COMP280: Specialisms in Creative Computing

7: AI Architectures

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What is AI?

What is AI?

- ✗ Simulating human brains or human intelligence
- ✓ Performing tasks by machine (or by software) which would ordinarily require human intelligence
- ✓ Making decisions to achieve goals

What is AI?

- ✗ Programming machines to learn by themselves
- ✓ Machine learning is an important sub-field of AI, but there are many other AI techniques

What is AI?

- ✗ Programming machines to possess general intelligence, self-awareness, consciousness
- ✓ Maybe one day, but for now this is pure sci-fi
- ✓ Programming machines to carry out (or learn to carry out) a specific type of task

Computers vs brains

Discuss:

- For what kinds of tasks are digital computers "better" than human brains?
- For what kinds of tasks are human brains "better" than digital computers?
- For what kinds of tasks are both "good", but approach the task in different ways?

Is it AI?

Discuss: are these examples of AI?

- Calculator
- Computer opponent in a chess program
- Enemy in a video game
- Facebook newsfeed
- Autocorrect in a text messaging app
- Autocompletion in an IDE
- Spellchecker
- Satellite navigation
- Virtual assistant (e.g. Siri, Alexa, Cortana etc.)
- Amazon product recommendations
- Search function in a text editor
- Google search
- C++ compiler
- Robot

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AI in games

Applications of AI in games

- Enemies and other NPCs
- Opponents in {board, card, strategy} games
- Automated playtesting
- Directors, hints, adaptive difficulty
- Procedural content generation
- Content production tools
- Procedural narrative
- Agent-based simulations
- ...

Design considerations

- Creating "perfect" AI is an interesting technical challenge, but may be bad game design

```
procedure EnemySoldierAI
    while player.isAlive do
        AimAt(player.head)
        Shoot( )
    end while
end procedure
```

- A common (and difficult) challenge: creating AI which is **imperfect**, but not obviously **stupid**

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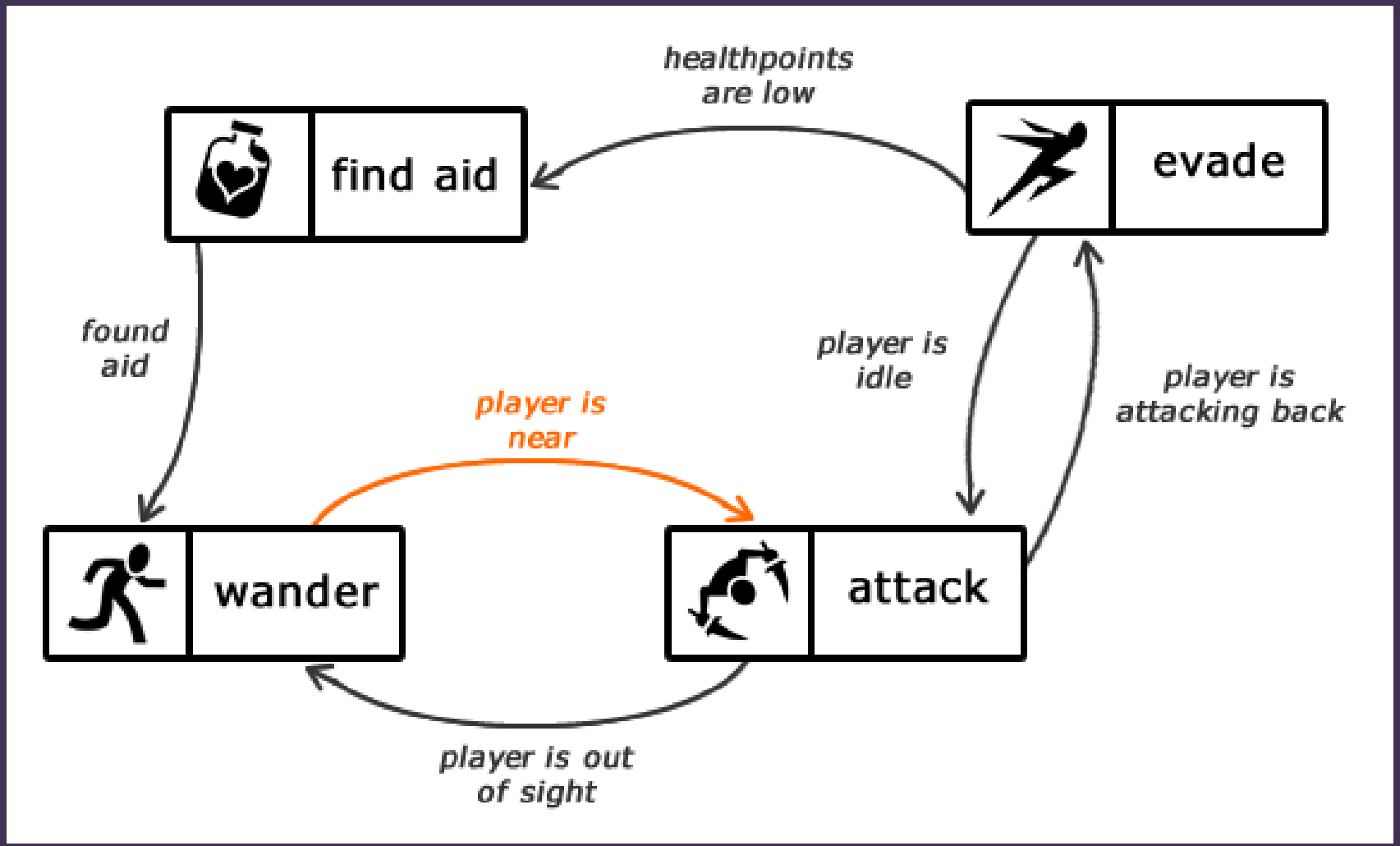
AI architectures

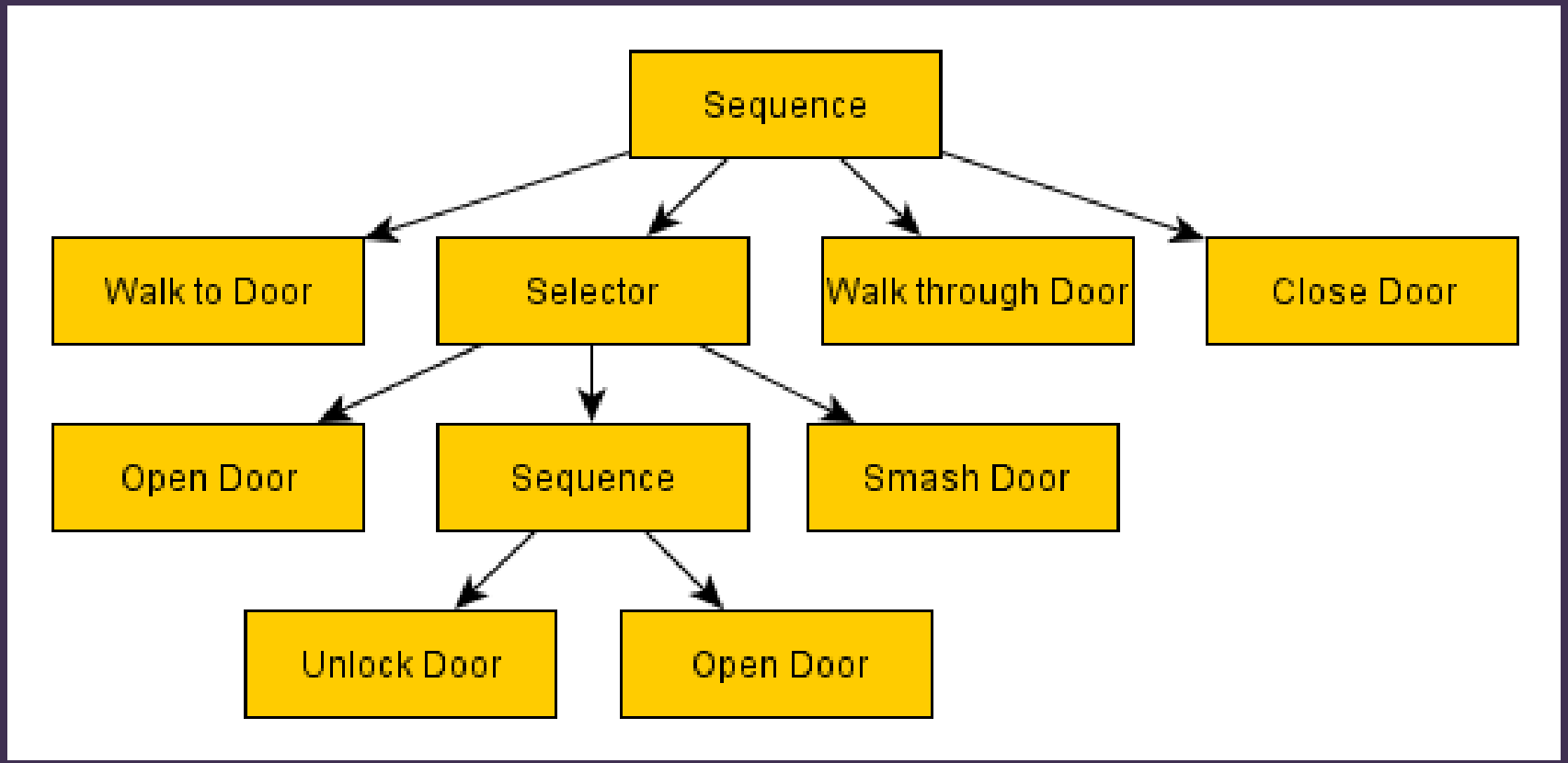
Rule-based AI

Generally implemented as `if` statements or event-based triggers

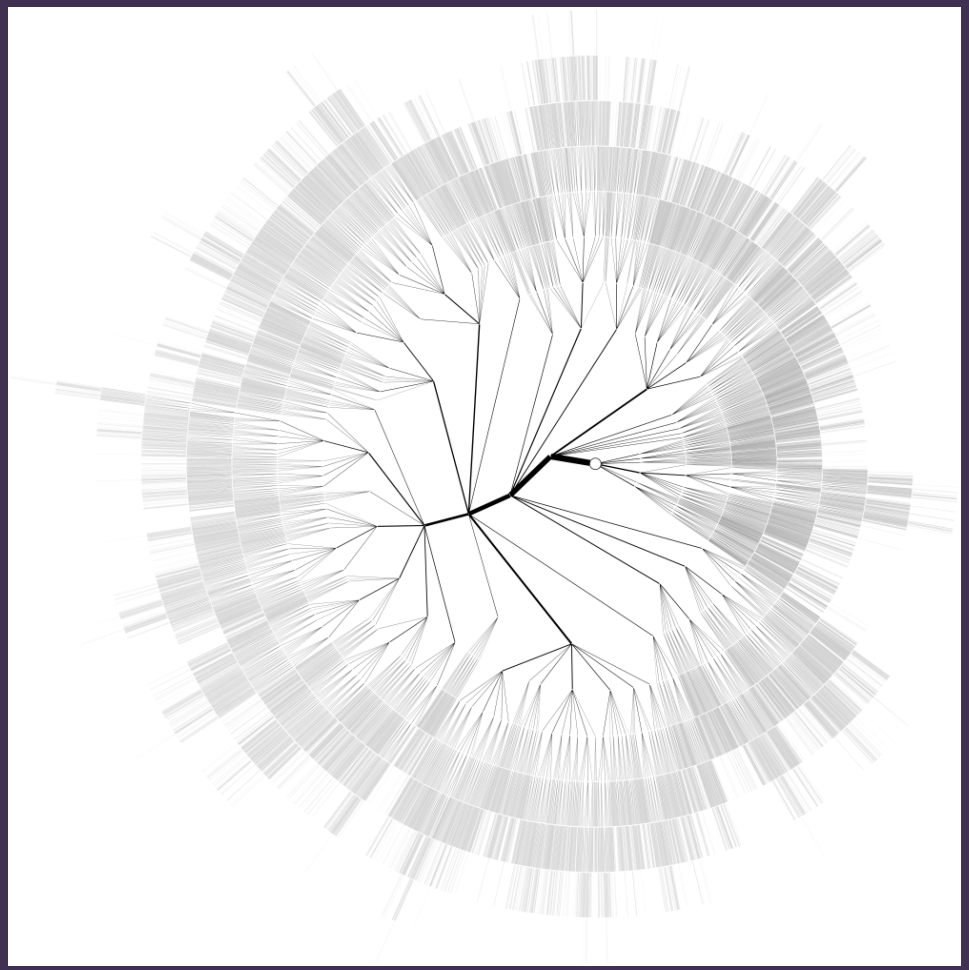
Finite state machines



Behaviour trees

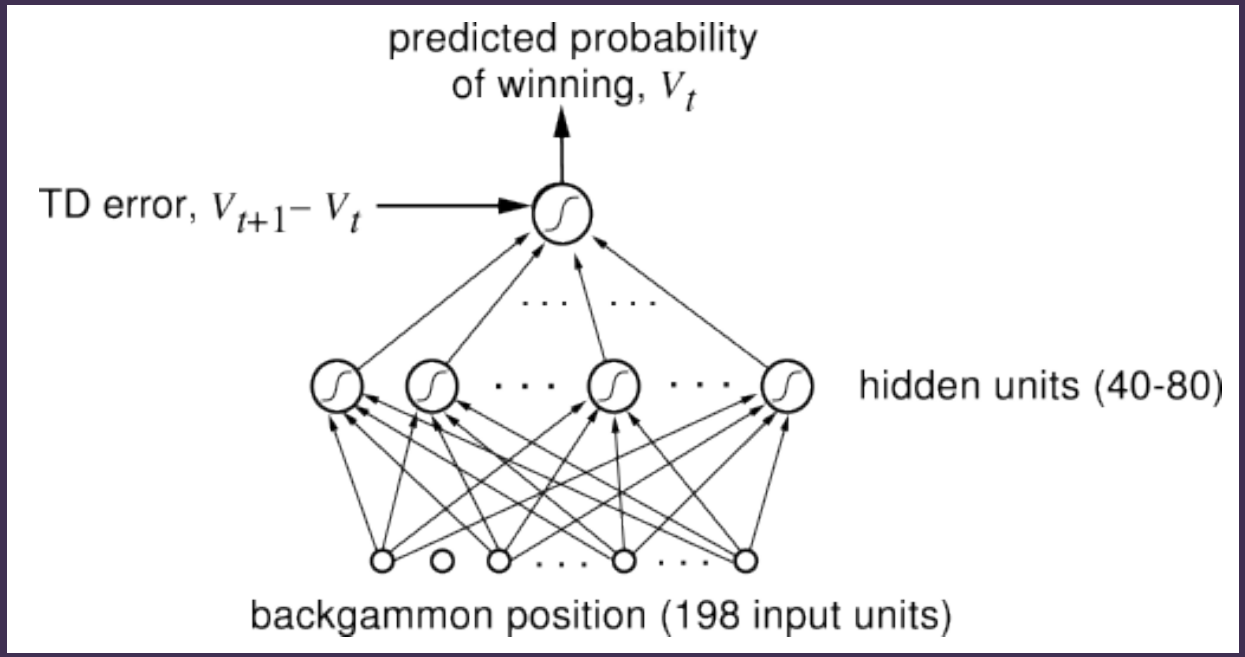


Game tree search



Multi-agent approaches (e.g. flocking)

Machine learning



AI architectures

- Can roughly be divided into **hand-authored**...
  - Rule-based, FSM, behaviour trees
- ... and **computational intelligence**
  - Search, multi-agent, machine learning
- Do you want to **design** the AI behaviours yourself, or do you want them to **emerge** from the system?
- Predictability and authorial control versus adaptability and novelty
- Can also combine the two
  - E.g. use a rule-based system to constrain a CI system
  - E.g. flocking — individual agents are usually rule-based, but overall flock dynamics are emergent

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Behaviour Trees

Behaviour trees (BTs)

- A **hierarchical** model of decision making
- Allow **complex behaviours** to be built up from **simple components**
- Allow for **more complex** behaviours than FSMs
- First used in Halo 2 (2005), now used extensively
- Also used in robotics and other non-game AI applications

Using BTs

- Fairly easy to implement; plenty of resources online
- **Unreal**: an advanced BT system is built in
- **Unity**: numerous free and paid options on the Asset Store e.g. Behavior Machine, Behavior Designer, Behave, RAIN

BT basics

- A BT is a **tree** of **nodes**
- On each game update (i.e. each frame), the root node is **ticked**
  - When a node is ticked, it might cause some or all of its **children** to tick as well
  - So ticks propagate down the tree from the root
- A ticked node returns one of three **statuses**:
  - Success
  - Running
  - Failure
- "Running" status allows nodes to represent operations that **last multiple frames**

Node types

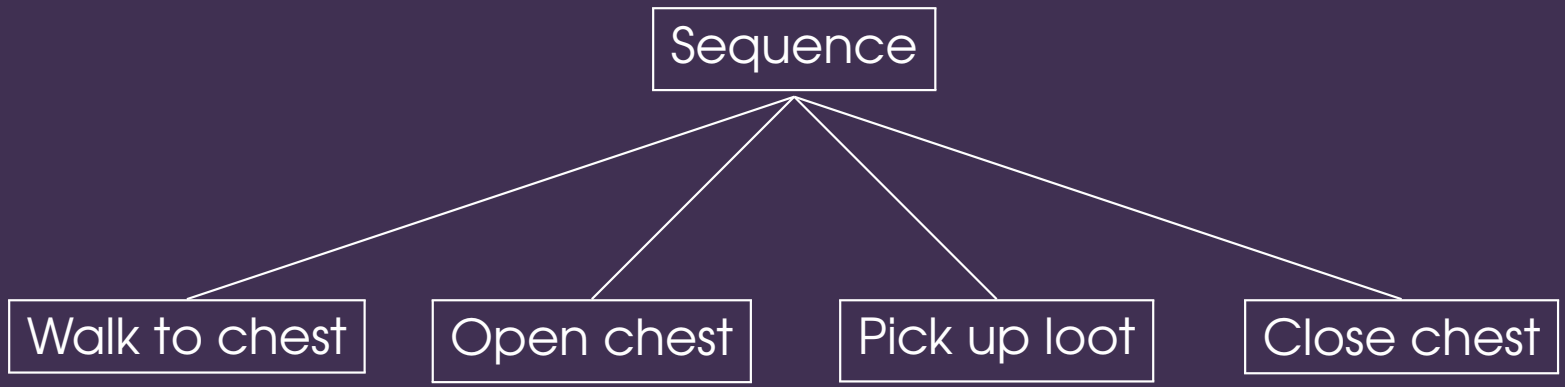
- There are **two main types** of BT node
- **Leaf** nodes
  - No children
  - Represent **tasks** (i.e. the AI agent actually doing something)
- **Composite** nodes
  - One or more children
  - Control which of the children run on each tick

Leaf nodes

- Represent **atomic actions**
  - I.e. actions which can't sensibly be broken down into smaller actions
- E.g. walk to, crouch, attack, open door
- Status:
  - Success means "the action is done"
  - Failure means "the action cannot be done"
  - Running means "the action is still in progress"
- Leaf nodes can also be used to represent **conditions**
  - E.g. "is my health below 10%?"
  - Returns success for true, failure for false
- … although this is not recommended in Unreal — conditionals should be implemented as **decorators** instead

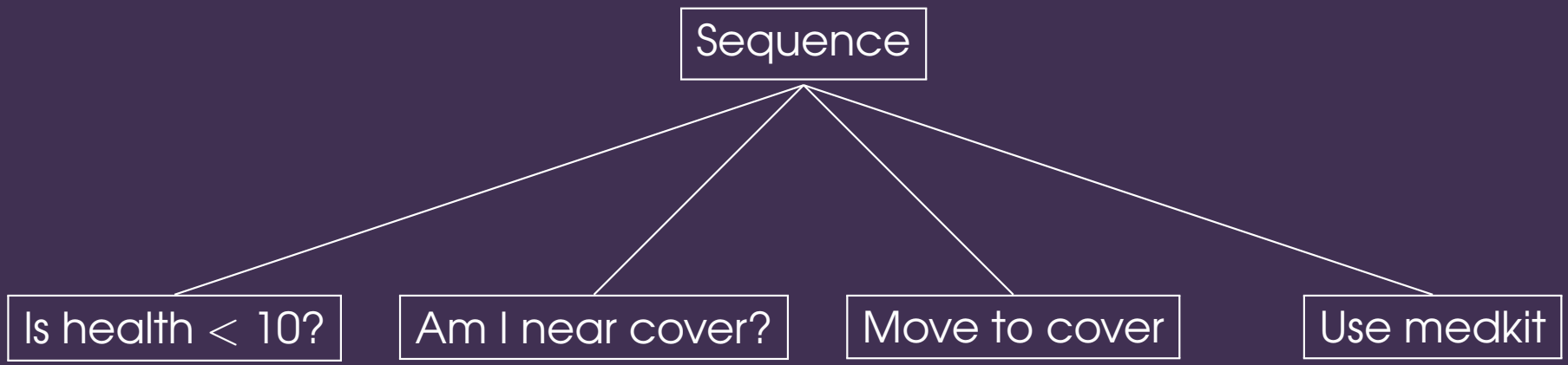
Composite nodes: sequence

- Run each child, in order
- If **any** child returns failure, stop and return failure
- If **all** children return success, stop and return success



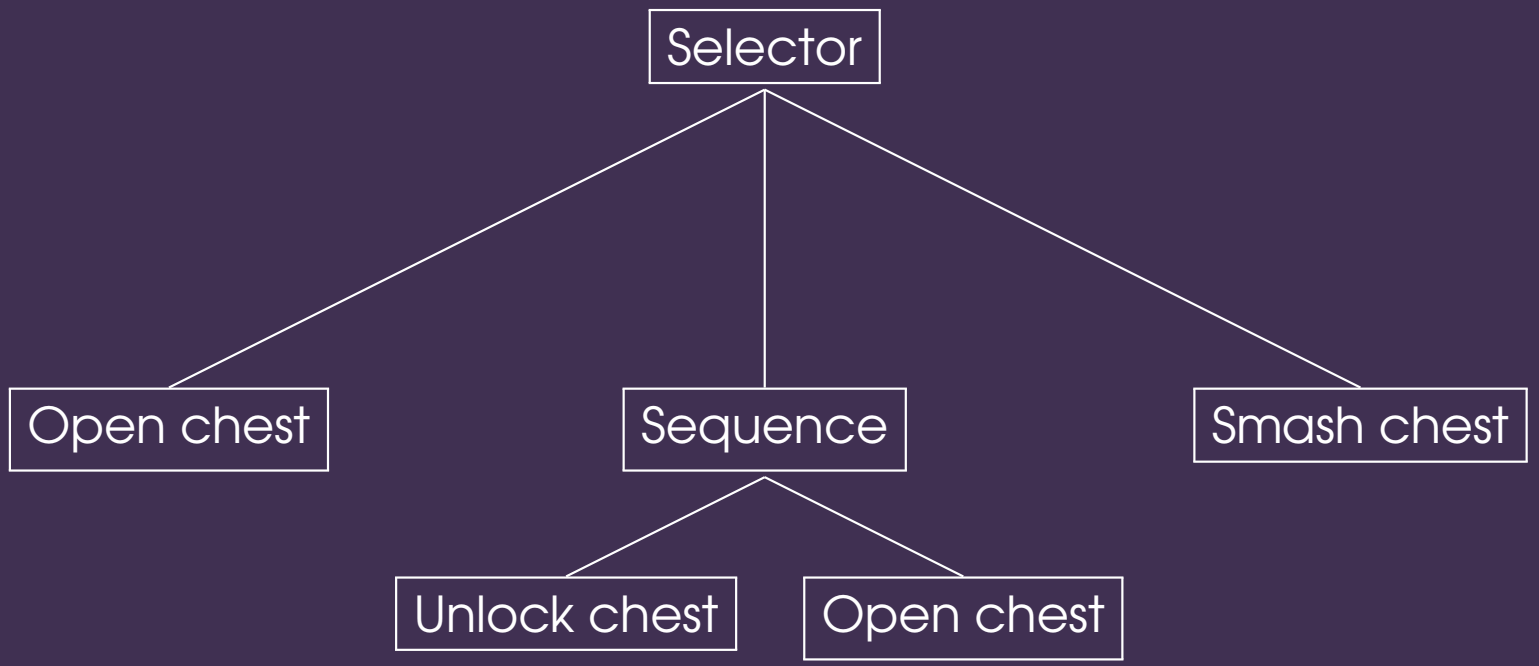
Sequence nodes and conditions

- A sequence node can be used like an `if (cond1 && cond2)` statement



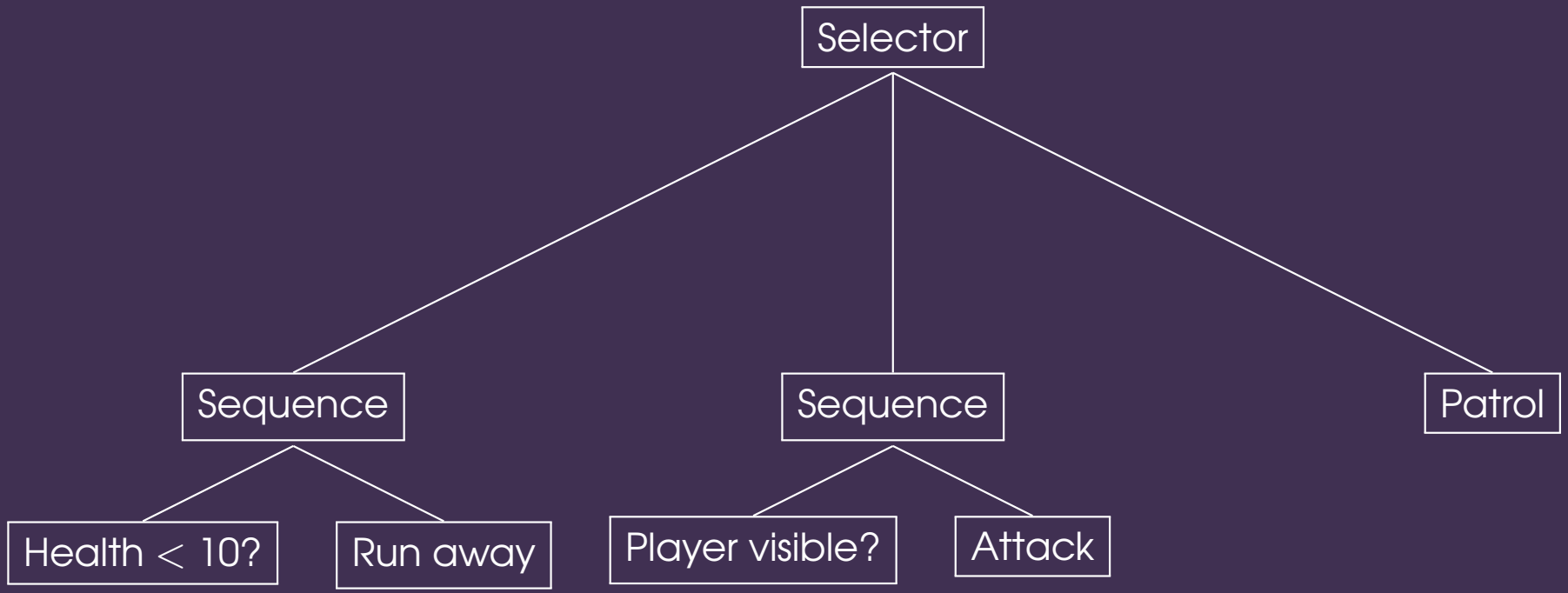
Composite nodes: selector

- Run each child, in order
- If a child returns failure, move onto the next one
- If **any** child returns success, stop and return success



Selectors and priority

- Order of selector children represents the **priority** of different alternatives



Sequence vs selector

- Sequence: perform a list of actions; if one of them fails then abandon the task
- Selector: try a list of alternatives; stop once you find one that works
- Sequence works like `and`, selector works like `or`

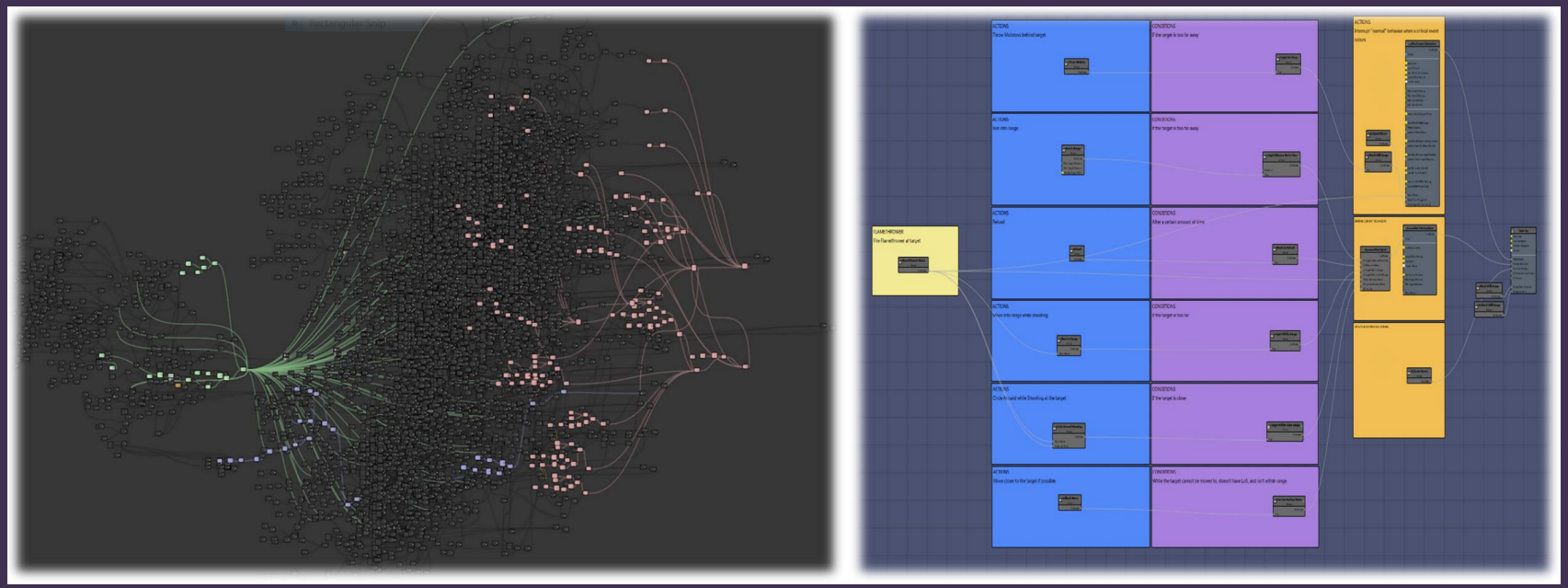
Other composite nodes

- Execute children in **random** order
- Execute children in **parallel**
- **Decorator** nodes
  - **Inverter**: if child returns success then return failure, and vice versa
  - **Repeater**: run the child a number of times, or forever
  - Most BT frameworks allow programmers to create custom decorator nodes
- Some BT frameworks allow programmers to create custom composite nodes

Blackboard

- It is often useful to **share** data between nodes
- A **blackboard** (sometimes called a **data context**) allows this
- Blackboard defines **variables**, which can be **read** and **written** by nodes
- Some BT frameworks allow blackboards to be **local** to the AI agent, **shared** between several agents, or **global** to all agents
- (Shared blackboards mean that your AI has "telepathy" — this may or may not be desirable!)

BTs in The Division



http://www.gdcvault.com/play/1023382/AI-Behavior-Editing-and-Debugging

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Worksheet

COMP280 worksheet 2

- Implement AI ghost behaviours for a Pac-Man game
- Brief on LearningSpace
- Template project on GitHub

Workshop

- Make a start on the worksheet!
- Follow the tutorial linked in the worksheet to implement a simple **behaviour tree based ghost AI**
- Start experimenting with modifying your AI