Programs that make decisions

- Programs that perform the same action every time are boring!
- You can vary the action in a program
  - By clicking different buttons
  - By getting input from the user:

```
String name = UI.askString("name:");
      :
UI.printf("Hello %s, how are you?", name);
```


Programs that make decisions

- But this just changes the values, not the action itself.
- To vary the action inside a method:
  - Need a conditional, or choice, statement:

    IF some condition is true
    THEN do this action
    ELSE do that action

  We do this in English instructions all the time:

    IF you solved the mouse maze
    THEN raise your hand

    IF your name starts with “A” or your name starts with “J”
    THEN draw a small circle in the top left corner of your notes
    ELSE draw a small square in the bottom right corner of your notes.

Decisions in Java

Java has an **if … else …** statement:

- Can do an action only in some circumstances:

```
if ( countTimes > 10 ) {
    UI.clearGraphics();
    this.drawBoard(10, 10, 100);
}
```

- Can choose between different actions:

```
if ( userChoice.equals("Yes" ) ){
    UI.drawImage("Nod.png", left, top);
}
else {
    UI.drawImage("Shake.png", left, top);
}
```


Java: if *and* if … else LDC 4.2

- Two forms of the **if** statement:

```
if ( ⟨condition⟩ ) {
    ⟨actions to perform if condition is true⟩
}
```

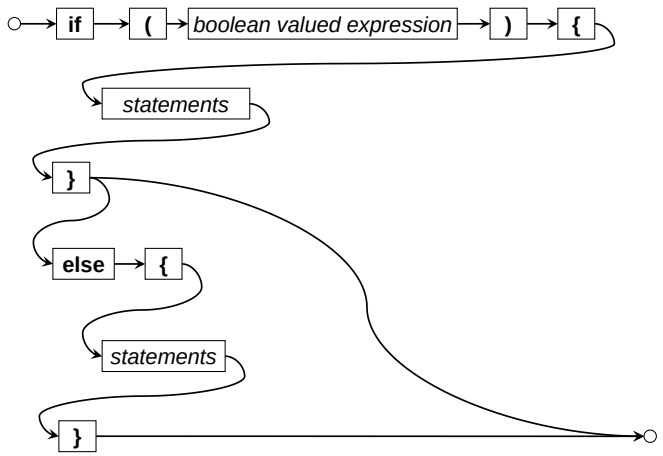
⇒ just skip the actions when the condition is not true !

and

```
if ( ⟨condition⟩ ) {
    ⟨actions to perform if condition is true⟩
}
else {
    ⟨actions to perform if condition is false⟩
}
```

Note: the **{** … **}** represent a "Block" – a sequence of actions that are wrapped up together into a single statement.

if … *vs* if … else …



Method with a condition

```
/** Ask for amount and currency; print note if –ve,  print value.*/
public void  convertMoney( ) { ;
    double amount = UI.askDouble("Enter amount $NZ");
    if ( amount < 0 ) {
        UI.println("Note: you have entered a debt!");
    }

    String currency = UI.askString ("Enter currency (US or Aus)");

    if ( currency.equals("US")  ) {
        UI.printf("$NZ%.2f  = $US%.2f\n", amount,  (amount * 0.668));
    }
    else  {
       UI.printf("$NZ%.2f  = $AUS%.2f\n", amountt,  (amount * 0.893));
    }
}
```

Like println, but can control the format:
- %.2f ⇒ floating point, 2dp
- %d ⇒ integer
- %s ⇒ string
- \n ⇒ new line

What is printf?

Multiway choice: if … else if … else if …

- Can put another **if** statement in the **else** part:

```
if ( 〈condition1 〉 ) {
  〈actions to perform if condition1 is true〉
    :
}
else if ( 〈condition2 〉 ) {
  〈actions to perform if condition 2 is true (but not condition 1) 〉
    :
}
else if ( 〈condition3 〉 ) {
  〈actions to perform if condition 3 is true (but not conditions 1, 2)〉
    :
}
else {
  〈actions to perform if other conditions are false〉
    :
}
```


Example with multiway choice

```
public void  convertMoney( ) {
    double amount = UI.askDouble("Enter amount");
    if (amount < 0 ) {
        UI.println("Note: you have entered a debt!");
    }
    String currency = UI.askString("Enter currency (US or Aus)");
    if (currency.equals("US")  ) {
        UI.printf("$NZ%.2f  = $US%.2f%n", amount , amount * 0.668);
    }
    else if ( currency.equals("Aus") ) {
       UI.printf("$NZ%.2f  = $AUS%.2f\n", amount , amount * 0.893);
    }
    else  {
       UI.printf("I cannot convert to %s currency%n", currency);
    }
}
```

Example 2 with multi way choice

```
public void  printPay( int day, int hours ) {
    double rate = 13.45;
    double pay = rate * hours;
    if ( day > 7 ) {
      UI.println(" Day must be between 1 and 7 ");
    }
    else if ( day < 6 ) {
      UI.printf("Pay = $ %.2f %n", pay);
    }
    else if ( day == 6 ) {
      pay = pay * 1.5;
      UI.printf("Pay = $ %.2f  ( time-and-a-half) %n", pay);
    }
    else {
      pay = pay * 2;
      UI.printf("Pay = $ %.2f  ( double-time) %n", pay);
    }
}
```


Boolean expressions LDC 4.1

What can go in the condition of an **if** statement?

- A Boolean value – a value that is either true or false.
- Boolean expressions:
  - constant values: true, false
  - numeric comparisons: (x > 0) (day <= 7), (x == y), (day != 7)
  - boolean method calls: month.equals("July") word.contains("th")
  - boolean variables: outlineOnly
    [if declared boolean outlineOnly;]
  - logical operators: !, &&, || (not, and, or)

```
( x > 0  &&  x < 7  && outlineOnly )
( month.startsWith("Ju") || month.equals("May") )
( ! fileModified ||  ! (cmd.equals("exit")) )
```

more methods on String
equalsIgnoreCase("John")
startsWith("Ab")
endsWith("ies")

Writing Boolean expressions

Mostly, boolean expressions are straightforward,
There are just a few traps:

- == is the "equals" operator for simple values,
  = is assignment
  (age == 15) *vs* ~~(age = 15);~~
  - But only use == for numbers (or characters, or references)
- Use the equals method for Strings, not ==
  (occasionally == will give the right answer by chance!)
  cur.equals("US") *vs* ~~cur == "US"~~
- String equality is case sensitive:
  "NZ".equals("nz") → false
  "NZ".equalsIgnoreCase("nz") → true

Boolean Variables

- A boolean value is a value!
  ⇒ it can be stored in a variable.
- Useful if the program needs to remember some option.
- Must declare the variable, and assign to it, before using it

```
boolean printSteps = UI.askBoolean("Print all steps?");
:
if ( printSteps )
   UI.println("Processed input");
:
if ( printSteps )
   UI.println("Computed Statistics");
:
```

Compound Boolean expressions: operators

Using logical operators:

Not: **!** eg (! currency.equalsIgnoreCase("US"))

And: **&&** eg (x > 0 && x < 7 && outlineOnly)

Evaluates each conjunct in turn.
If any conjunct false, then value of whole expression is false
If all conjuncts true, then value of whole expression is true

Or: **||** eg (month.startsWith("Ju") || month.equals("May"))

Evaluates each disjunct in turn.
If any disjunct true, then value of whole expression is true
If all disjuncts false, then value of whole expression is false

Can combine into complicated expressions:

(! fileModified || (cmd.equals("exit") && lastSaveTime > 5000))

safest to use lots of (…)

Traps with Boolean expressions

- When combining with && and ||, which binds tighter?

  if (x > 5 && y <= z || day == 0) { ….

  - Use (and) whenever you are not sure!

    if ((x > 5 && y <= z) || day == 0) { …

    if (x > 5 && (y <= z || day == 0)) { …

- The not operator ! goes in front of expressions:

  - **if (** !(x > 5 && y <= z **)** { … **NOT** **if (** (x !> 5 && y !<= z **)**
  - **if (** ! cur.equals("US") **)** { … **NOT** **if (** cur.!equals("US") **)** { …

  - **exception:** **if (** ! (count == 0) **)** { … *OR* **if (** count != 0 **)** { …

Object oriented programming

- Key idea of OO programming
  - program structured into classes of objects.
  - each class specifies a kind of object – eg, the actions it can perform.

- Calling methods in OO languages like java
  - tell an *object* to perform a *method*, passing *arguments*

- Making objects
  - Some objects are predefined.
  - Create objects with bluej:
    - Right-click on class, and select new ……
    - This is how we run programs with BlueJ.
    - not standard, and not a general solution

Objects

Question:
How can a program make new objects?

More Questions:
What is an object anyway?
Why do we need them?

- An object is typically a collection of data with a set of actions it can perform.

  - The objects we have made so far are a bit strange – no data; just actions. (TemperatureConverter, Drawer)

Examples of objects

Butterfly program

- Each butterfly is represented by an object which stores the state of the butterfly (position, wing state, direction)
- Butterflies have methods
  - move(double dist) and
  - land()

- CartoonFigure program
  - Each cartoon figure is represented by an object which stores the state of the cartoon figure (image, position, direction facing, smile/frown).
  - CartoonFigure objects have methods
    - walk(double dist)
    - smile() frown()
    - lookLeft() lookRight()
    - speak(String words) think(String words)

Using objects

- If the variable bf1 and bf2 contained Butterfly objects, you could do:

```
public void showButterflies(){
    Butterfly bf1 = ?????
    Butterfly bf2 = ?????
    bf1.move(10);
    bf2.move(20);
    bf1.land();
    bf2.move(20);
    bf1.move(5);
}
```

Nothing new here:
Just standard method calls!

Problem:
How do you get a Butterfly object into the variables?

Creating Objects

- Need to construct new objects:
- New kind of expression: **new**

```
Butterfly bf1 = new Butterfly(100, 300 );
```

Calling the constructor

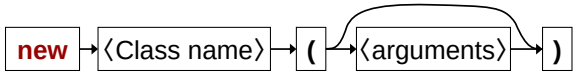
Creates a new object, which is put into bf1

- Constructor calls are like method calls that return a value.
  - have ( )
  - may need to pass arguments
  - returns a value – the new object that was constructed.
- Constructor calls are NOT method calls
  - there is no object to call a method on.
  - must have the keyword **new**
  - name must be the name of the class

Creating Objects: new

```
Butterfly b1 = new Butterfly(100, 300);

UI.setColor( new Color(255, 190, 0) );
```



- Calling a constructor:
  - **new** (a keyword)
  - Butterfly (the type of object to construct)
  - **(…)** (arguments: specifying information needed to construct the new object)
- This is an expression: it returns the new object
  - can put in a variable
  - can use in an enclosing expression or method call

Reading Documentation

- Documentation of a class:
  - Specifies the methods:
    - name
    - type of the return value (or void if no value returned)
    - number and types of the parameters.

      void move (double dist)
      moves the butterfly by dist, in its current direction.
  - Specifies the constructors:
    - number and types of the parameters
      (name is always the name of the class,
      return type is always the class)

      Butterfly(double x, double y)
      requires the initial position of the butterfly

Bluej lets you see the documentation of your classes

Example: Butterfly Grove program

```
public class ButterflyGrove{
   /** A grove of Butterflies which
       fly around and land   */

   public void oneButterfly(){
      Butterfly b1 = new Butterfly(50, 20);
      b1.move(5);
      b1.move(10);
      b1.move(15);
      b1.move(10);
      b1.move(11);
      b1.move(12);
      b1.move(13);
      b1.move(14);
      b1.move(15);
      b1.move(16);
      b1.move(10);
      b1.land();
   }

   public void twoButterflies(){
      Butterfly b1 =   new Butterfly(100, 20);
      b1.move(5);
      b1.move(10);
      b1.move(15);
      double x = 400*Math.random();
      Butterfly b2 = new Butterfly(x, 40);
      b2.move(10);
      b1.move(15);
      b2.move(10);
      b1.move(12);
      b2.move(10);
      b1.move(11);
      b1.move(7);
      b1.land();
      b2.move(20);
      b2.move(25);
      b2.land();
   }
```


Objects are values too:

- Objects can be passed to methods, just like other values.

```
public void Butterflies(){
    Butterfly b1 =   new Butterfly(100, 20);
    Butterfly b2 = new Butterfly(x, 40);
    this.upAndDown(b1);
    this.upAndDown(b2);
}

public void upAndDown(Butterfly b){
    b.move(10);
    b.move(15);
    b.land();
    b.move(15);
    b.move(20);
    b.land();
}
```


Menu

- More defining methods with parameters
- Methods that return values

Administration:

Another Java Program

- Design a Java program to measure reaction time of users responding to true and false "facts".
  - Ask the user about a fact: "Is it true that the BE is a 4 Year degree?"
  - Measure the time they took
  - Print out how much time.
- Need a class
  - what name?
- Need a method
  - what name?
  - what parameters?
  - what actions?

ReactionTimeMeasurer

```
/** Measures reaction times for responding to true-false statements */
public class ReactionTimeMeasurer {
    public ReactionTimeMeasurer(){
        UI.addButton("Measure Time", this::measureReactionTime);
    }
    /** Measure and report the time taken to react to a question */
    public void measureReactionTime() {
        .
        // find out the current time and remember it
        // ask the question and wait for answer
        .
        // find out (and remember) the current time
        // print the difference between the two times
    }
}
```

Write the method body in comments first,
(to plan the method without worrying about syntax)
Work out what information needs to be stored (ie, variables)

ReactionTimeMeasurer

```
/** Measure and report the time taken to react to a question */
public void measureReactionTime() {
    long startTime = System.currentTimeMillis();
    UI.askString("Is it true that the sky is blue?");
    long endTime = System.currentTimeMillis();
    UI.printf("Reaction time = %d milliseconds \n",  (endTime - startTime) );
}
}
```

Returns a very big integer
⇒ long
(milliseconds since 1/1/1970

Just asking one question is not enough for an experiment.
➔ need to ask a sequence of questions.

Multiple questions, the bad way

```
/** Measure and report the time taken to react to a question */
public void measureReactionTime(){
    long startTime = System.currentTimeMillis();
    UI.askString( "Is it true that John Quay is the Prime Minister");
    long endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );

    startTime = System.currentTimeMillis();
    UI.askString( "Is it true that 6 x 4 = 23");
    endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );

    startTime = System.currentTimeMillis();
    UI.askString( "Is it true that summer is warmer than winter");
    endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );

    startTime = System.currentTimeMillis();
    UI.askString( "Is it true that Wellington's population > 1,000,000");
    endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );
}
```

Lots of repetition.
But not exact repetition.
How can we improve it?

Good design with methods

- Key design principle:
  - Wrap up repeated sections of code into a separate method,
  - Call the method several times:

```
public void measureReactionTime ( ) {
    this.measureQuestion( "John Quay is the Prime Minister");
    this.measureQuestion( "6 x 4 = 23");
    this.measureQuestion( "Summer is warmer than winter");
    this.measureQuestion( "Wellington's population > 1,000,000 ");
}
public void measureQuestion ( String fact      ) {
    long startTime = System.currentTimeMillis();
    UI.askString("Is it true that " fact    . );
    long endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );
}
```

We need to *parameterise* the method

Improving ReactionTimeMeasurer (1)

```
public void measureReactionTime() {
    this.measureQuestion("John Quay is the Prime Minister");
    this.measureQuestion("6  x 4 = 23");
    this.measureQuestion("Summer is warmer than Winter");
    this.measureQuestion("Wellington's population > 1,000,000 ");
}
public void measureQuestion(String fact) {
    long startTime = System.currentTimeMillis();
    UI.askString("Is it true that" + fact);
    long endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );
}
```


Understanding ReactionTimeMeasurer

- What happens if we call the method on the object RTM1:

  RTM1 . measureTime();

```
public void measureReactionTime(){          this: RTM-1
    this.measureQuestion("John Quay is the Prime Minister");
    this.measureQuestion("6 x 4 = 23");
    this.measureQuestion("summer is warmer than Winter");
    this.measureQuestion("Wellington's population >1,000,000");
```

The object the method was called on is copied to "this" place

Understanding method calls

```
public void measureQuestion(String fact){ "          "   this: RTM-1
    long startTime = System.currentTimeMillis();
    UI.askString("Is it true that " + fact);
    long endTime = System.currentTimeMillis();
    UI.printf("You took %d milliseconds \n",  (endTime - startTime) );
}
```

Understanding ReactionTimeMeasurer

this:
RTM-1

```
public void measureReactionTime(){
✓ this.measureQuestion("John Quay is the Prime Minister");
  this.measureQuestion("6 x 4 = 23");
  this.measureQuestion("summer is warmer than Winter");
  this.measureQuestion("Wellington's population > 1,000,000");
```


Understanding ReactionTimeMeasurer

New measureQuestion worksheet:

this:
RTM-1

```
public void measureQuestion(String fact){ "          "
  ✓ long startTime = System.currentTimeMillis();
  ✓ UI.askString("Is it true that " + fact);
  ✓ long endTime = System.currentTimeMillis();
  ✓ UI.printf("You took %d milliseconds \n",  (endTime - startTime) );
  }
```

Each time you call a method,
it makes a fresh copy of the worksheet!

Understanding ReactionTimeMeasurer

this:
RTM-1

```
public void MeasureReactionTime(){
✓ this.measureQn("John Quay is the Prime Minister");
✓ this.measureQn("6 x 4 = 23");
  this.measureQn("summer is warmer than Winter");
  this.measureQn(" Wellington's population > 1,000,000");
```


Problem

- A good experiment would measure the average time over a series of trials
  - Our program measures and reports for each trial.
- Need to add up all the times, and compute average:
  - problem:
    - MeasureReactionTime needs to add up the times
    - MeasureQuestion actually measures the time, but prints it out.
    - How do we get the time back from MeasureQuestion to MeasureTime?

Methods that return values

- Some methods just have "effects":

```
UI.println("Hello there!");
UI.printf("%4.2f miles is the same as %4.2f km\n", mile, km);
UI.fillRect(100, 100, wd, ht);
UI.sleep(1000);
```

- Some methods just return a value:

```
long  now = System.currentTimeMillis();
double distance = 20 * Math.random();
double ans = Math.pow(3.5, 17.3);
```

- Some methods do both:

```
double height = UI.askDouble("How tall are you");
Color col =JColorChooser.showDialog(UI.getFrame(),  "paintbrush",   Color.red);
```


Defining methods to return values

Improving ReactionTimeMeasurer:

make measureQuestion **return** a value instead of just printing it out.

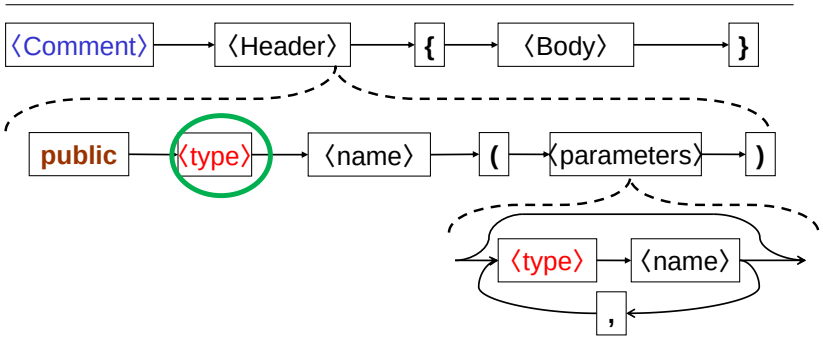
```
public void measureReactionTime() {
    long time = 0;
    time = time + this.measureQuestion("John Quay is the Prime Minister");
    time = time + this.measureQuestion("11 x 13 = 143");
    time = time + this.measureQuestion("Summer is warmer than Winter");
    time = time + this.measureQuestion(" Wellington's pop > 1,000,000 ");
    UI.printf("Average reaction time = %d milliseconds\n", (time / 4));
}
```

Specifies the type of value returned.
void means "no value returned"

```
public long measureQuestion(String fact) {
    long startTime = System.currentTimeMillis();
    ……
}
```


Syntax: Method Definitions (v3)

```
/** Measure time taken to answer a question*/
    public long measureQuestion ( String fact ){
        long startTime = System.currentTimeMillis();
          :
```



Defining methods to return values

If you declare that a method returns a value,
then the method body must return one!

```
public  long  measureQuestion(String fact) {
    long startTime = System.currentTimeMillis();
    String  ans = UI.askString("Is it true that " + fact);
    long endTime = System.currentTimeMillis();
    return  (endTime - startTime) ;
}
```

New kind of statement
Means: exit the method and return the value
The value must be of the right type

Returning values.

- What happens if we call the method:
  RTM-1 . askQuestions();

this: RTM-1

```
public void measureReactionTime(){
✓ long time = 0;                    0.
  time = time + this.measureQuestion("John Quay is the Prime Minister");
  time = time + this.measureQuestion("6 x 4 = 23");
  time = time + this.measureQuestion("summer is warmer than Winter");
  time = time + this.measureQuestion("Wellington's pop > 1,000,000");
```


Returning values

return value: . this: RTM-1

```
public long measureQn(String fact){   "                    "
   .    long startTime = System.currentTimeMillis();
 "  "    UI.askString("Is it true that " + fact);
   .    long endTime = System.currentTimeMillis();
        return (endTime - startTime) ;
}
```


Returning values.

- What happens if we call the method:
  RTM-1 . askQuestions();

this: RTM-1

```
public void measureReactionTime(){
✓ long time = 0;                    0.
✓ time = time + this.measureQuestion("John Quay is the Prime Minister");
  time = time + this.measureQuestion("6 x 4 = 23");
  time = time + this.measureQuestion("summer is warmer than Winter");
  time = time + this.measureQuestion(" Wellington's pop > 1,000,000");
```


Aside: Random numbers

- Math.random() computes and returns a random double
  - between 0.0 and 1.0
- To get a random number between min and max:
  - min + random number * (max-min)

  (50.0 + Math.random() * 70.0)

  gives a value between 50.0 and 120.0
- This is an expression:
  - can assign it to a variable to remember it
  - can use it inside a larger expression
  - can pass it directly to a method