Create Jar File dialog.



Create a single Java archive (jar) file containing the project. Executable if main class is specified.

Main class: Game

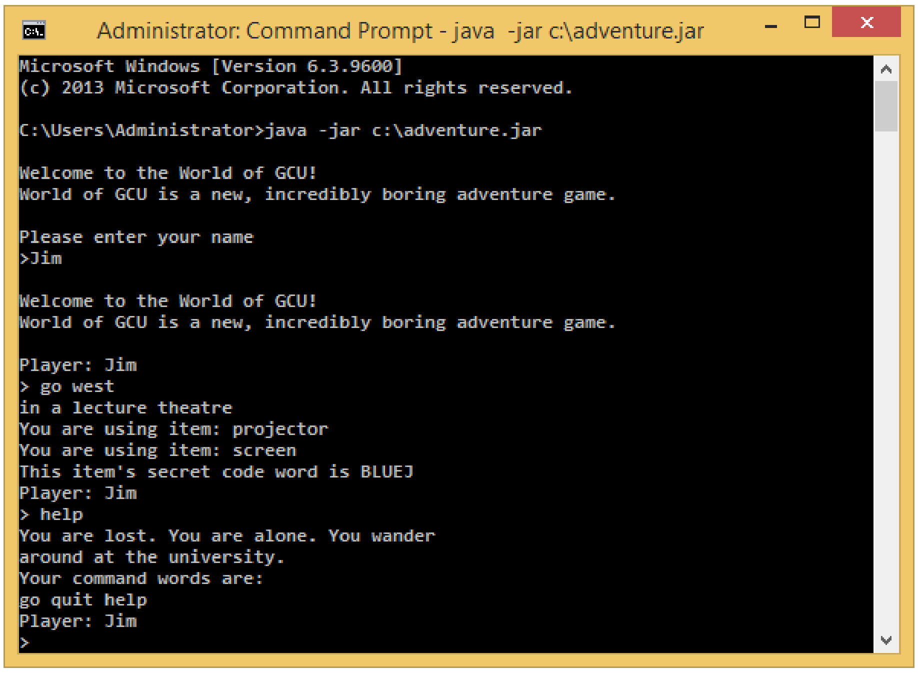
☐ Include source

☐ Include Bluej project files

We can then name the jar file and save it in a suitable location, for example C:\adventure.jar.

The application can then be run by entering the command:

java –jar c:\adventure.jar



```
Microsoft Windows [Version 6.3.9600]
(c) 2013 Microsoft Corporation. All rights reserved.

C:\Users\Administrator>java -jar c:\adventure.jar

Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Please enter your name
>Jim

Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Player: Jim
> go west
in a lecture theatre
You are using item: projector
You are using item: screen
This item's secret code word is BLUEJ
Player: Jim
> help
You are lost. You are alone. You wander
around at the university.
Your command words are:
go quit help
Player: Jim
>
```

Compiling and running Java programs without an IDE

Throughout this module we have used the BlueJ IDE (Integrated Development Environment) to help manage the process of editing, compiling, testing, debugging and deploying Java applications. Most programmers use an IDE because it helps them to do their job and to be more productive. BlueJ is designed to help you to learn about object-oriented programming, while more advanced IDEs like NetBeans and Eclipse (for Java) and Visual Studio (for C#) will provide support as you develop and apply your skills.

It is, however, useful to know how to work “without a tightrope”. The Java JDK provides a range of command prompt tools which, together with a simple text editor, can be used to create and run Java programs without an IDE. We have just looked at one example, the java command, which can be used to execute a JAR file created with BlueJ.

Here, we will look at how the adventure game application can be compiled and run using command prompt tools. There are also many other tools in the JDK, including the javadoc tool for creating documentation.

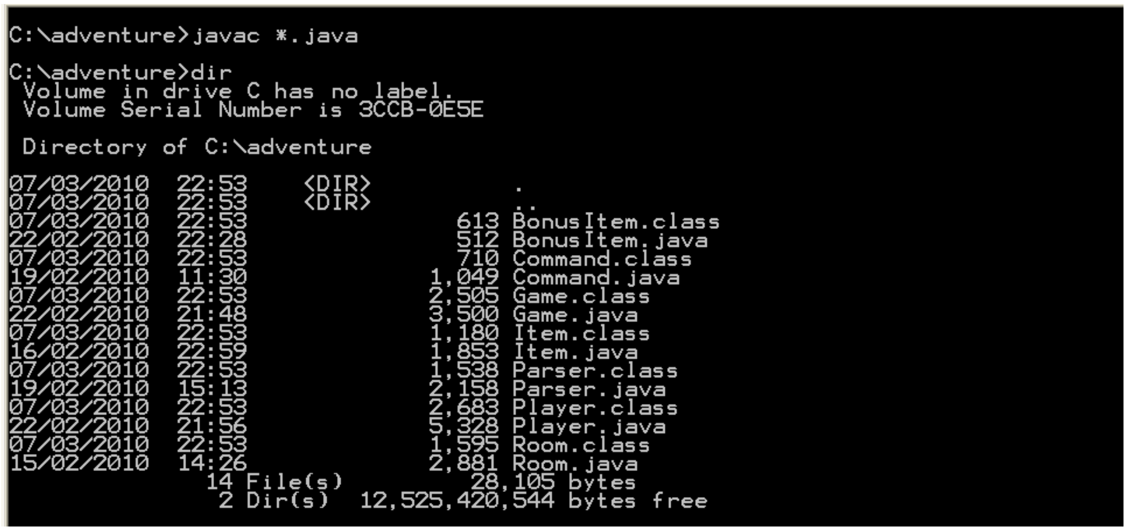
Compiling

The Java compiler is called **javac**. To compile a Java source file, for example Game.java, you use the command:

javac Game.java
In the figure below, the Java source files for the game are in a folder called *C:\adventure*, and this is the current working directory. The command:

javac *.java

uses the wildcard character * to select all Java source files in the folder and compile them. A compiled **.class file** is created for each class in the Java source files.



```
C:\adventure>javac *.java

C:\adventure>dir
 Volume in drive C has no label.
 Volume Serial Number is 3CCB-0E5E

 Directory of C:\adventure

07/03/2010  22:53    <DIR>          .
07/03/2010  22:53    <DIR>          ..
07/03/2010  22:53               613 BonusItem.class
22/02/2010  22:28               512 BonusItem.java
07/03/2010  22:53               710 Command.class
19/02/2010  11:30             1,049 Command.java
07/03/2010  22:53             2,505 Game.class
22/02/2010  21:48             3,500 Game.java
07/03/2010  22:53             1,180 Item.class
16/02/2010  22:59             1,853 Item.java
07/03/2010  22:53             1,538 Parser.class
19/02/2010  15:13             2,158 Parser.java
07/03/2010  22:53             2,683 Player.class
22/02/2010  21:56             5,328 Player.java
07/03/2010  22:53             1,595 Room.class
15/02/2010  14:26             2,881 Room.java
              14 File(s)         28,105 bytes
               2 Dir(s)  12,525,420,544 bytes free
```

Setting paths

Note that for this to work, the folder which contains the file *javac.exe* needs to be in the current **path**. Javac.exe is usually in a folder called **bin** within the JDK installation folder. You may need to add the Java *bin* folder to your path.

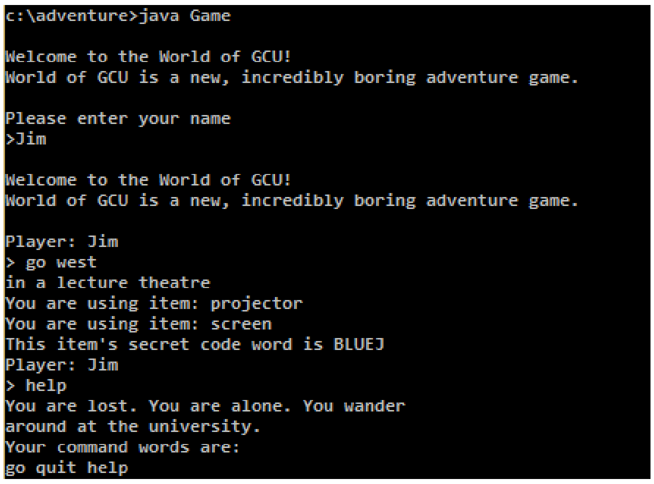
In Windows, the PATH environment variable contains a list of folders that Windows will search in when it is asked to execute a file that is not in the current folder. Other operating systems that support Java have similar environment variables that need to be set.

Instructions for setting the PATH variable for various operating systems can be found at
http://java.com/en/download/help/path.xml

Running

We can run the program by using the **java** command, specifying the name of the class which contains the main method. The command is:

java Game



```
c:\adventure>java Game

Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Please enter your name
>Jim

Welcome to the World of GCU!
World of GCU is a new, incredibly boring adventure game.

Player: Jim
> go west
in a lecture theatre
You are using item: projector
You are using item: screen
This item's secret code word is BLUEJ
Player: Jim
> help
You are lost. You are alone. You wander
around at the university.
Your command words are:
go quit help
```

When the `Game` class executes, it also requires the class files for the other classes in the game, for example *Player.class* and *Room.class*, which are in the current folder.

The **java** command is the same one we used earlier to execute a JAR file. The –jar option is required to execute a JAR. Note that the *java* command can also be used to create a JAR file. Deploying an application as a single JAR is more convenient than as a collection of separate class files.

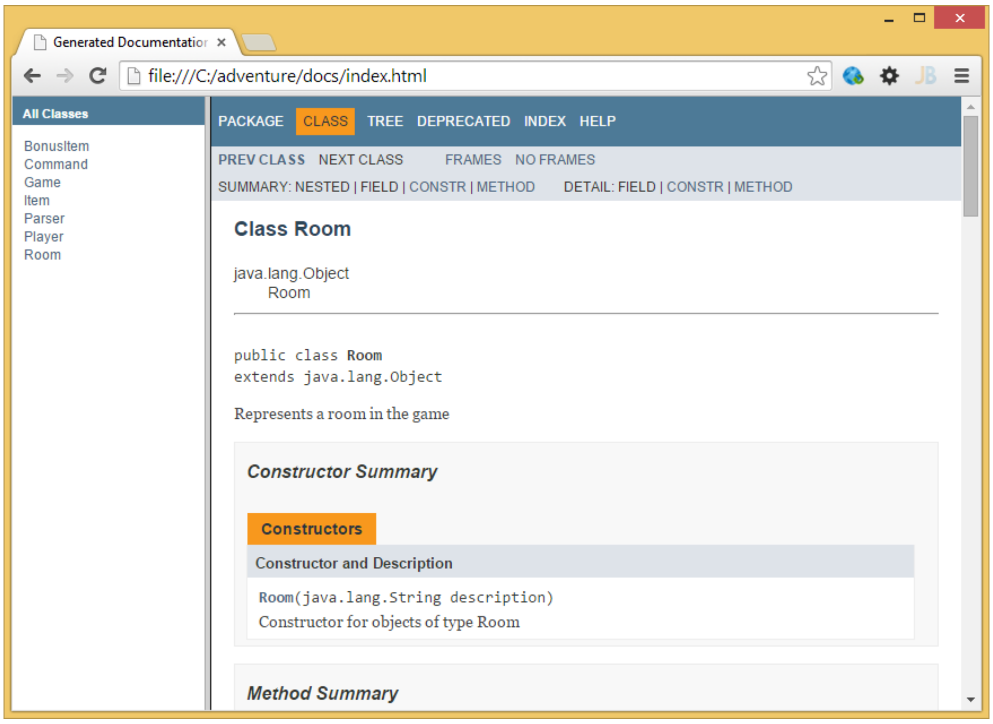
Creating documentation

You saw earlier that BlueJ can generate and show a documentation view of a class, making use of any javadoc comments you include in your code. The command line javadoc tool can do the same thing, but is much more powerful. For example, it can generate documentation for a complete program, as a set of HTML pages similar to the Java API documentation pages. In fact, Oracle's Java API documentation is created with the javadoc tool.

The following command will generate documentation for all the source code files in the current directory, and place the results in a subfolder called *docs*.

javadoc –d docs *

A list of messages in the command window shows the progress of the operation. If documentation comments are incomplete, for example missing @param elements, then you will see warnings. When the operation is complete you can view the results in a web browser, and you can browse all the classes.


Generated Documentation

file:///C:/adventure/docs/index.html

All Classes

BonusItem
Command
Game
Item
Parser
Player
Room

PACKAGE CLASS TREE DEPRECATED INDEX HELP

PREV CLASS NEXT CLASS FRAMES NO FRAMES

SUMMARY: NESTED | FIELD | CONSTR | METHOD DETAIL: FIELD | CONSTR | METHOD

Class Room

java.lang.Object
Room

```
public class Room
extends java.lang.Object
```

Represents a room in the game

Constructor Summary

Constructors

Constructor and Description
`Room(java.lang.String description)` Constructor for objects of type Room

Method Summary

Wrap up

You've been introduced in this lecture to the following concepts:

Switch statement, Interfaces, Jars, Java command-line tools

In the next lecture you will learn about using a more advanced Java IDE and to create Graphical User Interfaces for Java programs.

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