CT3536
(Games Programming using Unity3D)

Section 10

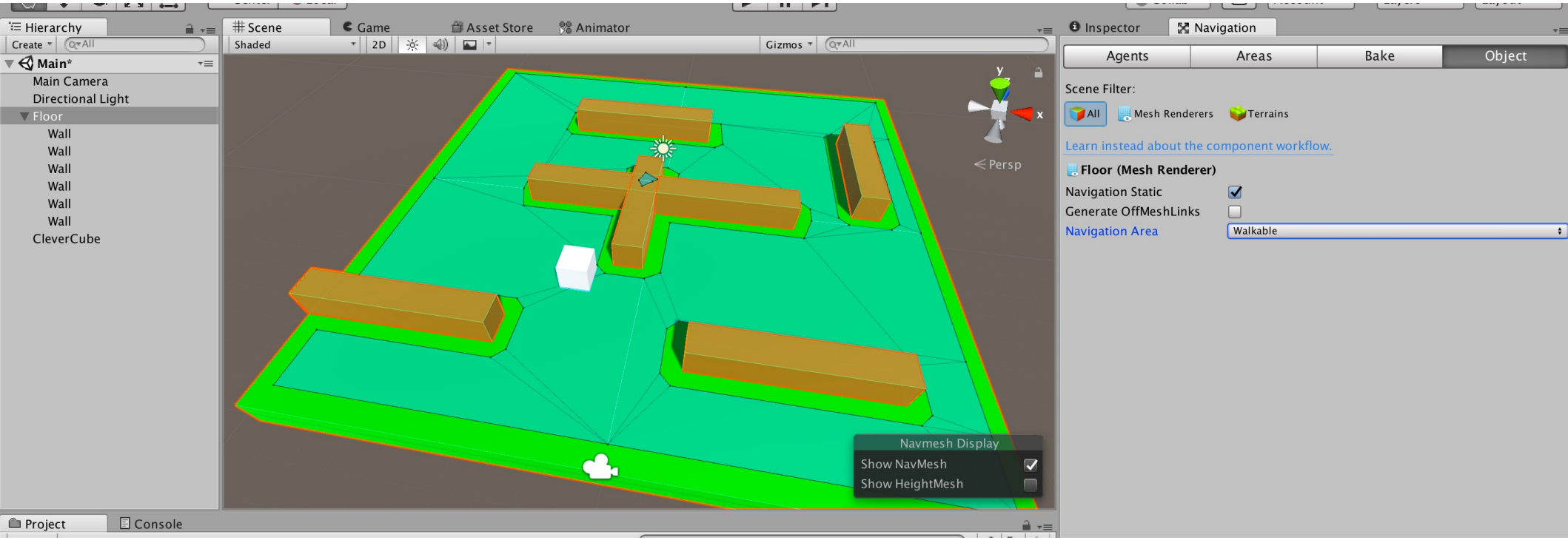
Pathfinding
C# Threads using “Thread Ninja”

Pathfinding in Unity using NavMesh and NavMeshAgent

- See demo project on Canvas “NavMeshDemo”
- This is loosely based on:

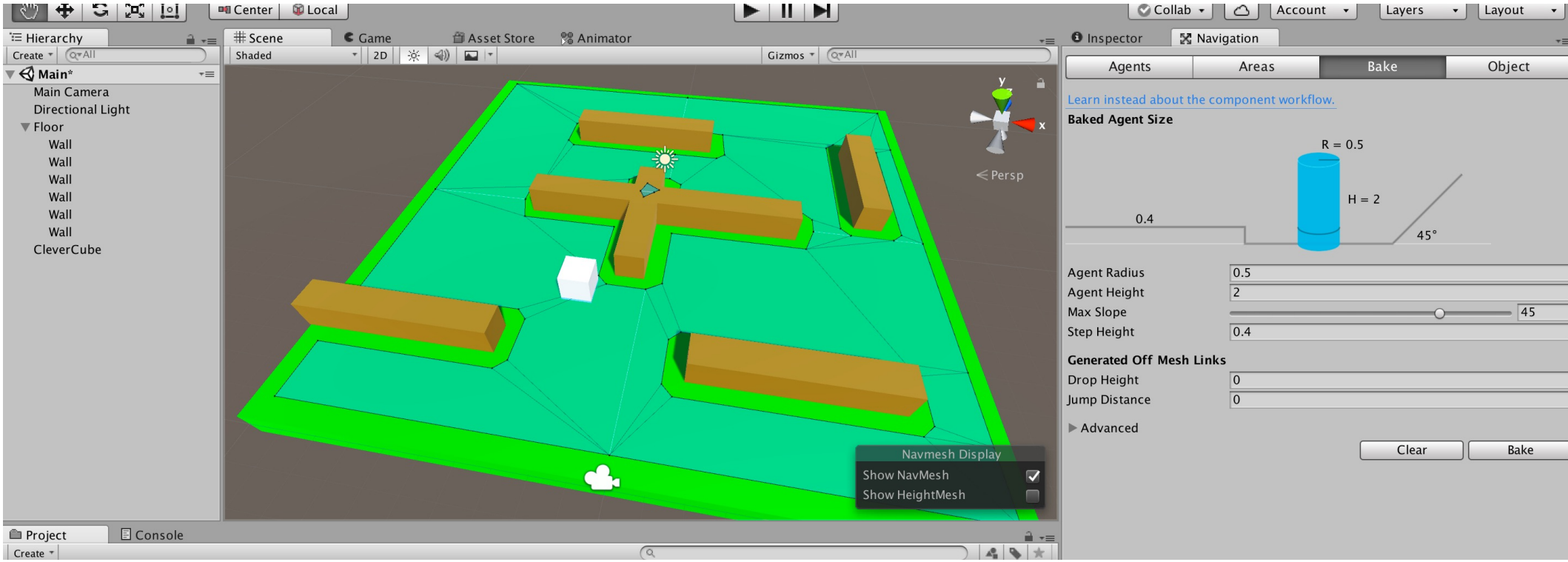
https://www.red-gate.com/simple-talk/dotnet/c-programming/pathfinding-unity-c/

- Use Window>Navigation to open the Navigation tab.
- Here we’re creating a NavMesh attached to Floor

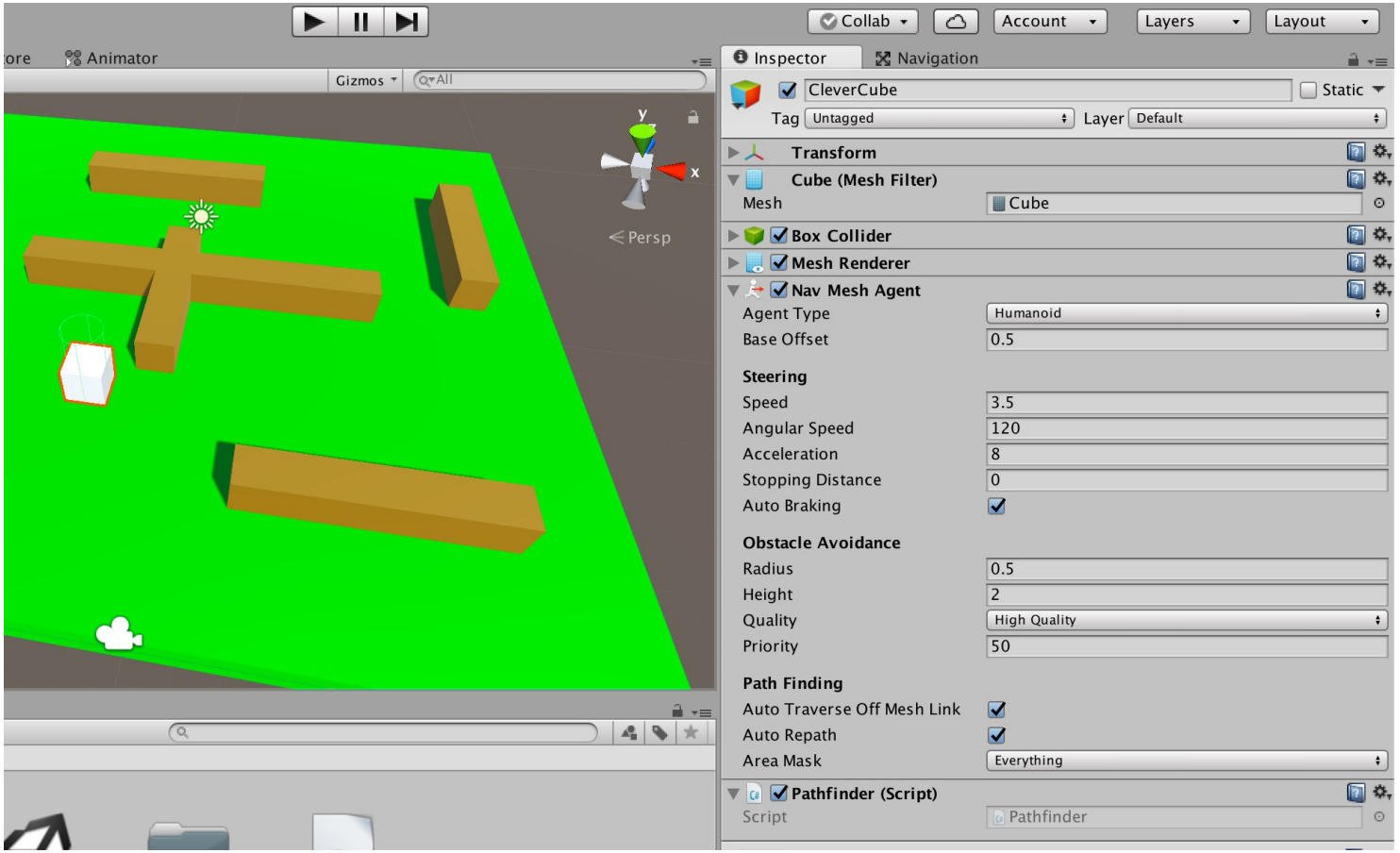


Pathfinding in Unity using NavMesh and NavMeshAgent

- In the ‘Bake’ settings you have various options
- The ‘Bake’ button creates the mesh
- This sparse navmesh has far fewer nodes than the grid-based approach we take below => more efficient to use



The CleverCube Object



- Has a NavMeshAgent component added
- Has a new custom script added: ‘Pathfinder’

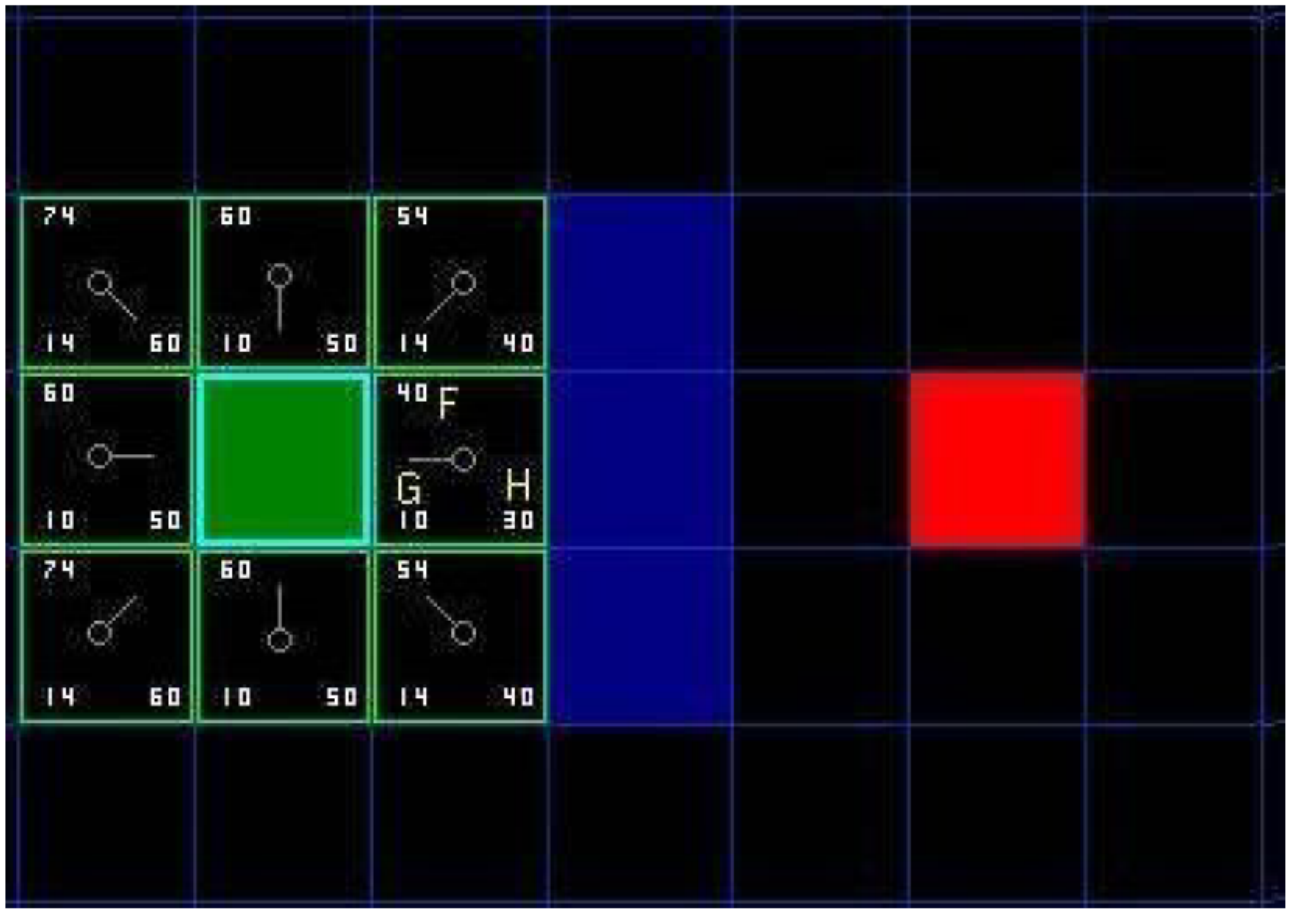
GameManager class

```
// attached to the Camera (a simple ‘follow cam’)

public class GameManager : MonoBehaviour {
   void Start () {
      Camera.main.transform.position = new Vector3(0f, 20f, 20f);
      Camera.main.transform.LookAt(Vector3.zero);
   }
}
```

Pathfinder Class

```
using UnityEngine.AI;

public class Pathfinder : MonoBehaviour {

    private NavMeshAgent nav;

    void Start () {
        nav = GetComponent<NavMeshAgent>();
        nav.destination = transform.position;
    }

    void Update () {
        if (Input.GetMouseButtonDown(0)) {
            Ray ray = Camera.main.ScreenPointToRay(Input.mousePosition);
            RaycastHit hitInfo;
            if (Physics.Raycast(ray, out hitInfo, 500f)) {
                nav.destination = hitInfo.point;
            }
        }
    }
}
```

A* Pathfinding
(The next few slides are from CT255)



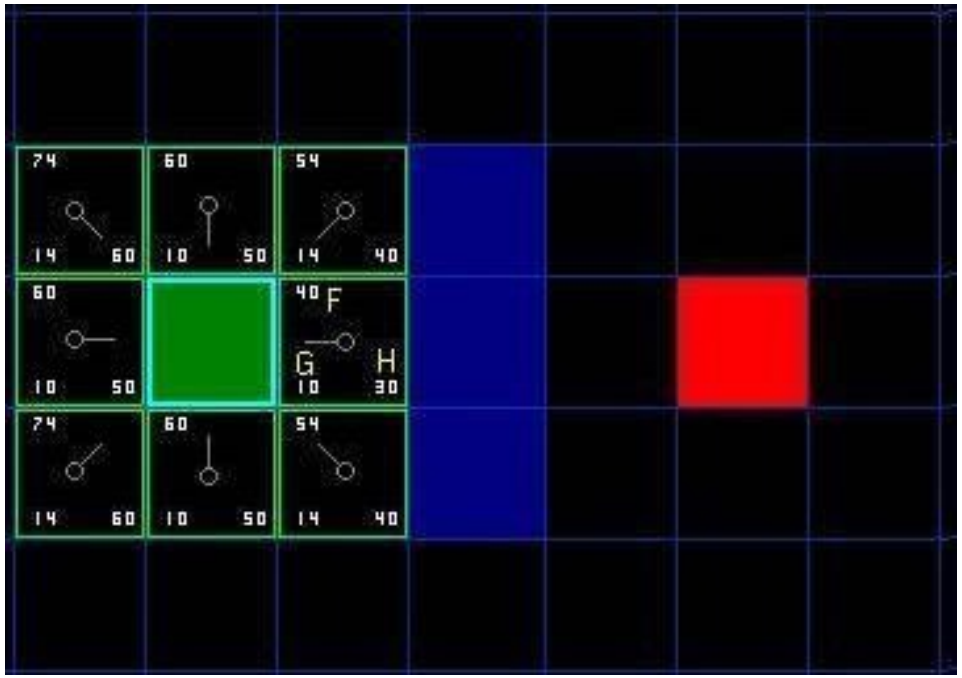
known cost from start to this node

est. cost from this node to goal

$$f = g + h$$

est. cost from start to goal via this node

images from: http://www.policyalmanac.org/games/aStarTutorial.htm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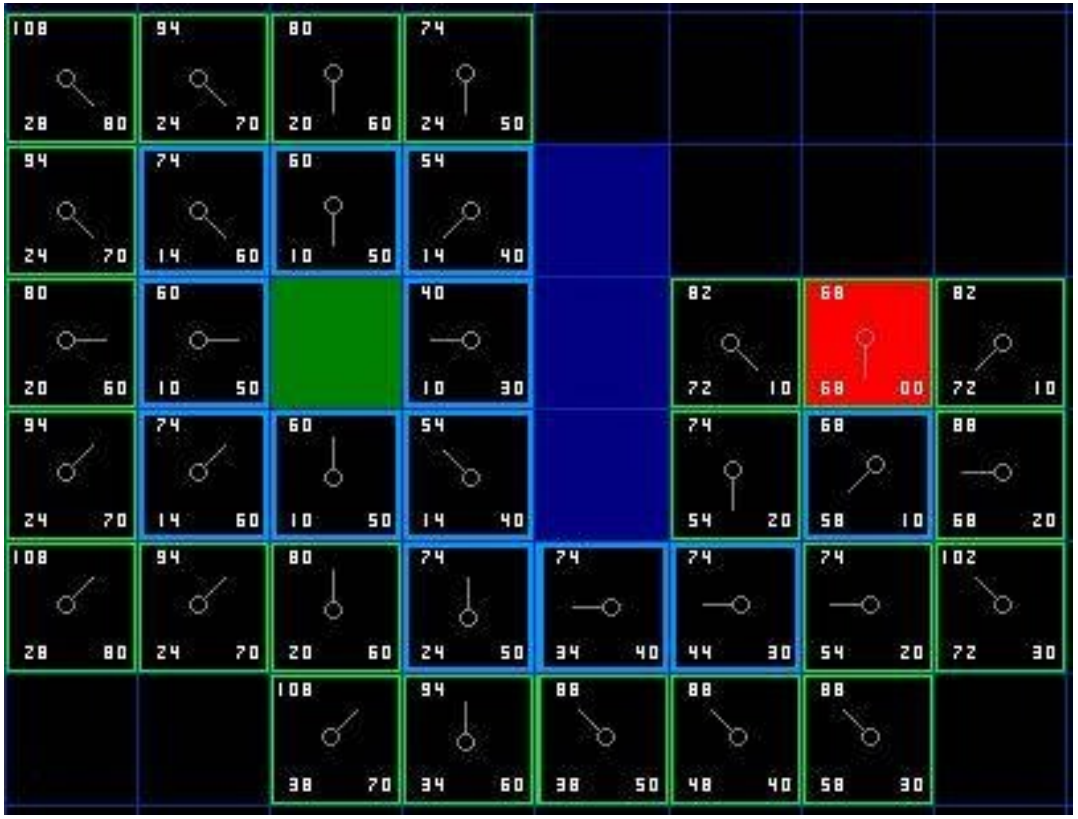
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A* Pathfinding

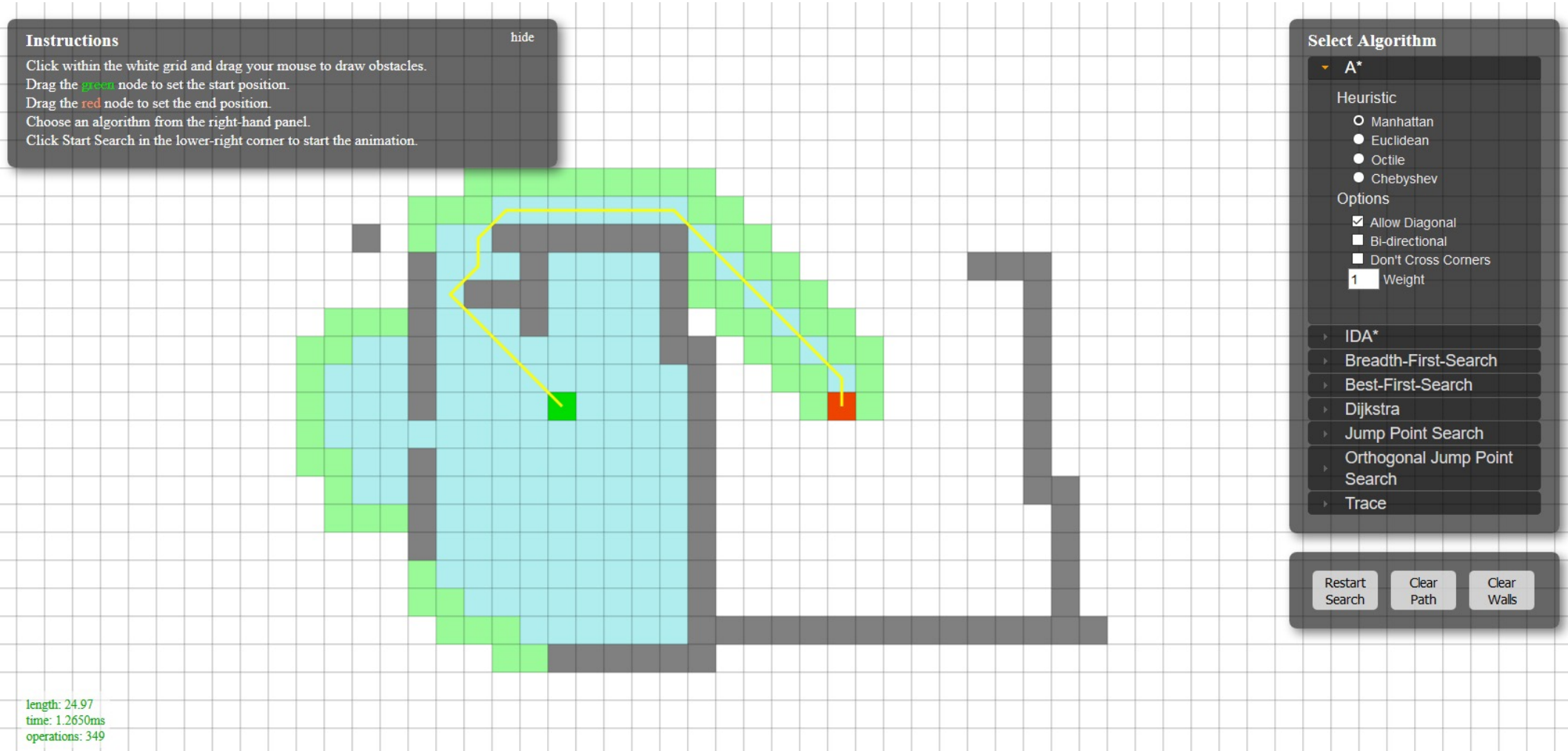
- The fundamental operation of the A* algorithm is to traverse a map by exploring promising positions (nodes) beginning at a starting location, with the goal of finding the best route to a target location.

- Each node has four attributes other than its position on the map:
  - *g* is the cost of getting from the starting node to this node
  - *h* is the estimated (heuristic) cost of getting from this node to the target node. It is a best guess, since the algorithm doesn't (yet) know the actual cost
  - *f* is the sum of *g* and *h*, and is the algorithm's best current estimate as to the total cost of travelling from the starting location to the target location via this node
  - *parent* is the identity of the node which connected to this node along a potential solution path

A* Pathfinding

- The algorithm maintains two lists of nodes, the *open* list and the *closed* list.
- The OPEN LIST consists of nodes to which the algorithm has already found a route (i.e, one of its connected neighbours has been evaluated or *expanded*) but which have not themselves, yet, been expanded.
- The CLOSED LIST consists of nodes that have been expanded and which therefore should not be revisited.
- Progress is made by identifying the most promising node in the open list (i.e., the one with the lowest *f* value) and expanding it by adding each of its connected neighbours to the open list, unless they are already closed.
- As nodes are expanded, they are moved to the closed list.
- As nodes are added to the open list, their *f, g, h* and *parent* values are recorded.
- The *g* value of a node is, of course, equal to the *g* value of its parent plus the cost of moving from the parent to the node itself.

https://qiao.github.io/PathFinding.js/visual/



(PathFinding.js.html)

Implementing A* Pathfinding..

- What data do we need? How might we structure the data?
  - Start loc, target loc
  - Nodes to map the game area (2D array of nodes)
  - Walkable/unwalkable map (2Darray of booleans)
  - Open list (as linked list of nodes?)
  - Storage of final path (as a stack of nodes?)

- What are the initial conditions for this data?
  - Each wall node is unwalkable -> 'closed'
  - All the rest are not open and not closed
  - Calculate f,g,h for starting node and set to 'open'

- What is the general algorithmic step?
  - Find open node with lowest f (call it X)
  - Look at its neighbours: any not closed and not open should become opened: calculate f,g,h and record parent position (i.e. position of X)
  - Close node X

- How will we know when we're finished?
  - If a neighbour is the target, we're done searching
  - If there are no open nodes, the maze is unsolvable

- How will we use what we found in order to have an AI-controlled '*badguy*' chase after a '*player*'?
  - Push target onto stack,
  - Push its parent onto stack
  - Push its parent onto stack
  - Etc.. Until we have pushed start node

Pathfinding in Demon Pit (1/2)

- Since the DemonPit arena periodically reconfigures (floors drop and rise back, walls rise and drop back), pathfinding can't be performed on a static mesh
- Whenever walls/floor have finished moving, a set of raycasts (at 1x1m intervals) is used to re-determine the walkability of each grid cell. This is carried out by the AStarMesh script, attached to the arena object
- The AI-controlled monsters have the AStarAgent script attached to them, which share use of the single AStarMesh in order to calculate paths

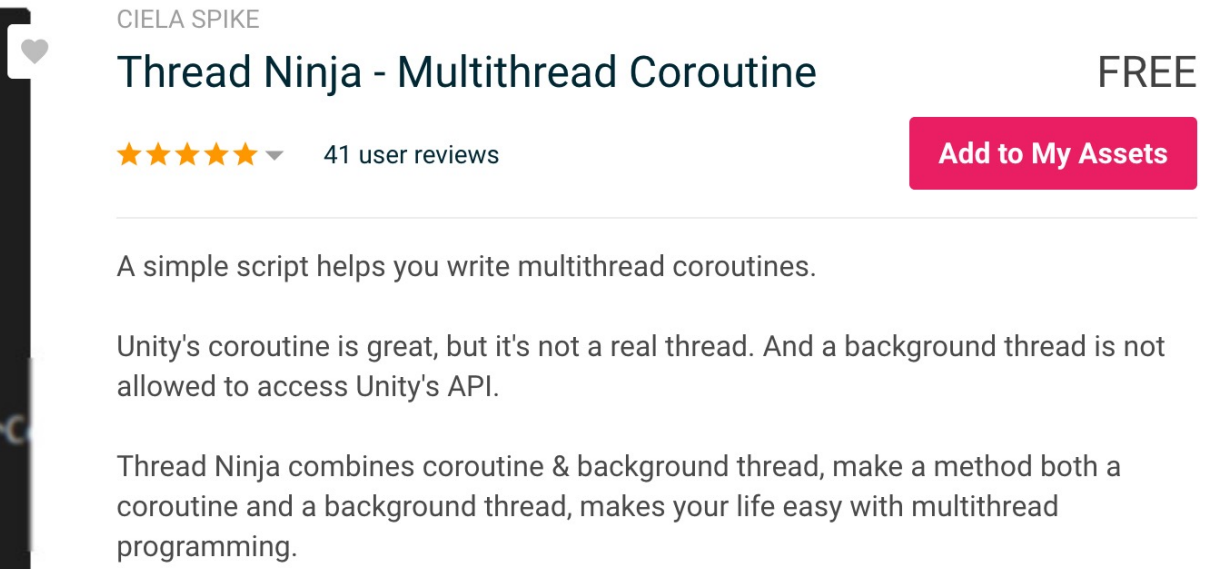
Pathfinding in Demon Pit (2/2)

- A* pathfinding is performed by the AStarAgent in a thread, using the free asset “Thread Ninja” from the asset store, which simplifies C# threads
- The AStarMesh is locked while an agent is using it, so other agents will potentially be delayed waiting for it, for a few frames
- In another game I’m working on (with much larger maps than Demon Pit), I have implemented a pool of AStarMeshes, each having their own set of Nodes. This allows multiple agents to simultaneously calculate paths

```
IEnumerator AsyncCoroutine()
{
    // On background thread.
    DoHeavyComputing();

    // Jump to Unity main thread.
    yield return Ninja.JumpToUnity;
    CallSomeUnityAPI();
    yield return StartCoroutine(AnotherC

    // Jump to background.
    yield return Ninja.JumpBack;
    DoHeavyComputing();
}
```



Pathfinding in Demon Pit

- See separate document for code:
  - AStarMesh.cs
  - AStarAgent.cs
  - Relevant code from Monster.cs

  - NB this is relatively advanced so don't be concerned if you can't follow it. It's definitely not examinable material for this module, but hopefully it's a useful example nevertheless.