



COMP110: Principles of Computing  
**2: Algorithms**



# Programming languages and paradigms



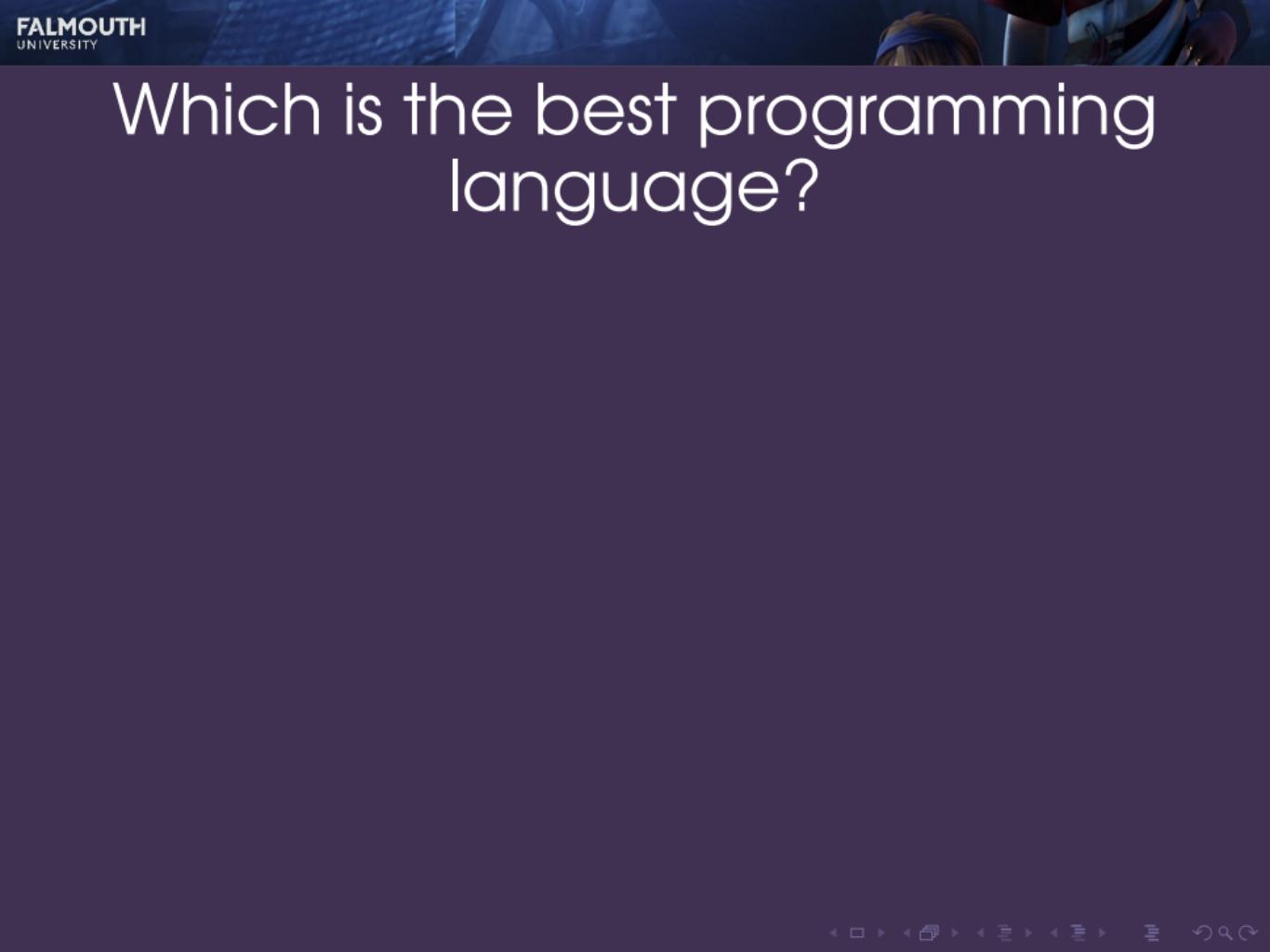
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- ▶ A **program** is a sequence of instructions for a computer to perform a specific task
- ▶ A **programming language** is a formal language for communicating these sequences of instructions



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- ▶ There are hundreds of programming languages, each better suited to some tasks than others
- ▶ Sometimes your choice is dictated by your choice of platform, framework, game engine etc.
- ▶ To become a better programmer (and maximise your employability) you should learn several languages (but one at a time!)

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- ▶ **High level languages** give the programmer **abstraction**, hiding the details of the hardware
- ▶ High level languages trade efficiency for ease of programming
- ▶ Lower level languages were once the choice of game programmers, but advances in hardware mean that higher level languages are often a better choice

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- ▶ **Declarative**: does not define the control flow of a program, but rather defines logical relations

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- ▶ Purely **functional** languages are mainly used in academia, but favoured by some programmers
- ▶ Purely **declarative** languages have uses in academia and some special-purpose languages

# Machine code

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00000000 4d 5a 90 00 03 00 00 00 04 00 00 00 ff ff 00 00
00000010 b8 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00
00000020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
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- ▶ More on this later in the module
- ▶ Nobody has actually written programs in machine code since the 1960s...

# Assembly language

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section      .text
global       _start

_start:

    mov      edx,len
    mov      ecx,msg
    mov      ebx,1
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- ▶ Also not portable between CPU architectures

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#include "stdafx.h"
#include "GameObject.h"
#include "CoinGame.h"

GameObject::GameObject(CoinGame* game, Texture* sprite)
    : game(game), sprite(sprite), isDead(false)
{
    x = rand() % CoinGame::WINDOW_WIDTH;
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GameObject::~GameObject()
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void GameObject::render(SDL_Renderer* renderer)
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    sprite->render(renderer, x, y, CoinGame::SPRITE_SIZE, CoinGame::SPRITE_SIZE);
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bool GameObject::checkCollision(int otherX, int otherY)
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    double distance = sqrt(pow(otherX - x, 2) + pow(otherY - y, 2));
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- ▶ Also used by developers of operating systems and embedded systems, but falling out of favour with other software developers

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There are many others, but these are the most commonly used in game development

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- ▶ UnrealScript, Blueprint (Unreal Engine)

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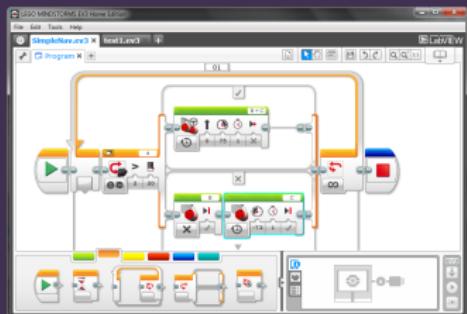
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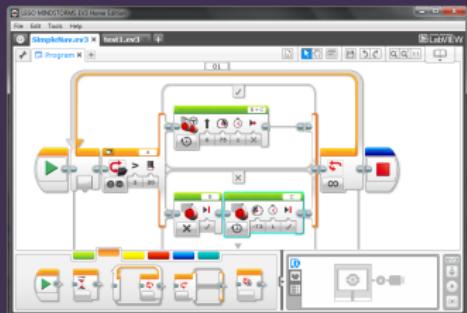
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- ▶ UnrealScript, Blueprint (Unreal Engine)
- ▶ GML (GameMaker)

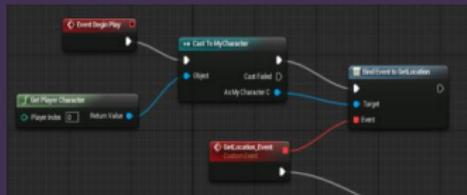
# Visual programming languages



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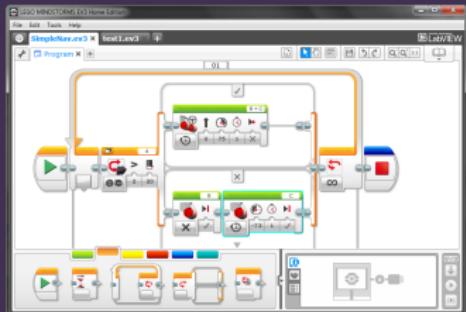


Based on connecting graphical blocks rather than writing code as text



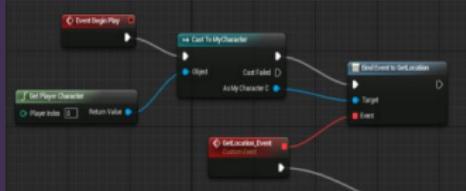


# Visual programming languages

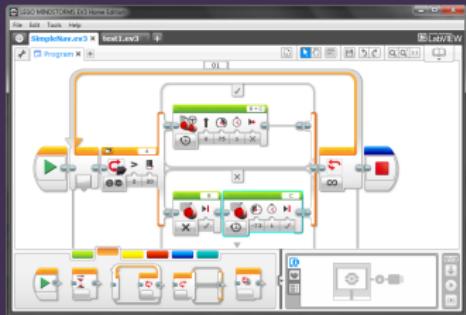


Based on connecting graphical blocks rather than writing code as text

- ▶ Scratch (used for teaching in school)

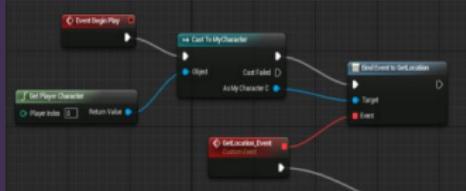


# Visual programming languages



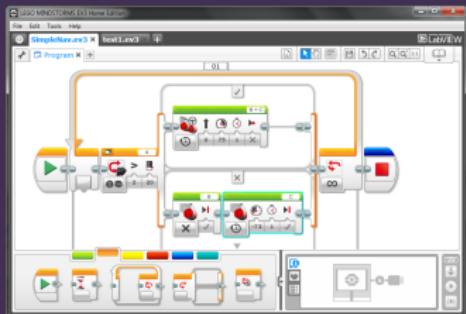
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# Visual programming languages

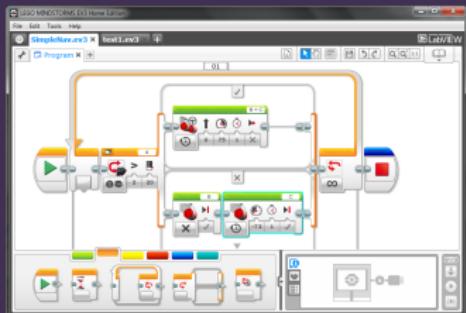


Based on connecting graphical blocks rather than writing code as text

- ▶ Scratch (used for teaching in school)
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- ▶ Blueprint (Unreal)



# Visual programming languages



Based on connecting graphical blocks rather than writing code as text

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Note: despite the name, Microsoft Visual Studio is **not** a visual programming environment!

# Special purpose languages

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- ▶ LEX, YACC (script interpreters)

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- ▶ HTML, CSS (web pages)
- ▶ LaTeX, Markdown (documentation)
- ▶ XML, JSON (data storage)

# Which programming language is most popular?

<http://githut.info>

# “Family tree” of programming languages

<https://www.levenez.com/lang/lang.pdf>

# Algorithms



# What is an algorithm?

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A **sequence of instructions** which can be followed **step by step** to perform a **(computational) task**.

# Algorithms historically

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- ▶ Used in mathematics to describe steps for calculations
  - ▶ E.g. Euclid's algorithm for finding the greatest common divisor of two numbers
- ▶ Computers developed as machines for carrying out mathematical algorithms

# Programs vs algorithms

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  - ▶ E.g. Microsoft Word is not an algorithm, but it implements many algorithms
  - ▶ E.g. it implements an algorithm for determining where to break a line of text, how much space to add to centre a line, etc.

# Algorithms outside computing

- 1 Preheat the oven to 180C, gas 4.
- 2 Beat together the eggs, flour, caster sugar, butter and baking powder until smooth in a large mixing bowl.
- 3 Put the cocoa in separate mixing bowl, and add the water a little at a time to make a stiff paste. Add to the cake mixture.
- 4 Turn into the prepared tins, level the top and bake in the preheated oven for about 20-25 mins, or until shrinking away from the sides of the tin and springy to the touch.
- 5 Leave to cool in the tin, then turn on to a wire rack to become completely cold before icing.
- 6 To make the icing: measure the cream and chocolate into a bowl and carefully melt over a pan of hot water over a low heat, or gently in the microwave for 1 min (600w microwave). Stir until melted, then set aside to cool a little and to thicken up.
- 7 To ice the cake: spread the apricot jam on the top of each cake. Spread half of the ganache icing on the top of the jam on one of the cakes, then lay the other cake on top, sandwiching them together.
- 8 Use the remaining ganache icing to ice the top of the cake in a swirl pattern. Dust with icing sugar to serve.

# Algorithms outside computing

**How To : Solve A Rubik's Cube**

**THINGS TO KNOW BEFORE YOU START**

- The square in the middle of one side indicates that color's code, e.g. green square = green side.
- Always hold the cube so the 'Front' face is towards you when completing moves.
- The cube can be inverted or counter-clockwise in direction.
- Each turn is 1/4 turn (rotation/90°).

**LAYERS**

**MOVES**

**STEP 1: CROSS**

Locate the orange center piece and place it to the top layer.

**STEP 2: CORNERS**

Locate orange corner pieces in the top layer and place it to its corresponding corner cubies.

**STEP 3: NUBBLE**

Flip the cube, compare layer colors on bottom. Find and move centre cubies in top layer to align colors with middle layer.

**STEP 4: TOP CROSS**

Locate orange in top layer and move it to the top-right corner.

Do F R U R U L F R U L F

**STEP 5: TOP CORNERS**

Rotate top layer so one corner is matching with its corner colors and place it to bottleneck.

Do sequence: U R U D U R U L

Repeat sequence until the correct corner is in the bottleneck. If movements have corresponding unnecessary turns, do all or all the colors will be scrambled.

**C:** Starting the bottom right cubie: R U R U

Repeat until corner is completed. Enter CF-B into the top layer and continue sequence for other corners.

**COMPLICATIONS**

Color is inverted after completing top layer.

Do left or right sequence and this will bring it to the top layer. Repeat step 5.

Opposite sides match up with **C** and continue from **C**.

**COMPLETION**

If the puzzle is finished, do F U E U.

**COMPLETION**

Rotate top and bottom layers to match middle layer colors.

**COMPLETED**

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- ▶ Can **prove** mathematically that an algorithm does what it is supposed to
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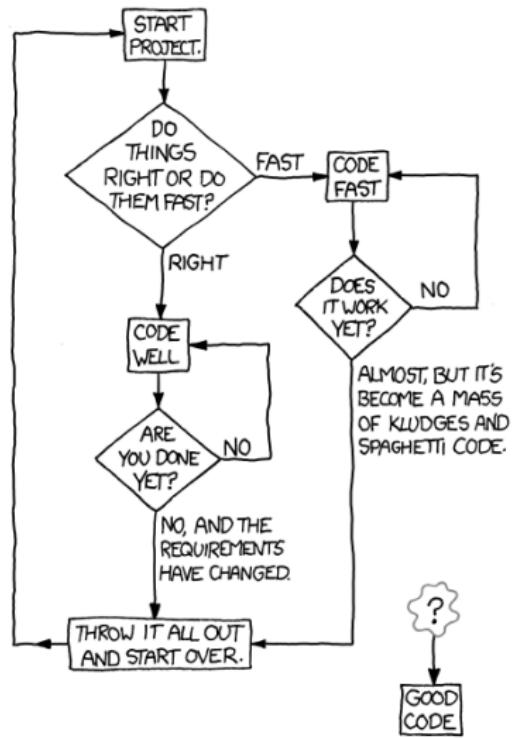
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- ▶ Can **prove** mathematically that an algorithm does what it is supposed to
- ▶ Can reason about the **complexity** (time, space etc) of an algorithm — and place **lower bounds** on the best possible algorithm
- ▶ **Computability** theory lets us reason about what computations are and are not possible

# Flowcharts

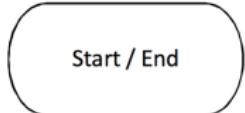


## HOW TO WRITE GOOD CODE:

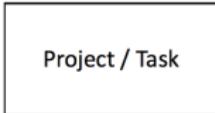


<http://xkcd.com/844/>

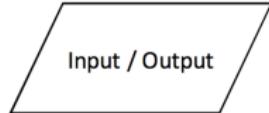
# Flowchart symbols



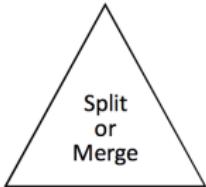
The start or end of a workflow.



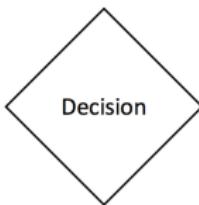
Process or action.



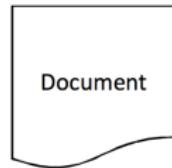
Data: Inputs to, and outputs from, a process.



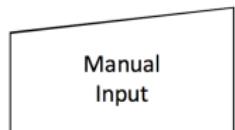
Upright indicates a process split, inverted indicates a merge of processes.



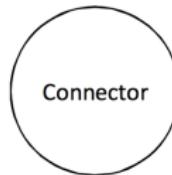
Decision point in a process or workflow.



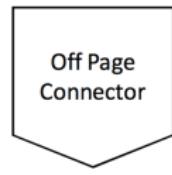
Document



Prompt for information, manually entered into a system.

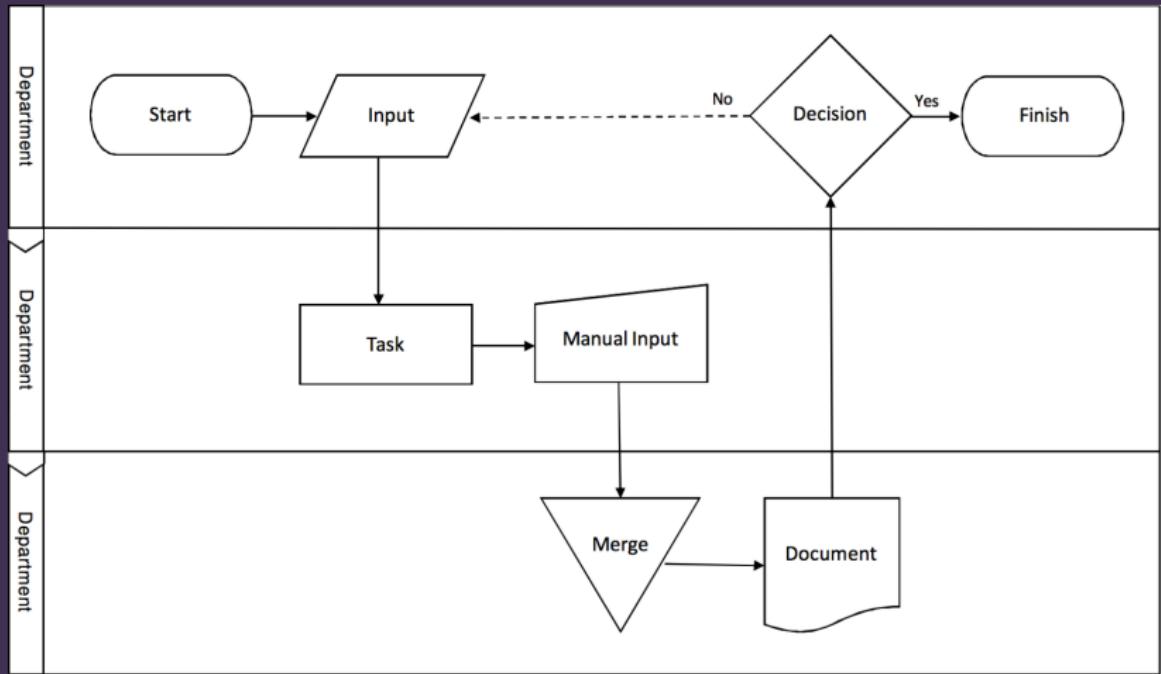


Used to connect one part of a flowchart to another.



Connector used to connect one page of a flowchart to another.

# Swimlanes



# Software for drawing flowcharts

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If you're desperate:

- ▶ Any drawing package (Inkscape, Adobe Illustrator, Apple Keynote, ...)
- ▶ MS Paint
- ▶ Pen and paper

# Activity

- ▶ In your **breakout groups**
- ▶ **Draw** a flowchart for **logging into Facebook**
- ▶ Include at least two swimlanes: **the user's browser/device** and **the Facebook server**
- ▶ Post your flowchart in **chat**



Session will resume at 16:05

# UML activity diagrams

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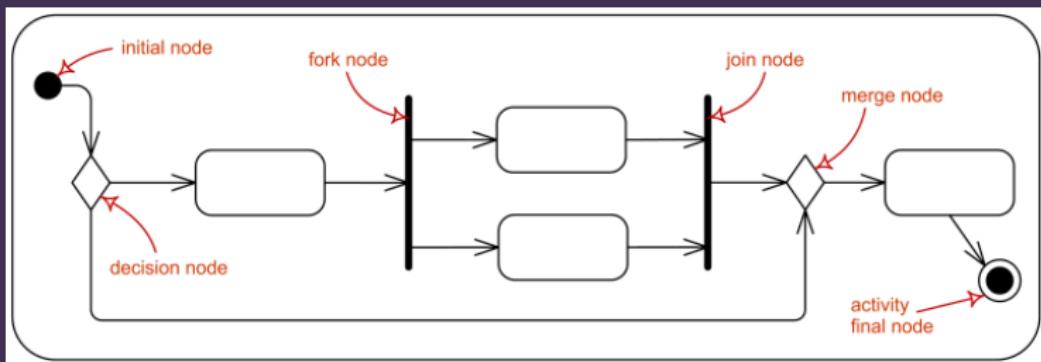
- Modern counterpart of flowcharts

# UML activity diagrams

- ▶ Modern counterpart of flowcharts
- ▶ UML = Unified Modeling Language — defines 14 types of diagram to represent various aspects of computing systems, of which activity diagrams are one

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**Pseudocode** expresses an algorithm in a way that looks more like a structured program

# Pseudocode example

```
print "How old are you?"  
read age  
if age < 13 then  
    print "You are a child"  
else if age < 18 then  
    print "You are a teenager"  
else  
    print "You are an adult"  
end if
```

# Pseudocode example

```
sum ← 0           ▷ initialisation
for i in 1, . . . , 9 do
    sum ← sum + i
end for
print sum       ▷ print the result
```

<https://socrative.com>, room code FALCOMPED:  
what would this print?

# Pseudocode example

```
a ← 1           ▷ initialisation
while a < 100 do
    a ← a × 2
end while
print a         ▷ print the result
```

<https://socrative.com>, room code FALCOMPED:  
what would this print?

# Formatting pseudocode

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- ▶ Pseudocode is a **communication tool**, not a **programming language**
- ▶ Important: **clear, concise, unambiguous, consistent**
- ▶ **Not** important: adhering to a strict set of style guidelines, ensuring direct translatability to your chosen programming language

# Level of abstraction

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Whether working with flowcharts or pseudocode, choose your **level of abstraction** carefully

# Level of abstraction: Good

Fill kettle

Turn kettle on

Put teabag in mug

**if** sugar wanted **then**

    Add sugar

**end if**

Wait for kettle to boil

**if** milk wanted **then**

    Pour water to  $\frac{4}{5}$  full

    Add milk

**else**

    Fill mug with water

**end if**

Stir

# Level of abstraction: Not so good

Position kettle beneath tap

Turn tap on

**while** water is below halfway point **do**

    Wait

**end while**

Turn tap off

Place kettle on base

Press power button

...

# Level of abstraction: Silly

Place right palm on kettle handle

Bend fingers on right hand

Lift arm upwards

**while** tap spout is not directly above kettle **do**

    Move arm to the right

**end while**

Place left palm on tap handle

Bend fingers on left hand

Rotate left hand

...

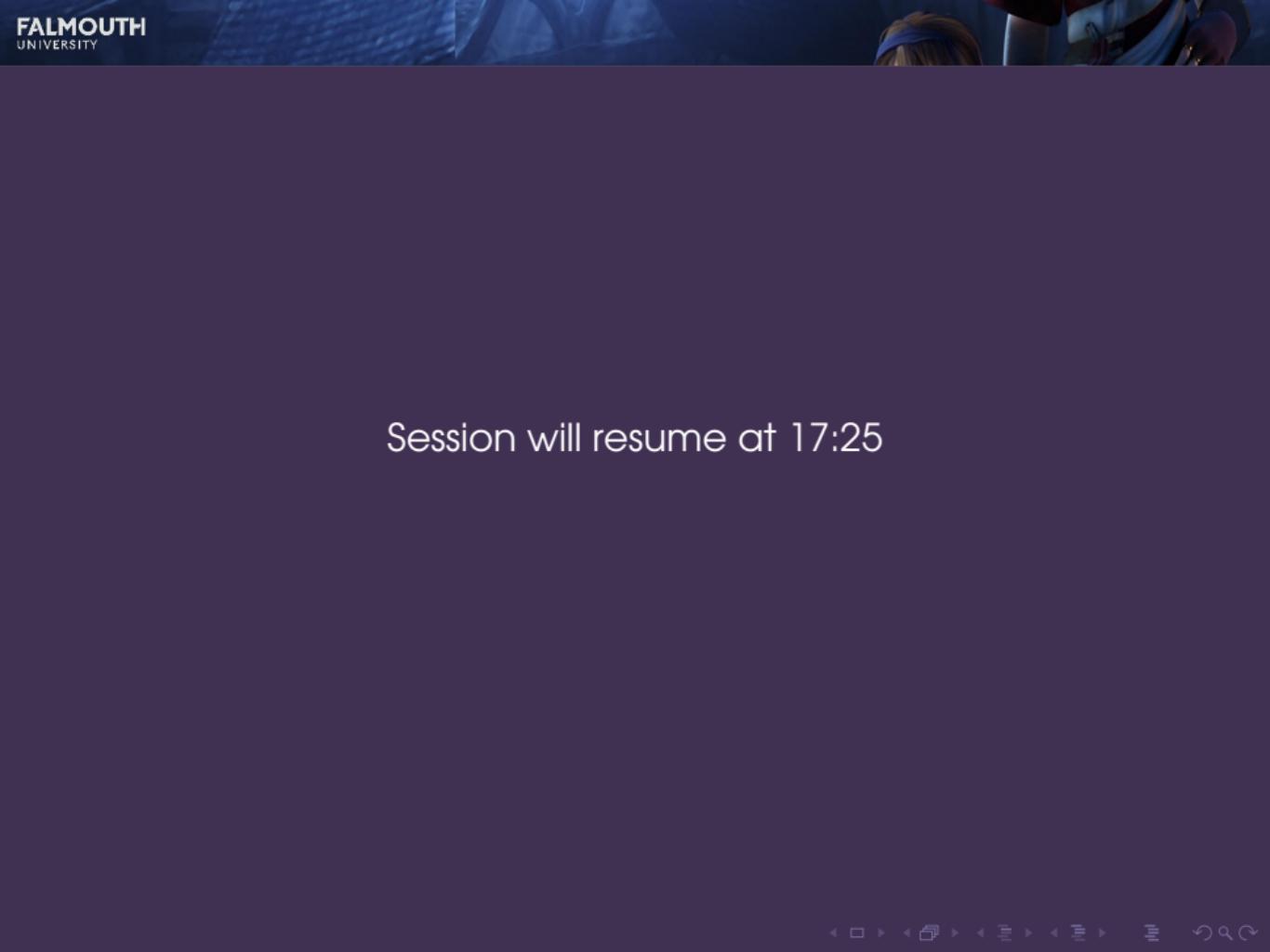
# Level of abstraction: also silly

Make a cup of tea

# Activity

A number guessing game: The computer chooses a number between 1 and 20 at random. The player guesses a number. The computer says whether the guessed number is “too high”, “too low” or “correct”. The game ends when the correct number is guessed, or after 5 incorrect guesses.

- ▶ In your **breakout groups**
- ▶ **Write** pseudocode for the number guessing game
- ▶ **Post** your pseudocode in chat
- ▶ Tip: type ` ` (top left key on a UK keyboard) **before and after** your pseudocode to preserve indentation and line breaks!



Session will resume at 17:25