



GAM250: Advanced Games Programming

8: AI

Learning outcomes

- ▶ **Understand** navigation in Video Games
- ▶ **Implement** Finite State Machines in Unity
- ▶ **Implement** Behaviour Trees in Unity

Pathfinding



The problem

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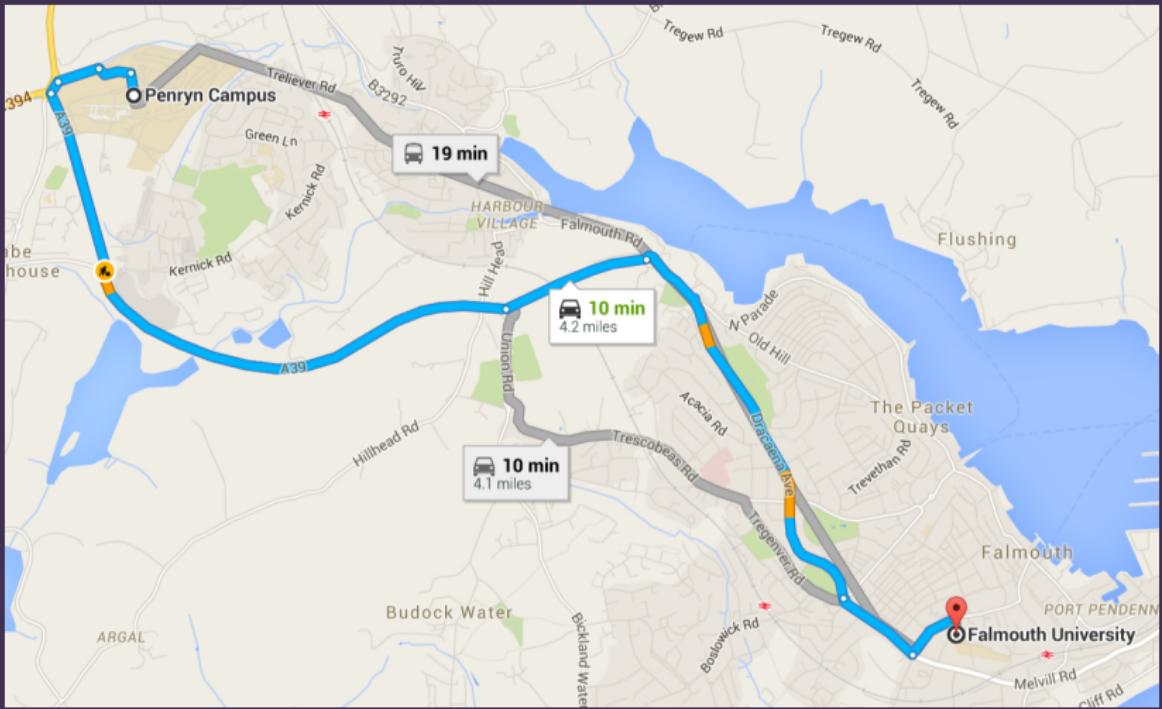
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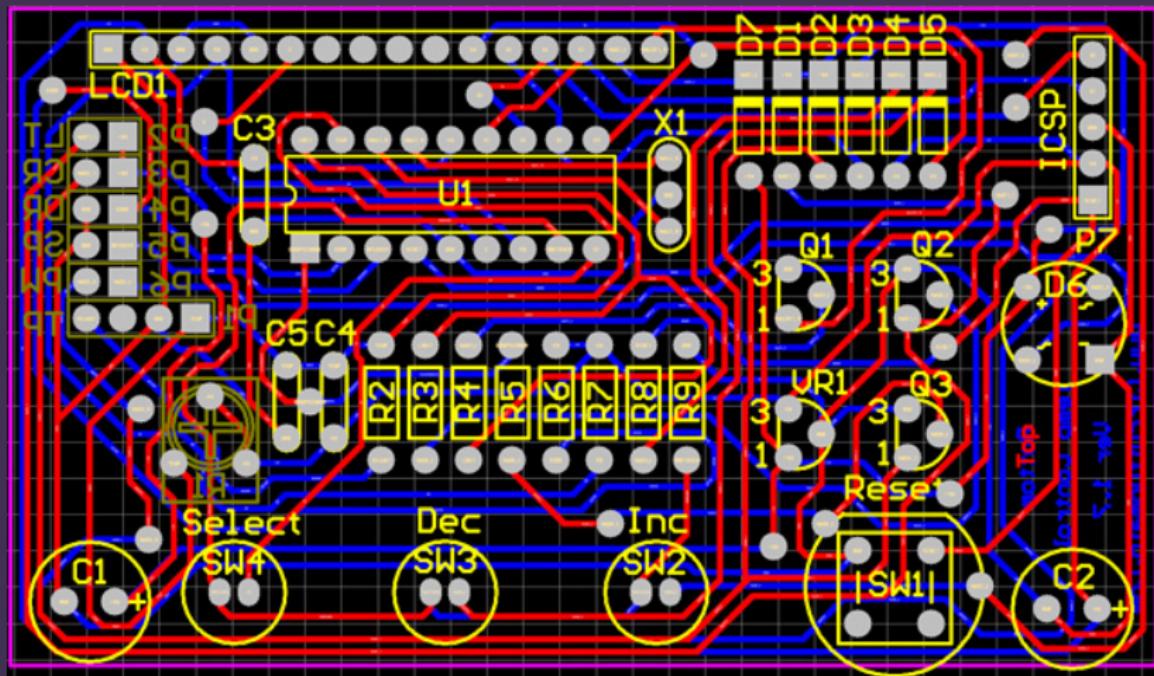
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 - ▶ “Shortest” in terms of edge lengths — could be distance, time, fuel cost, ...

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 - ▶ ... but implementations are available for all popular programming languages

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- ▶ Finds a path, but probably not the **shortest**

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- ▶ Choose a node that minimises $g(x) + h(x)$
 - ▶ Contrast with greedy search, which just minimises $h(x)$

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 - ▶ Heuristics are often used to prioritise search, i.e. explore the most promising options first

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- ▶ Different $h(x)$ can lead to different paths (if there are multiple “shortest” paths)

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 - ▶ Repeat until there are no more points that can be removed

Navigation meshes



Pathfinding in videogames

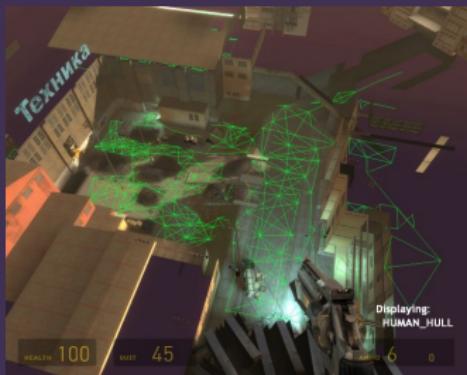
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- ▶ A* works on any **graph**
- ▶ But what if the game world is not a graph? E.g. complex 3D environments

Waypoint navigation



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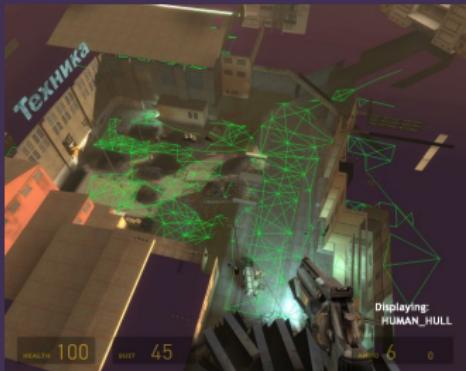
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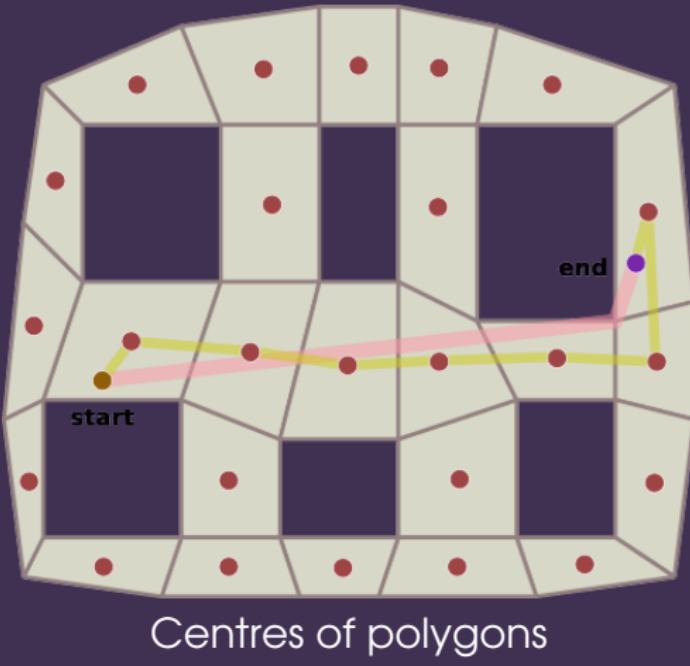
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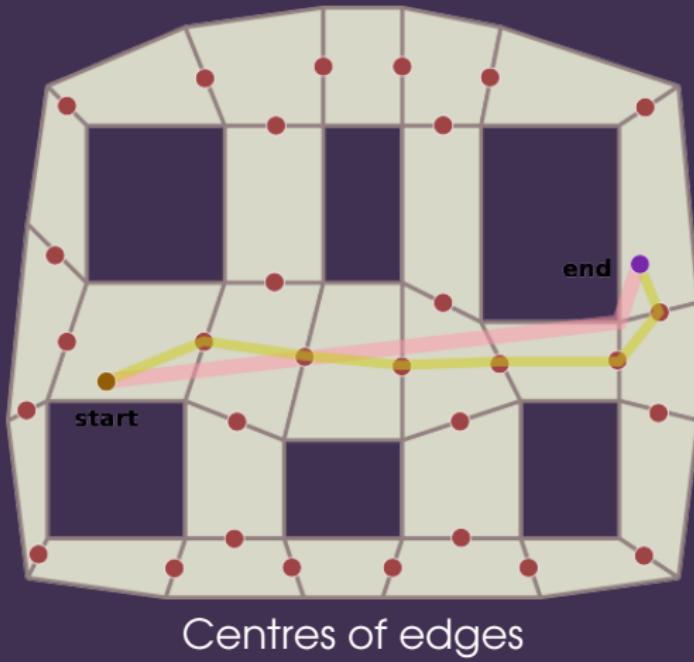


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 - ▶ Generate graph from polygons

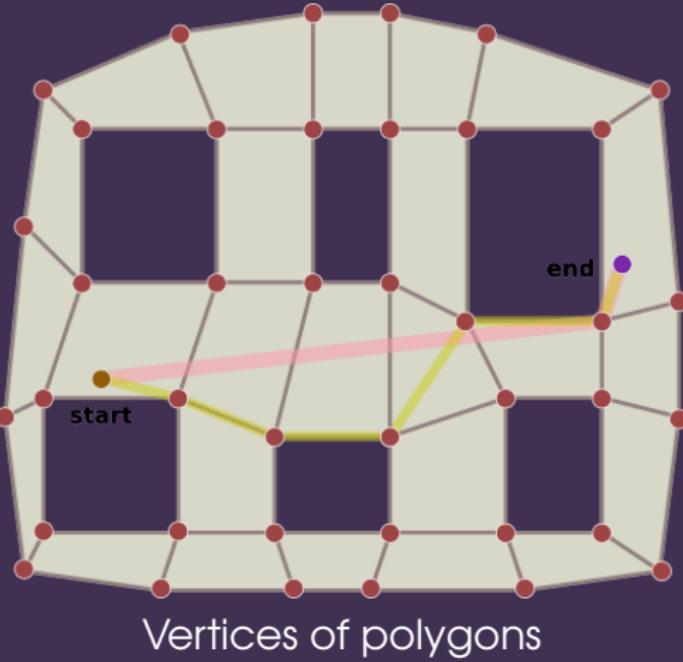
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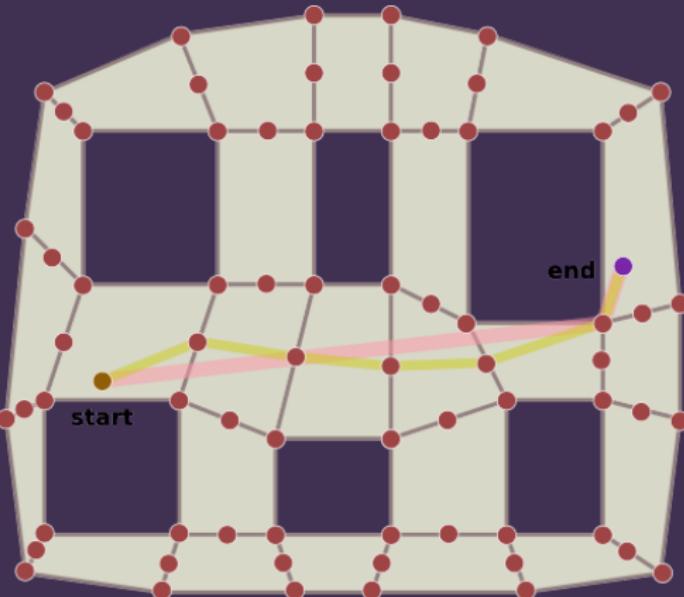
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Hybrid approach: edges and vertices

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- ▶ **Steering:** don't have your AI agent follow the path exactly, but instead try to stay close to it
- ▶ **Dynamic environments:** may need to re-run pathfinder if environment changes (e.g. movable obstacles, destructible terrain)

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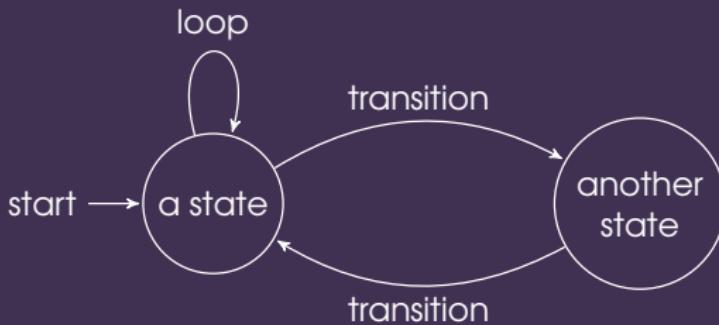
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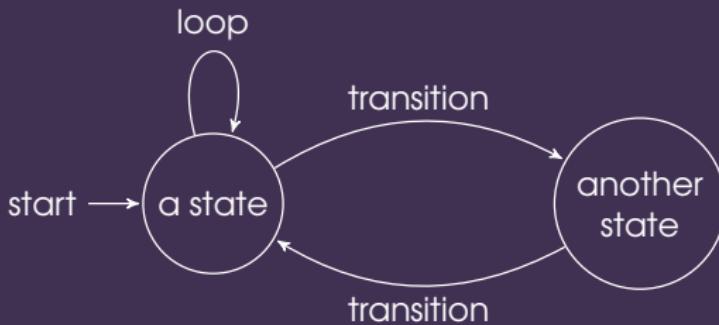
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- ▶ **Inputs** or **events** can cause the FSM to transition to a different state

State transition diagrams



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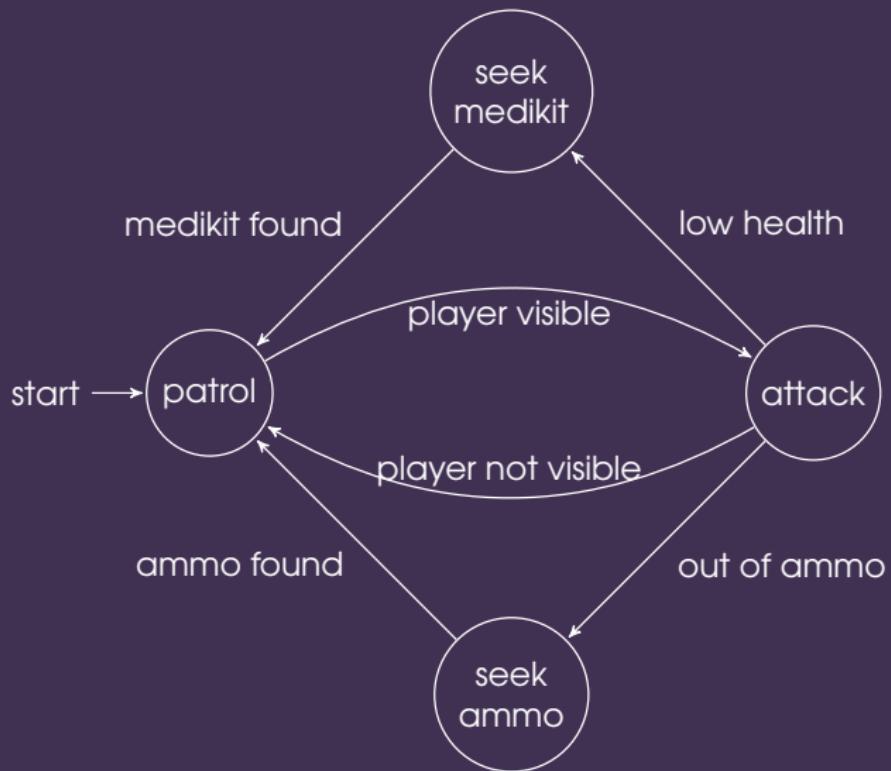
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Beyond FSMs

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- ▶ Hierarchical FSMs
- ▶ Nested FSMs
- ▶ Stack-based FSMs
- ▶ Hierarchical task networks
- ▶ ...

Plus the topic we will be looking at today: **behaviour trees**

Behaviour Trees



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- ▶ Also used in robotics and other non-game AI applications

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- ▶ We will be using the free **Behaviour Machine** library for Unity

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 - ▶ So ticks propagate down the tree from the root
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- ▶ “Running” status allows nodes to represent operations that **last multiple frames**

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- ▶ Leaf nodes often have **parameters** to allow for reuse in different situations

Leaf node example

```
using UnityEngine;
using System.Collections;
using BehaviourMachine;

public class GoTo : ActionNode
{
    public GameObjectVar objectToMove;
    public Vector3Var target;
    public FloatVar speed;

    public override Status Update()
    {
        float distance = (objectToMove.Value.transform.position - target.Value).magnitude;
        float step = speed.Value * Time.deltaTime;
        if (distance < step)
        {
            objectToMove.Value.transform.position = target.Value;
            return Status.Success;
        }
        else
        {
            objectToMove.Value.transform.position = Vector3.MoveTowards(
                objectToMove.Value.transform.position, target.Value, step);
            return Status.Running;
        }
    }
}
```

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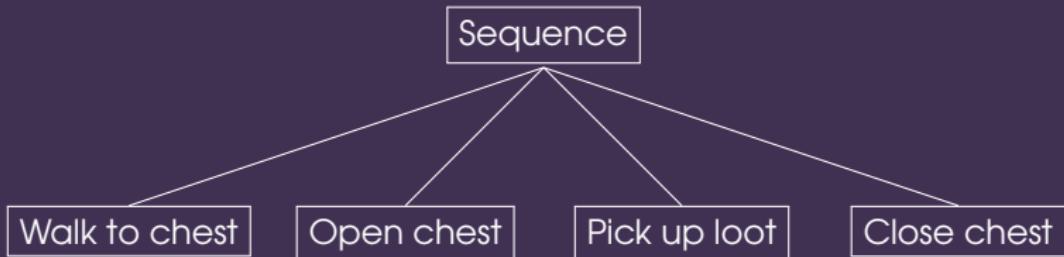
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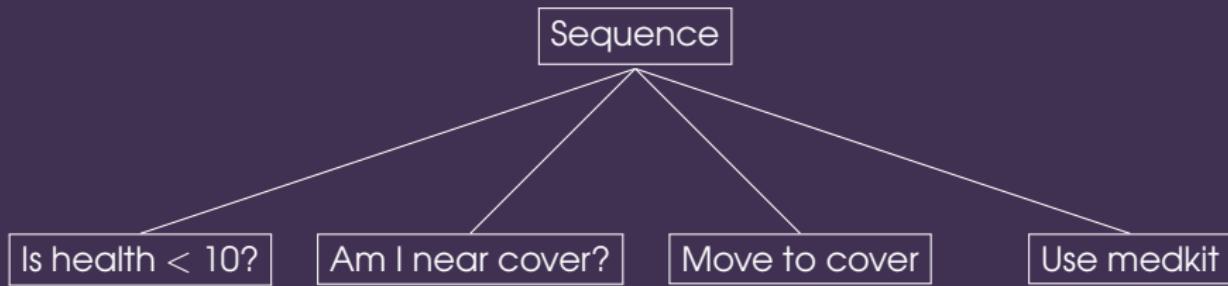
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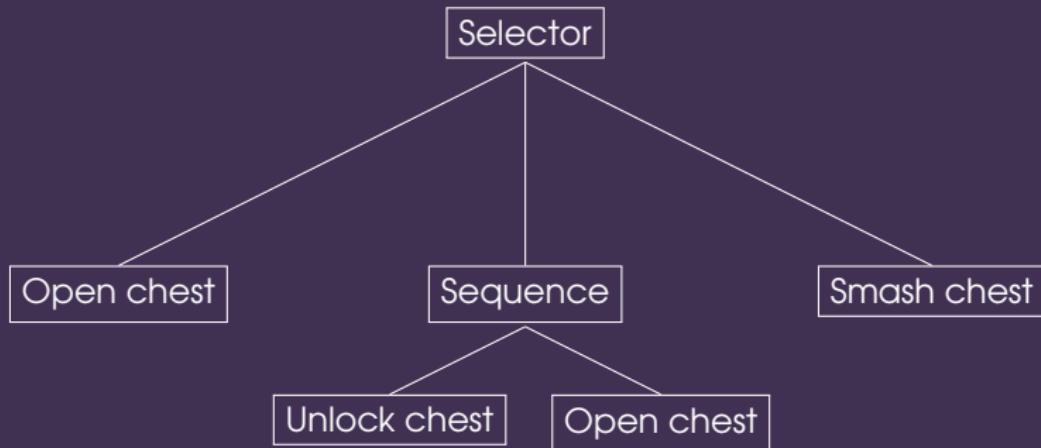
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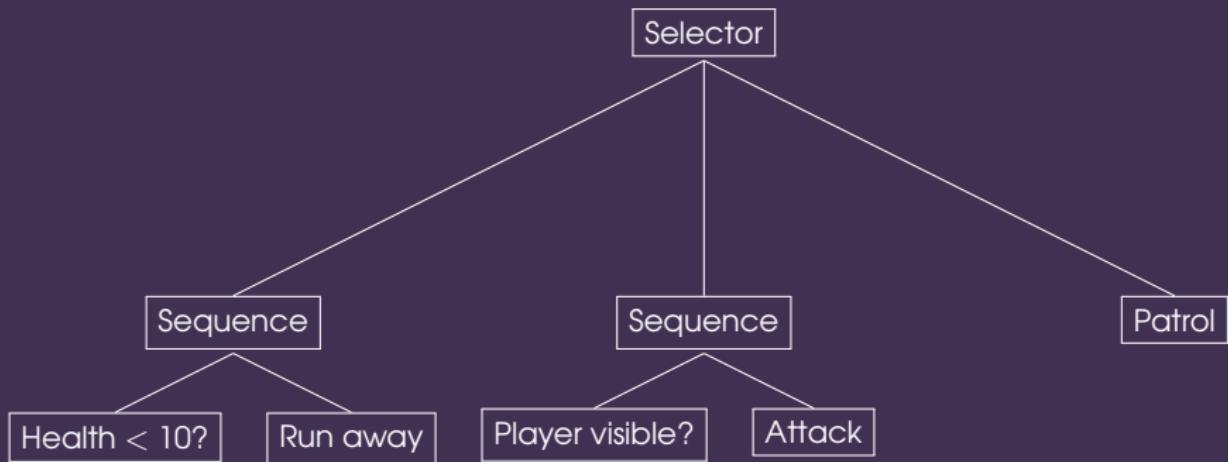
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- ▶ Sequence works like **and**, selector works like **or**

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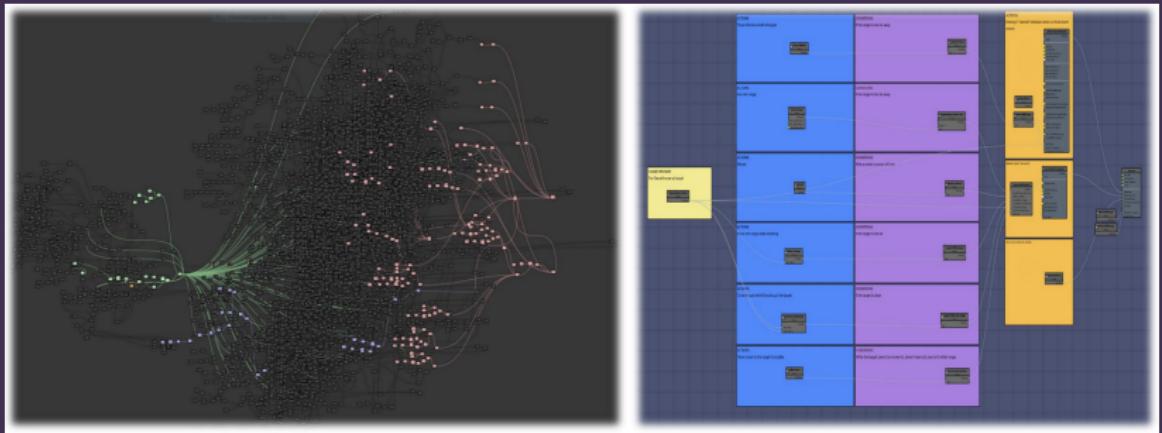
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- ▶ (Shared blackboards mean that your AI has “telepathy” — this may or may not be desirable!)

BTs in The Division



[http://www.gdcvault.com/play/1023382/
AI-Behavior-Editing-and-Debugging](http://www.gdcvault.com/play/1023382/AI-Behavior-Editing-and-Debugging)

Exercise

- ▶ Using FSM or Behaviour Trees, create an AI agent which does the following
 - ▶ Navigates a series of waypoints
 - ▶ Shoots at the player when in range
 - ▶ When low on health it attempts to heal by collecting an item
- ▶ Stretch Goal: Make an AI Agent to replace the player!

Further Reading 1

- ▶ Finite State AI in Unity -

<https://unity3d.com/learn/tutorials/topics/navigation/finite-state-ai-delegate-pattern>

- ▶ Using Unity Animator as an FSM - <https://medium.com/the-unity-developers-handbook/dont-re-invent-finite-state-machines-how-to-rep>

- ▶ Behaviour Machine (FSM & BT for Unity) -

<http://www.behaviourmachine.com/>

- ▶ Unity Behavior Library - <https://github.com/listentorick/UnityBehaviorLibrary/>

- ▶ Unity Crystal AI -

<https://igiagkiozis.github.io/CrystalAI/>

Further Reading 2

- ▶ Behaviour Trees in Project Zomboid -
https://www.gamasutra.com/blogs/ChrisSimpson/20140717/221339/Behavior_trees_for_AI_How_they_work.php
- ▶ Behaviour Trees in Unreal -
<https://docs.unrealengine.com/latest/INT/Engine/AI/BehaviorTrees/QuickStart/>