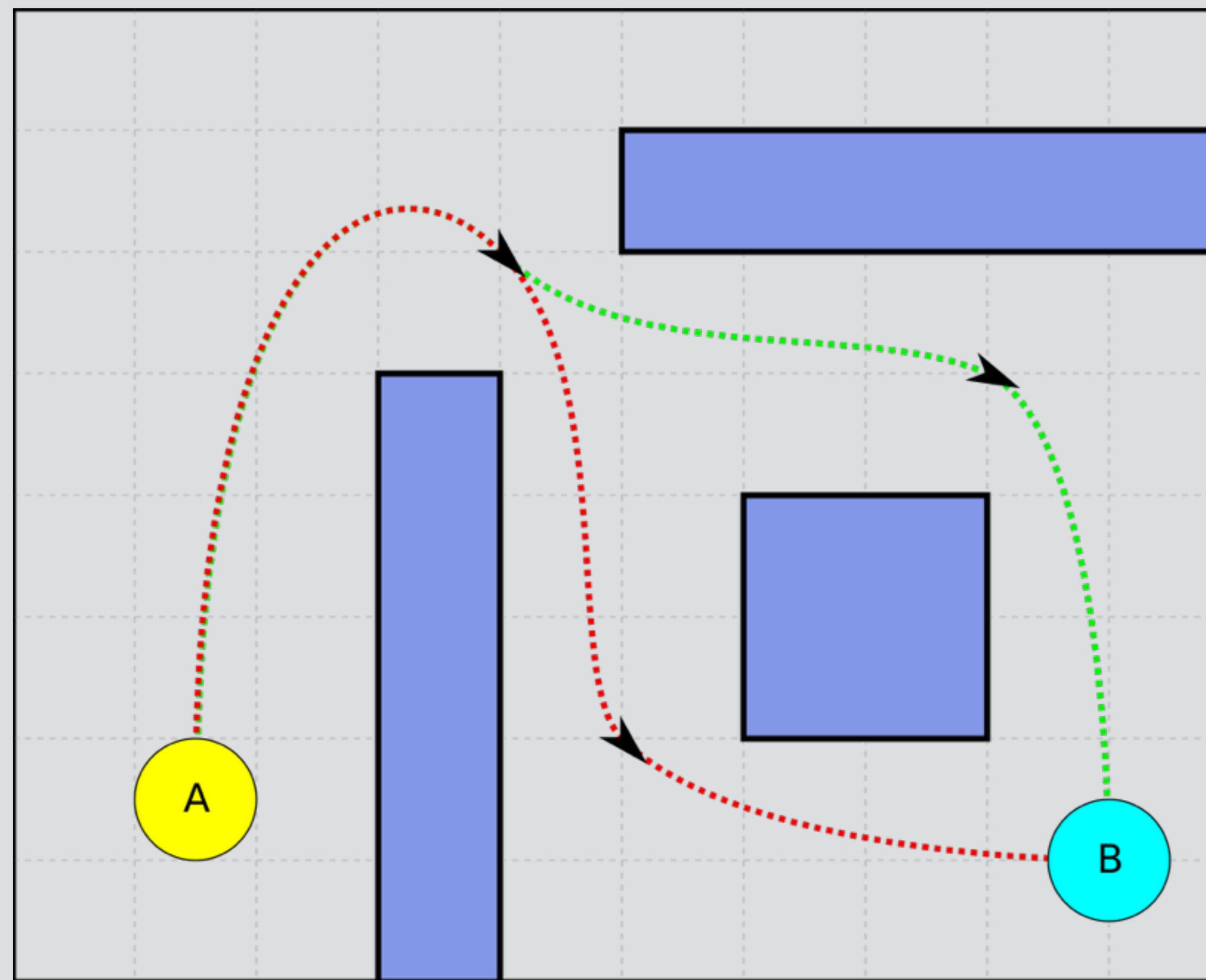


Game AI.

Part 2



Pathfinding

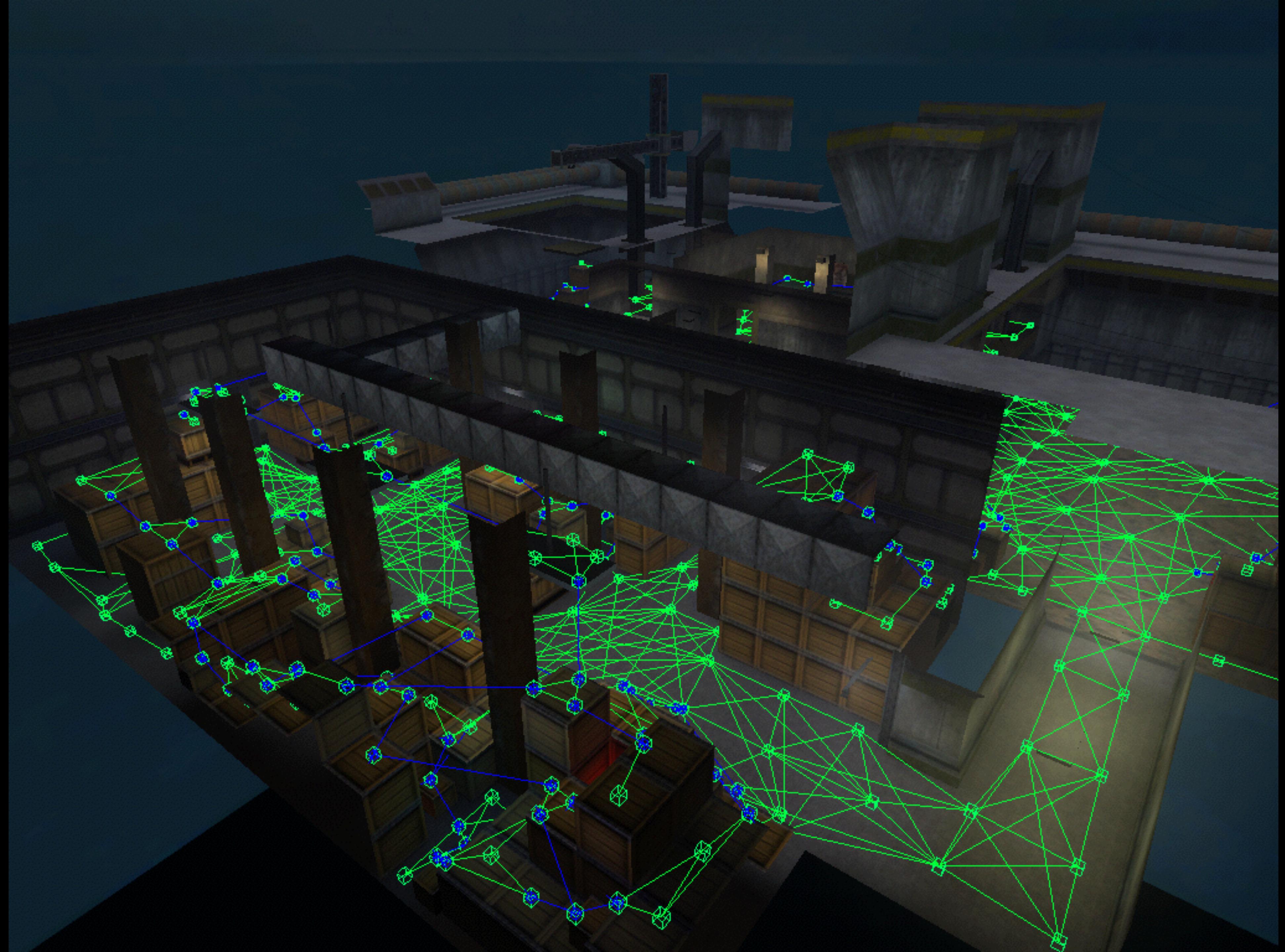
Navigating game maps.

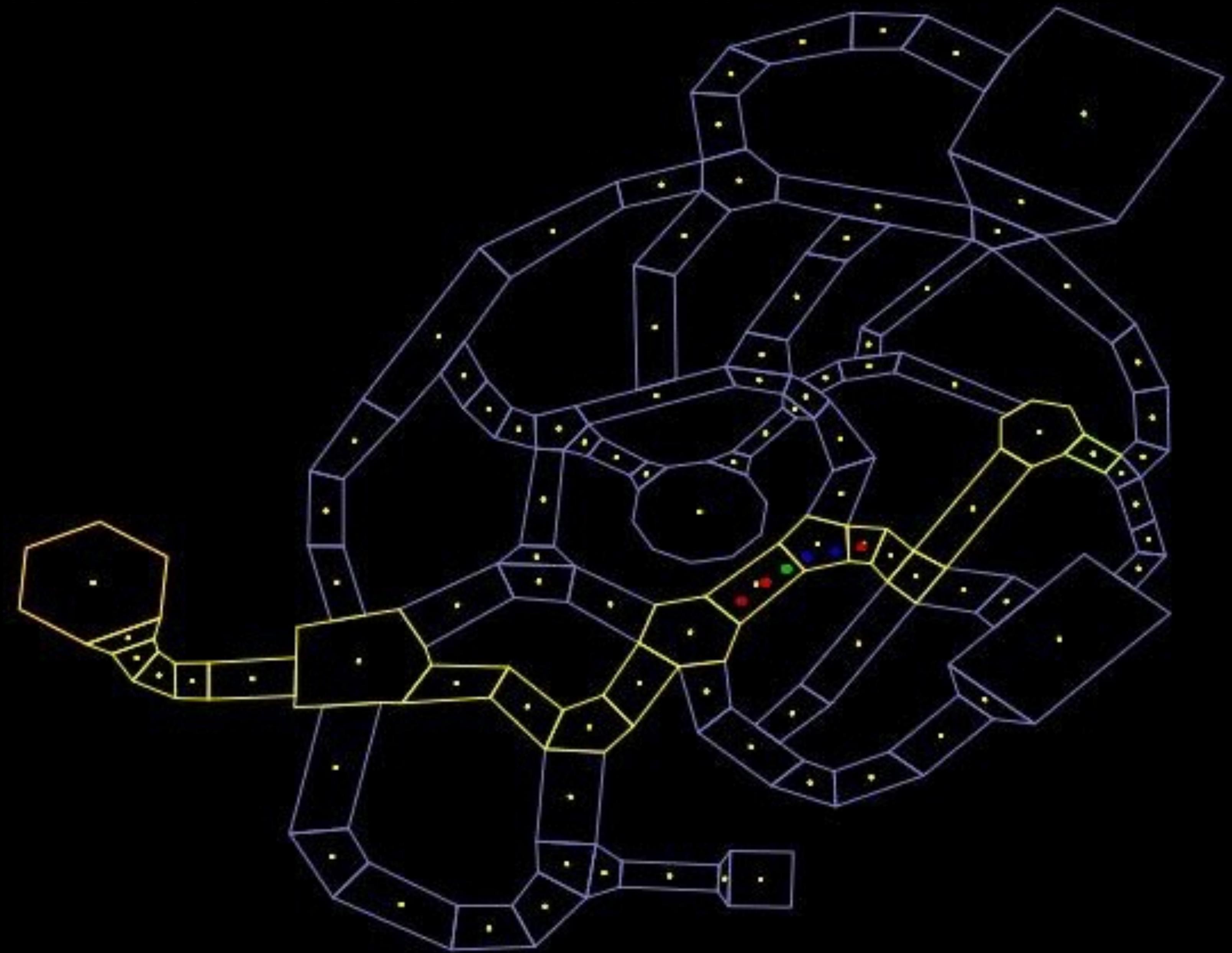


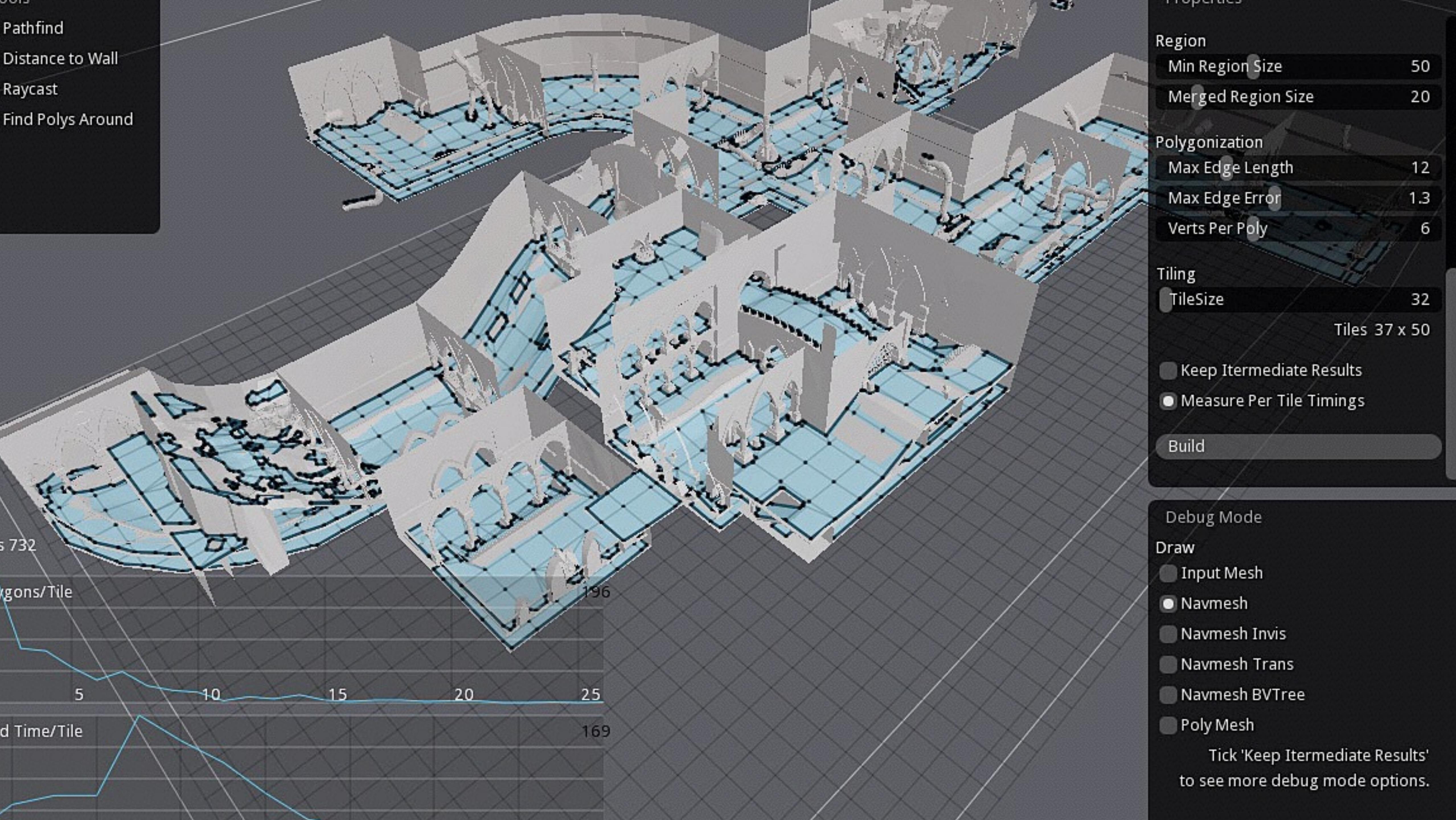




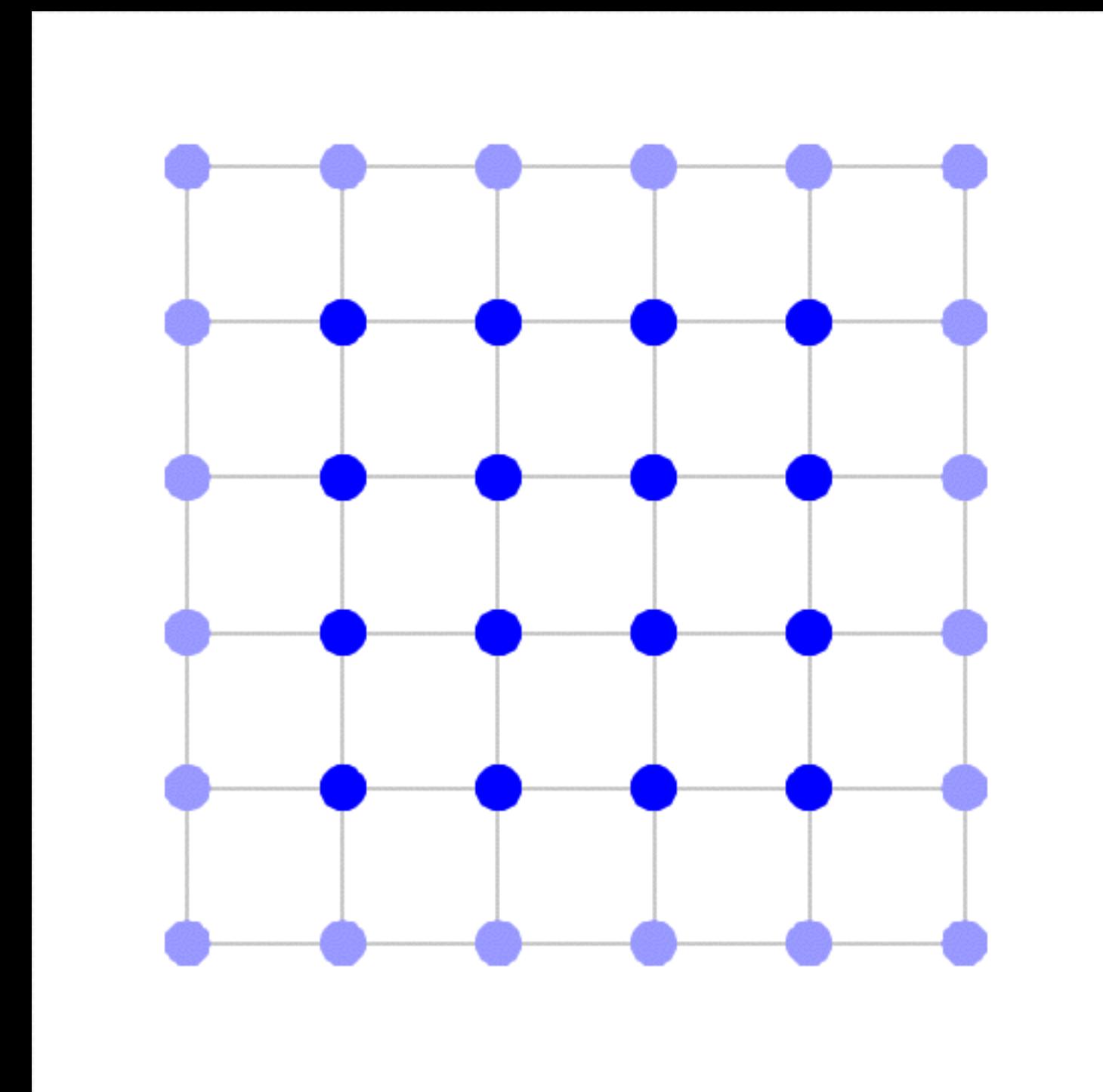
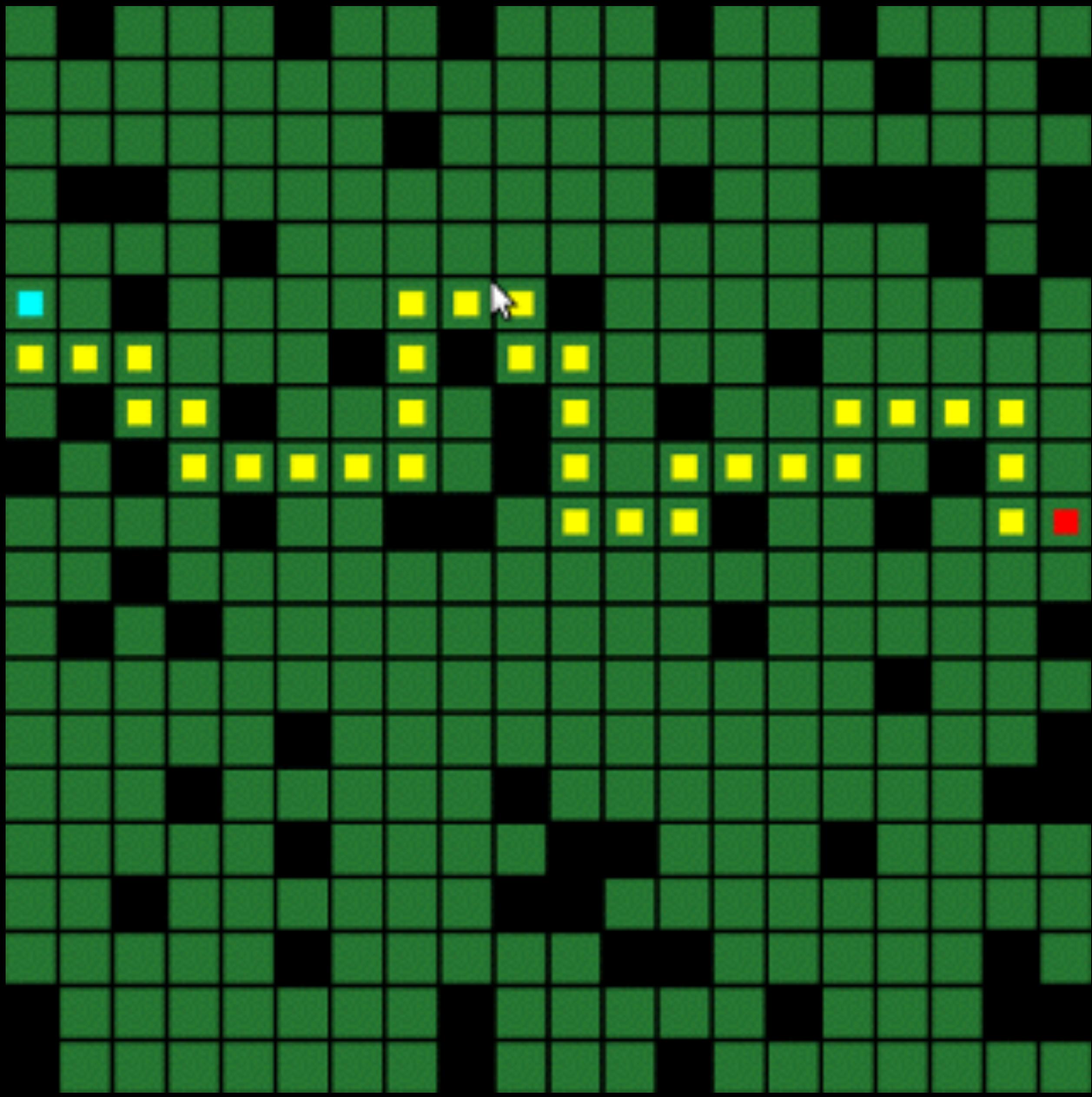
Navigation nodes.



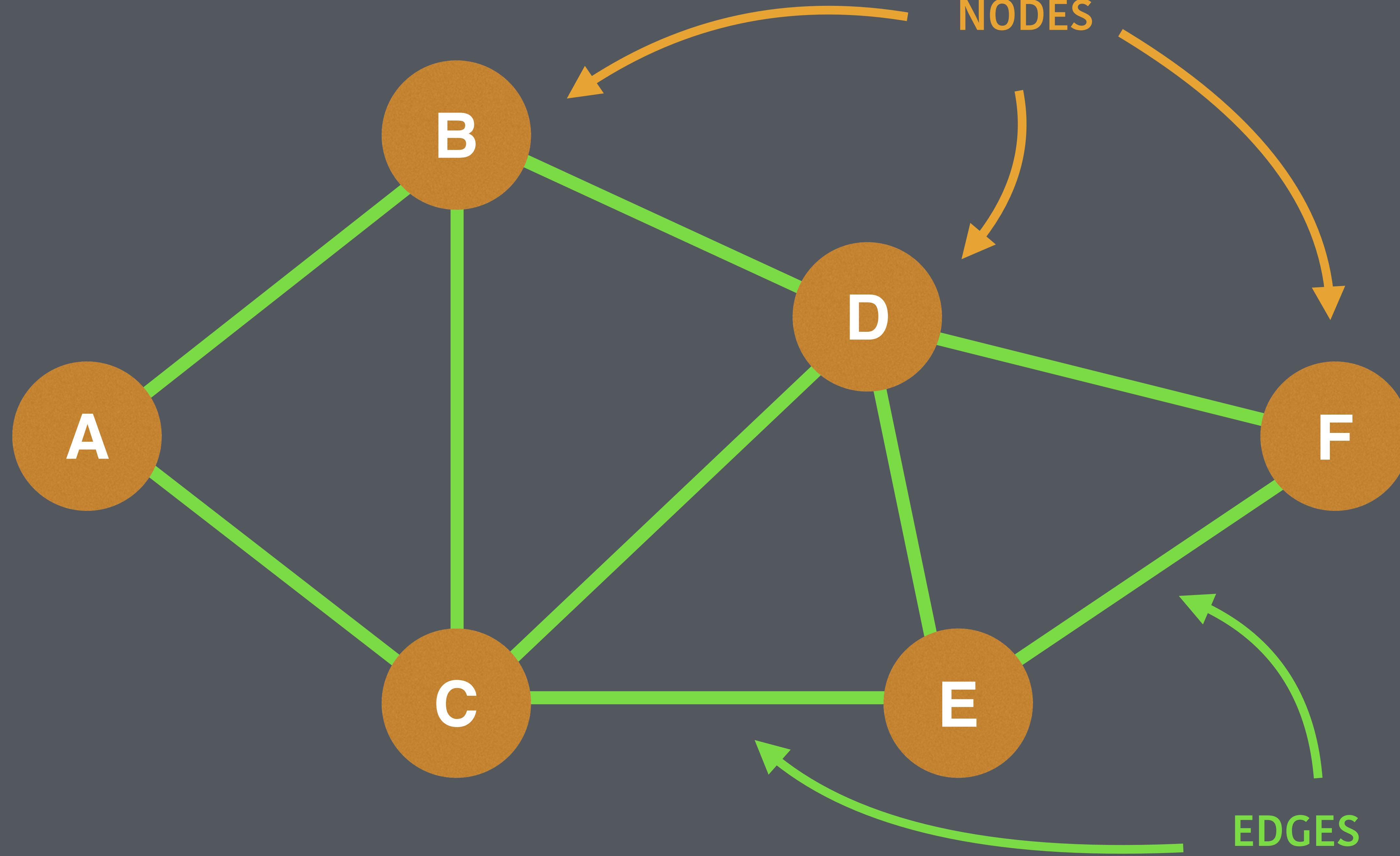








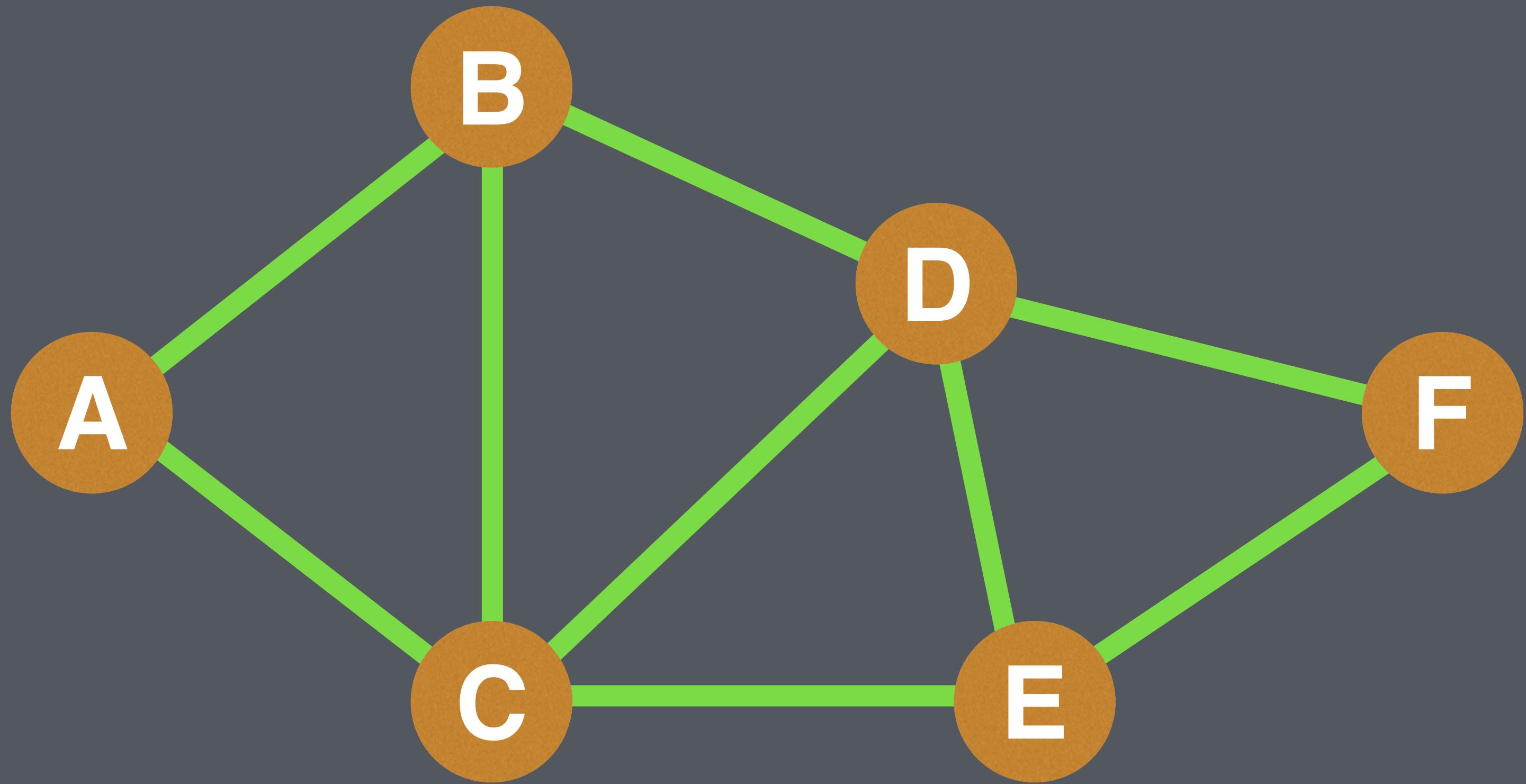
Graphs



Finding the path between two graph nodes.

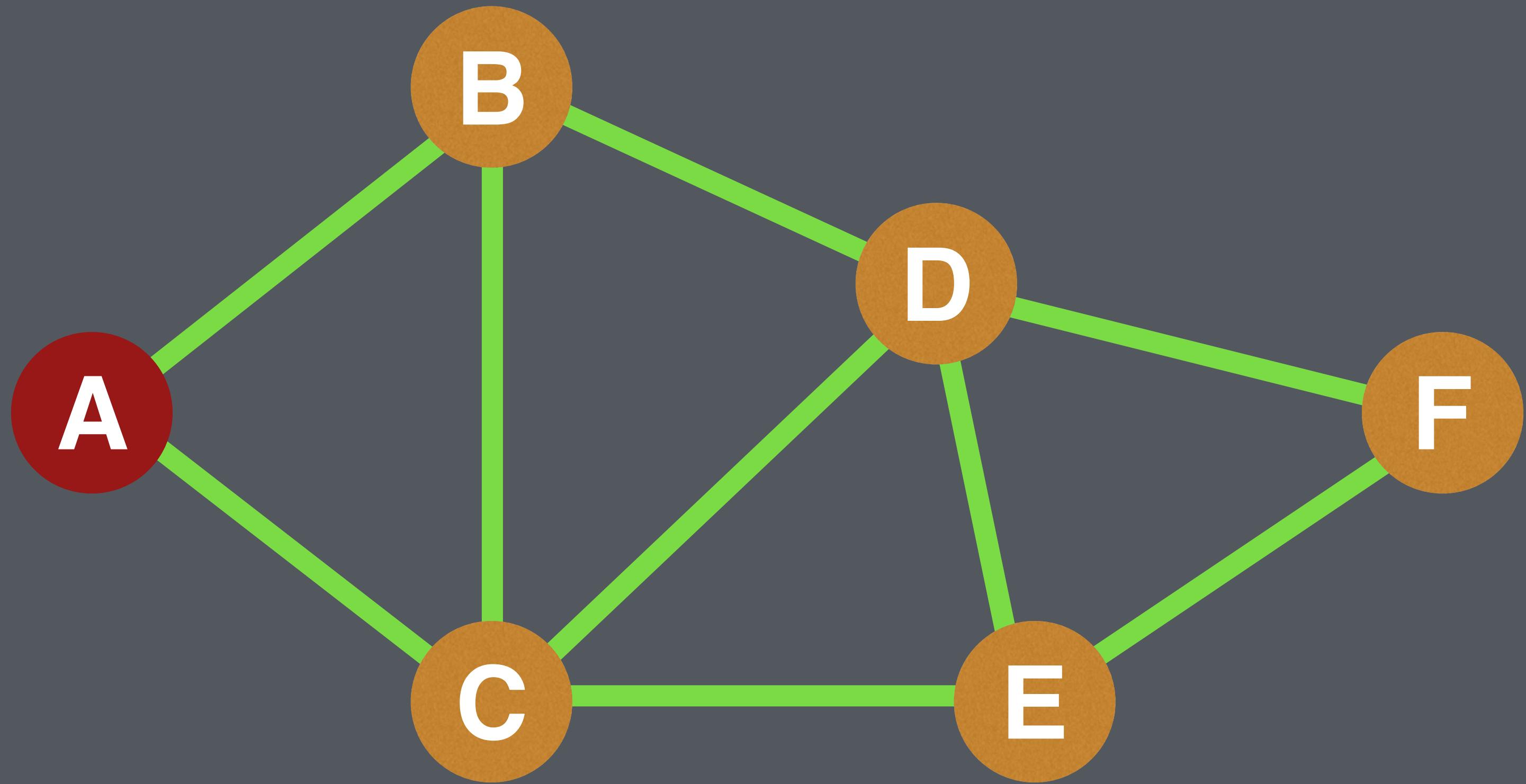
Breadth First Search algorithm.

```
class Node {  
public:  
    Node(float x, float y) : x(x), y(y){}  
    float x;  
    float y;  
    bool visited;  
    Node *cameFrom;  
    std::vector<Node*> connected;  
};
```



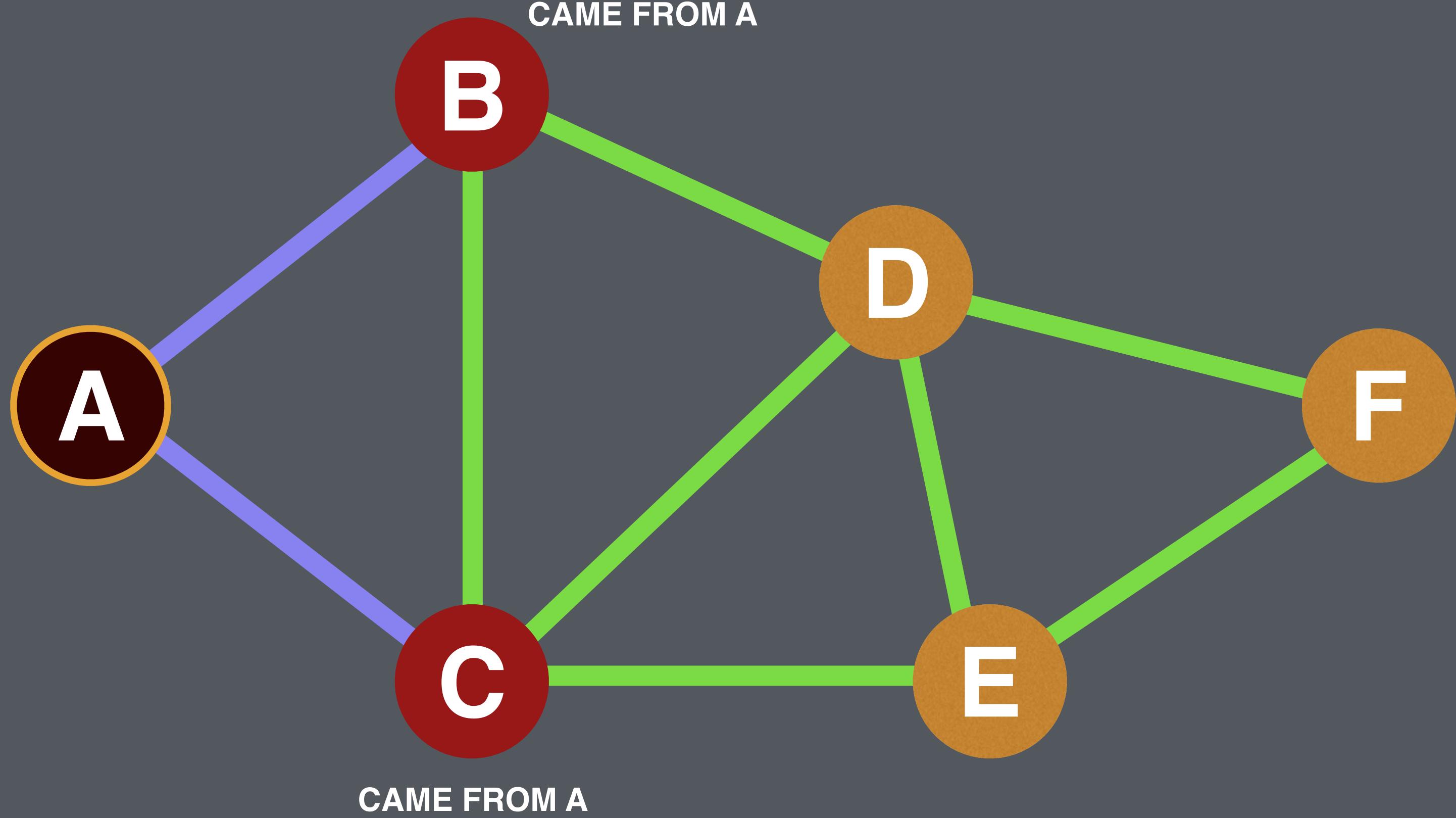
Finding the path from A to F using Breadth First Search

QUEUE:



Add our starting node to the queue.

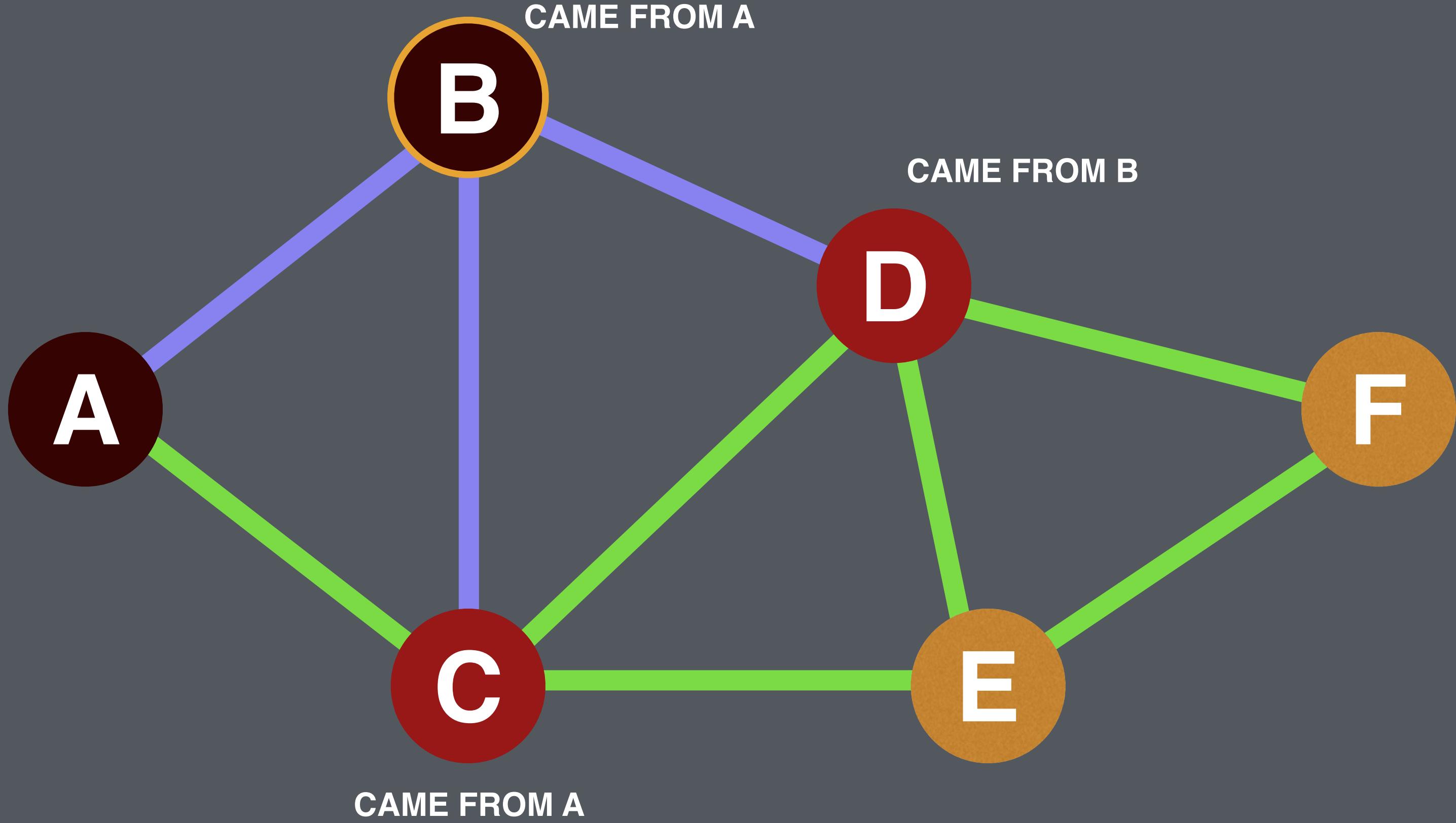
QUEUE: A



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: A

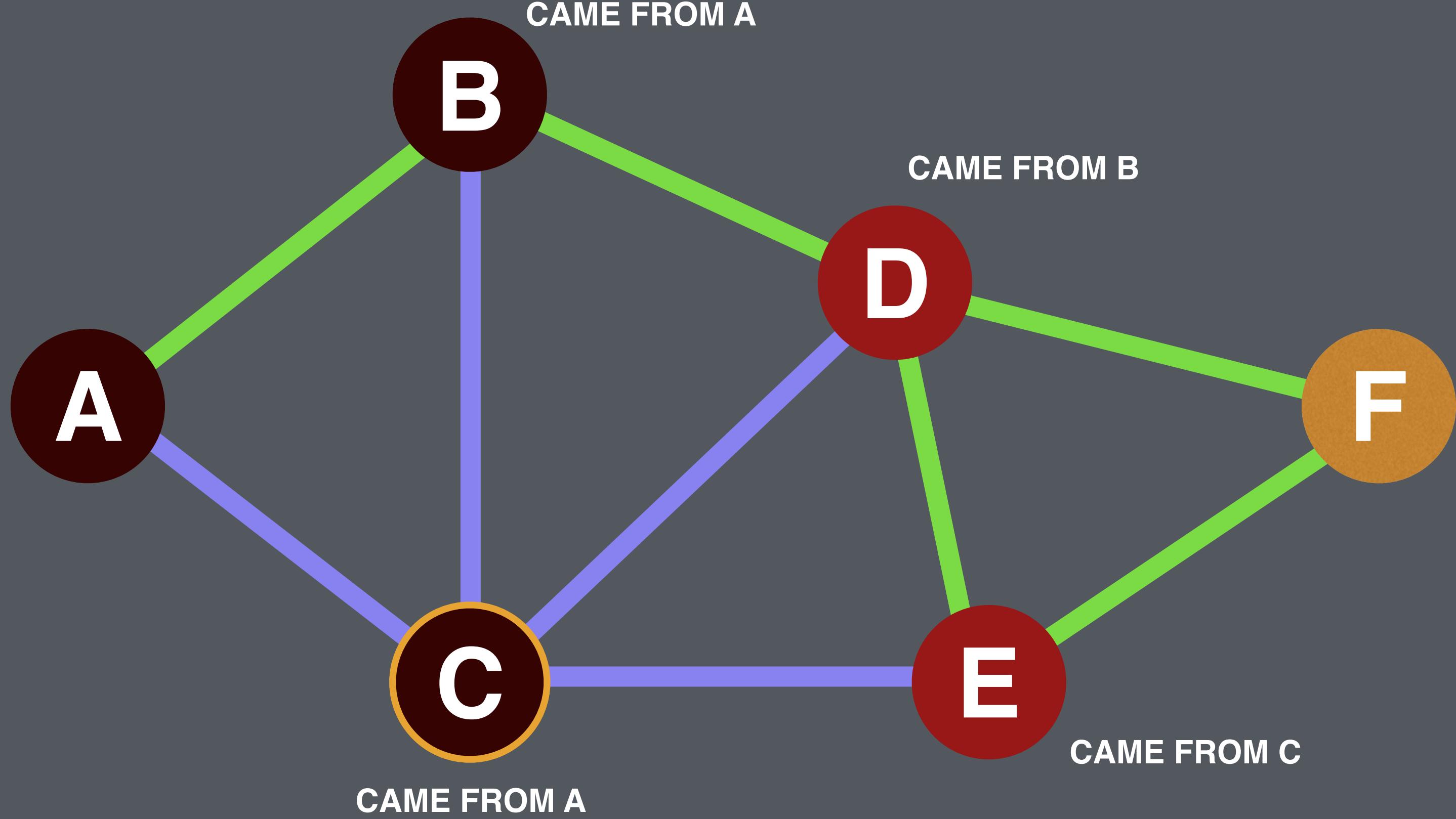
QUEUE: B,C



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: B

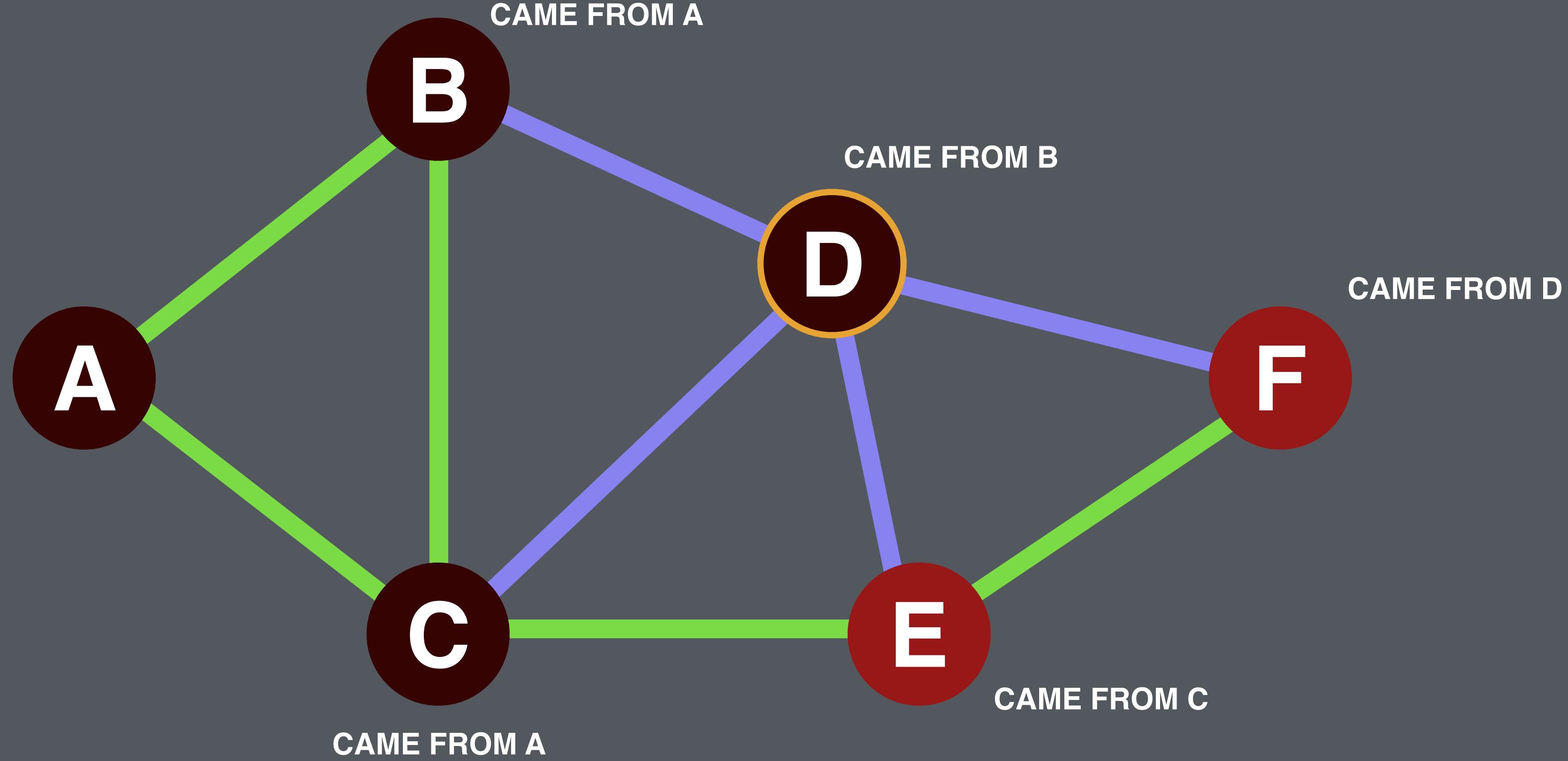
QUEUE: C,D



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: C

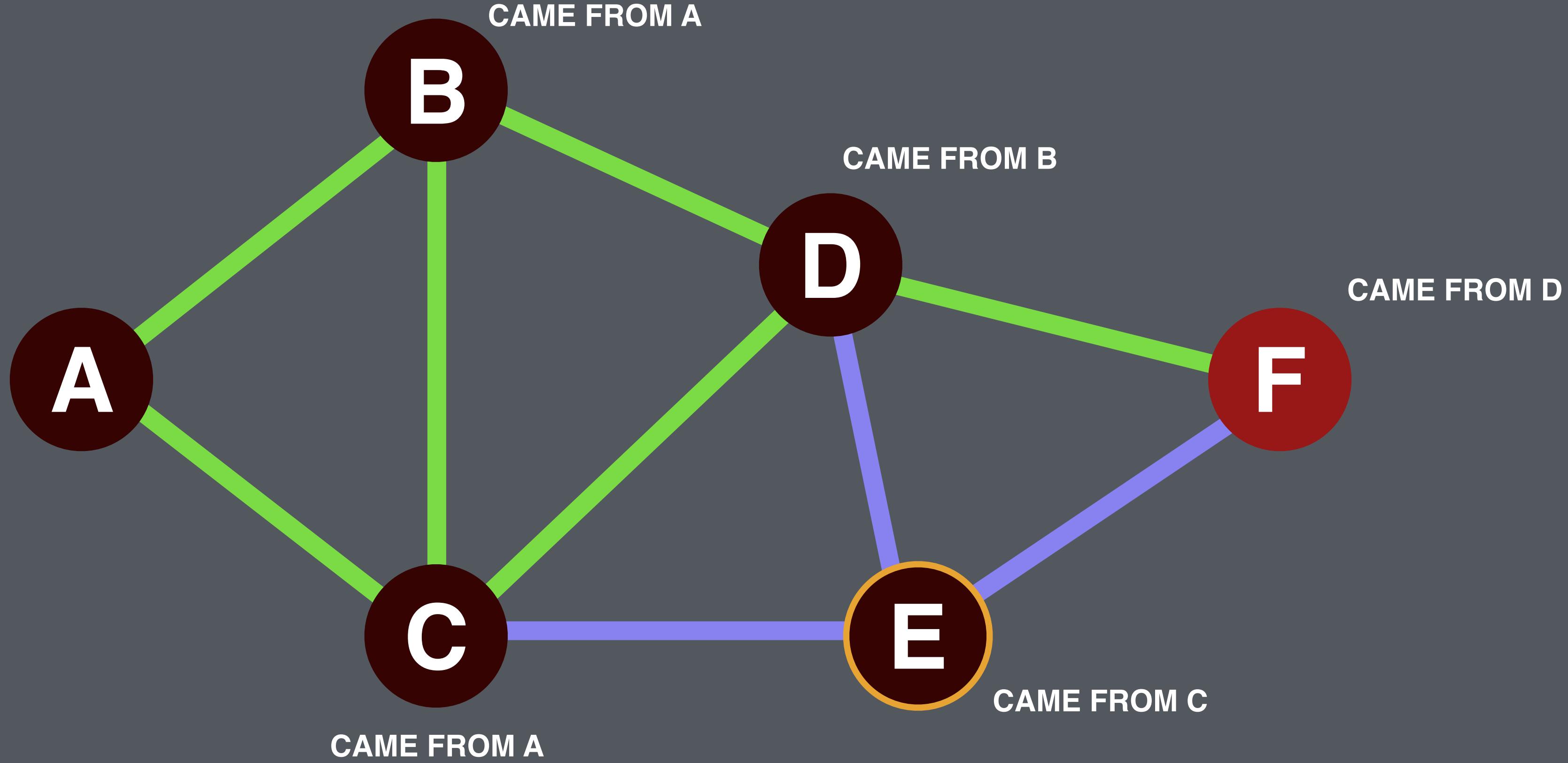
QUEUE: D,E



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their "cameFrom" node to the node we popped from the queue.

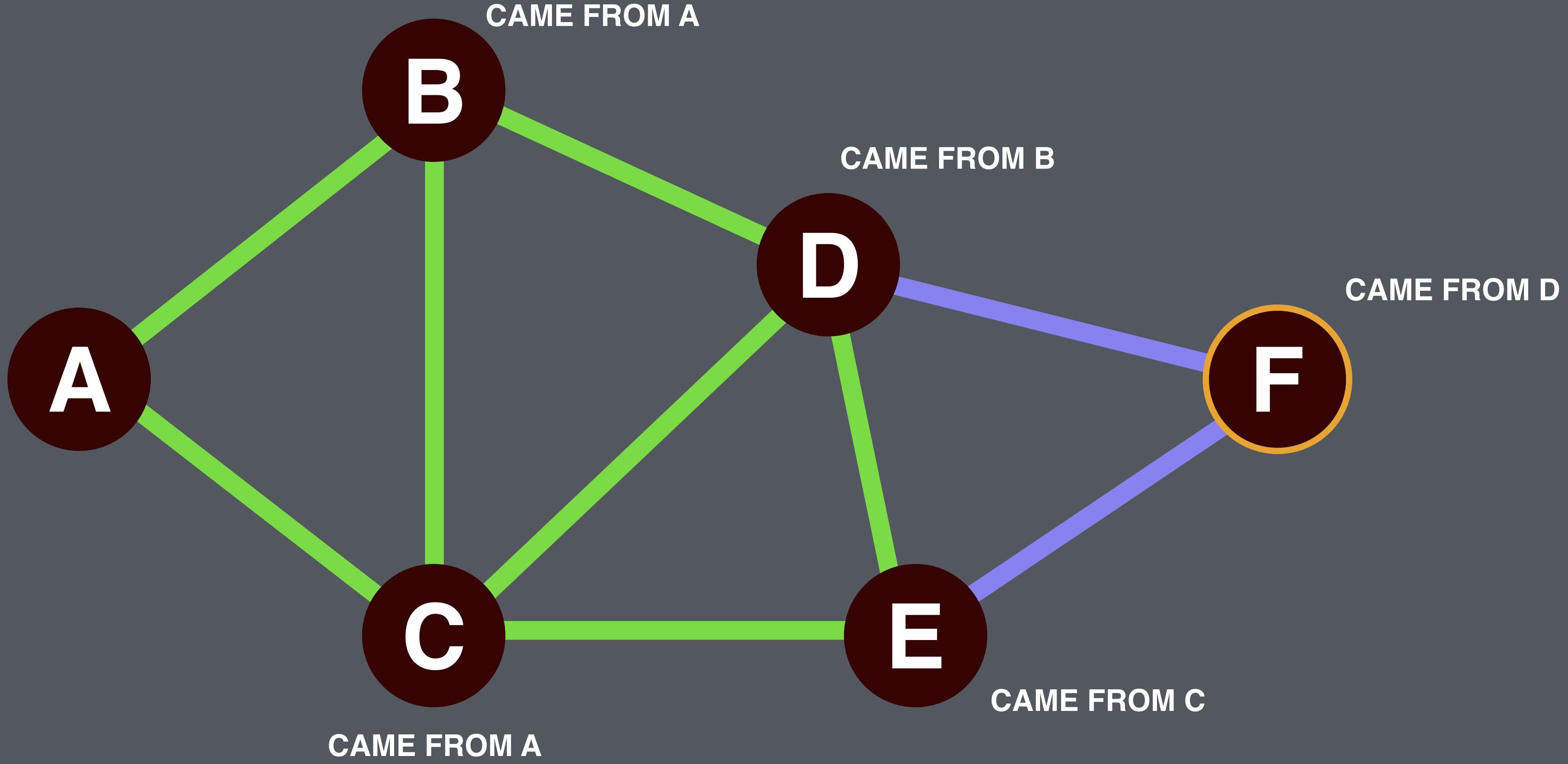
CURRENT NODE: D

QUEUE: E,F



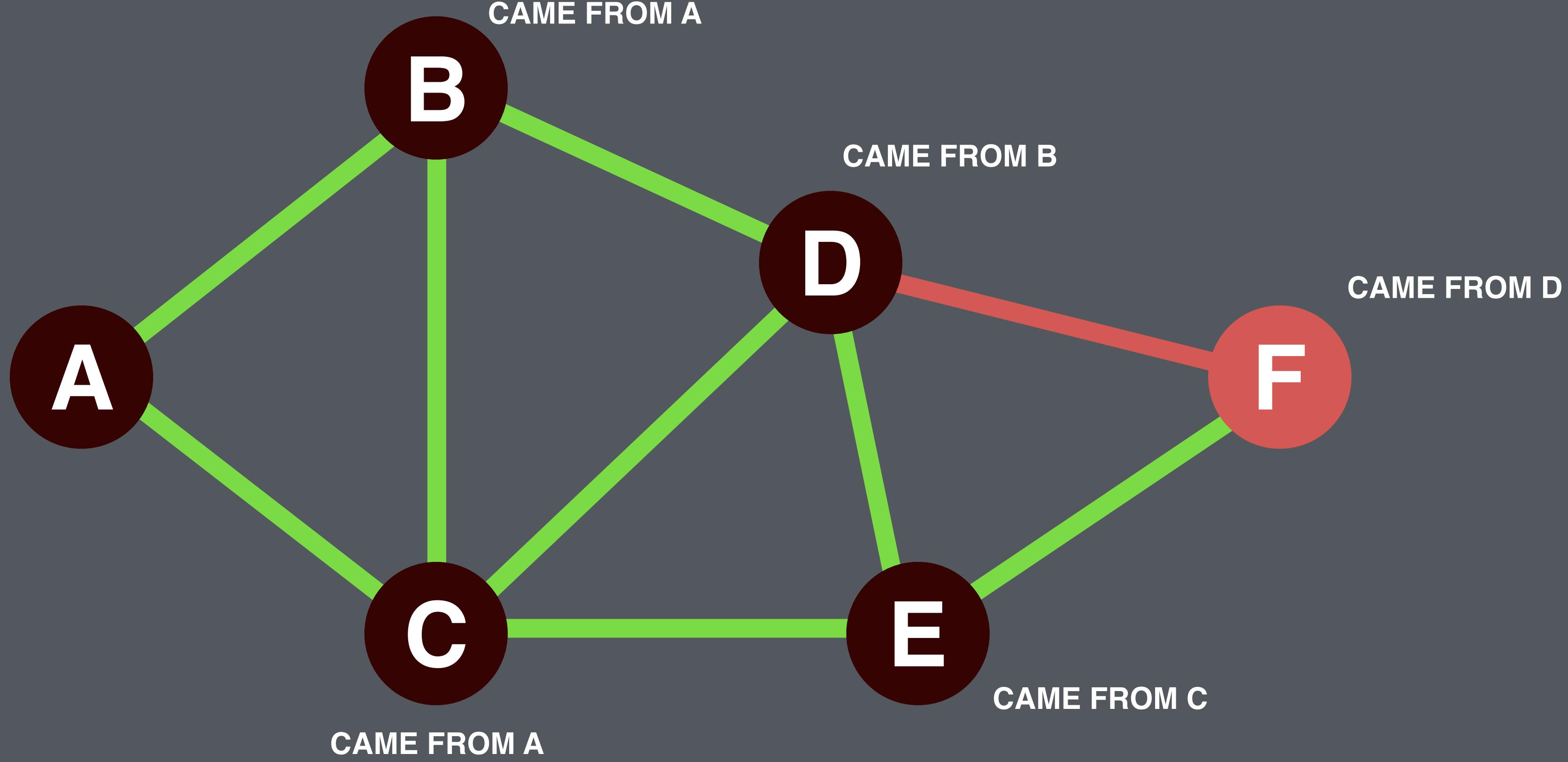
While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their “cameFrom” node to the node we popped from the queue.

QUEUE: F



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited, mark them visited and set their “cameFrom” node to the node we popped from the queue.

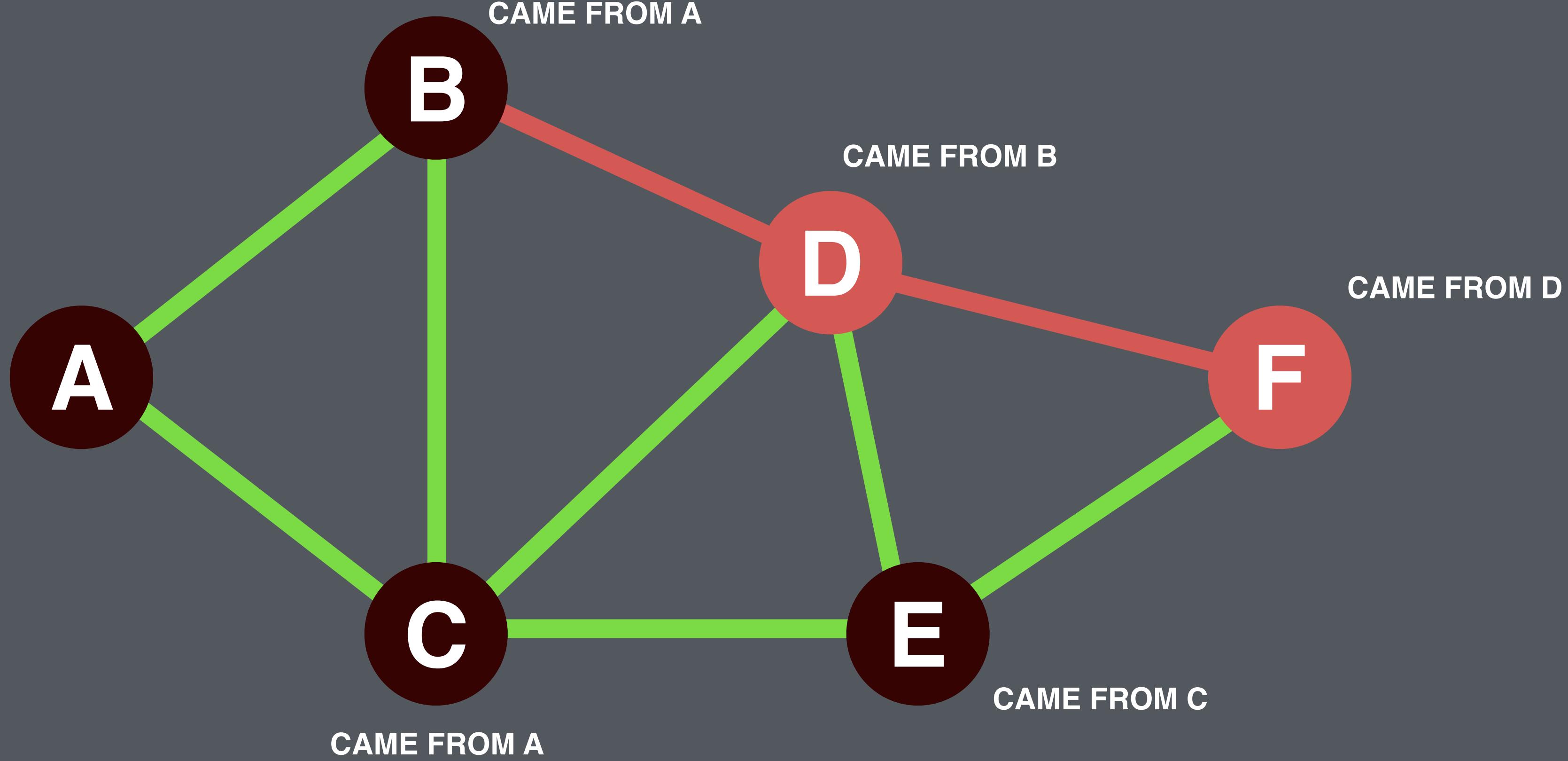
QUEUE:



Now, starting at the goal node (F), look at the cameFrom nodes, adding them to a list of nodes until we hit the starting node.

CURRENT NODE: F CAME FROM: D

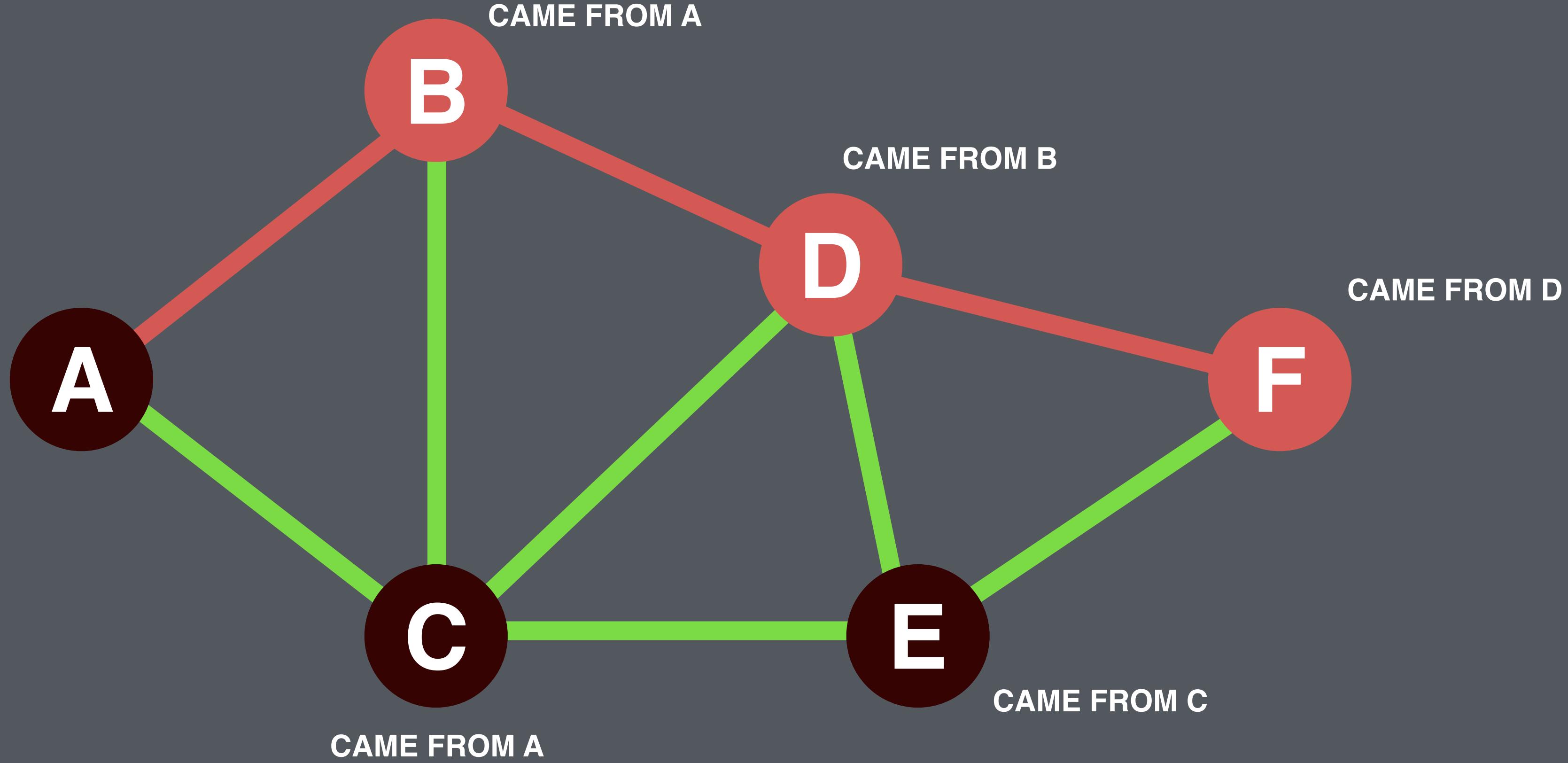
PATH: F



Now, starting at the goal node (F), look at the cameFrom nodes, adding them to a list of nodes until we hit the starting node.

CURRENT NODE: D CAME FROM: B

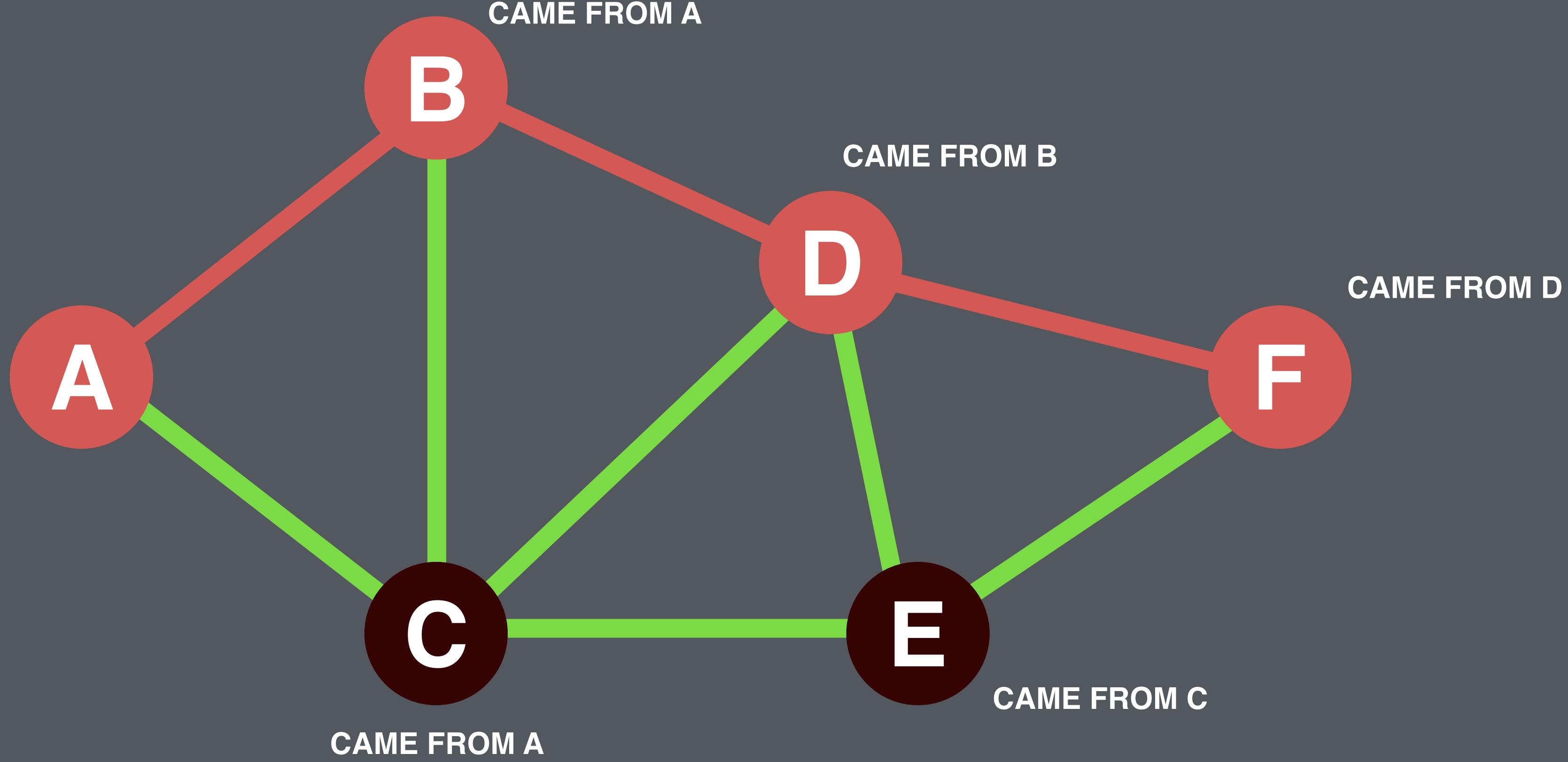
PATH: F,D



Now, starting at the goal node (F), look at the cameFrom nodes, adding them to a list of nodes until we hit the starting node.

CURRENT NODE: B CAME FROM: A

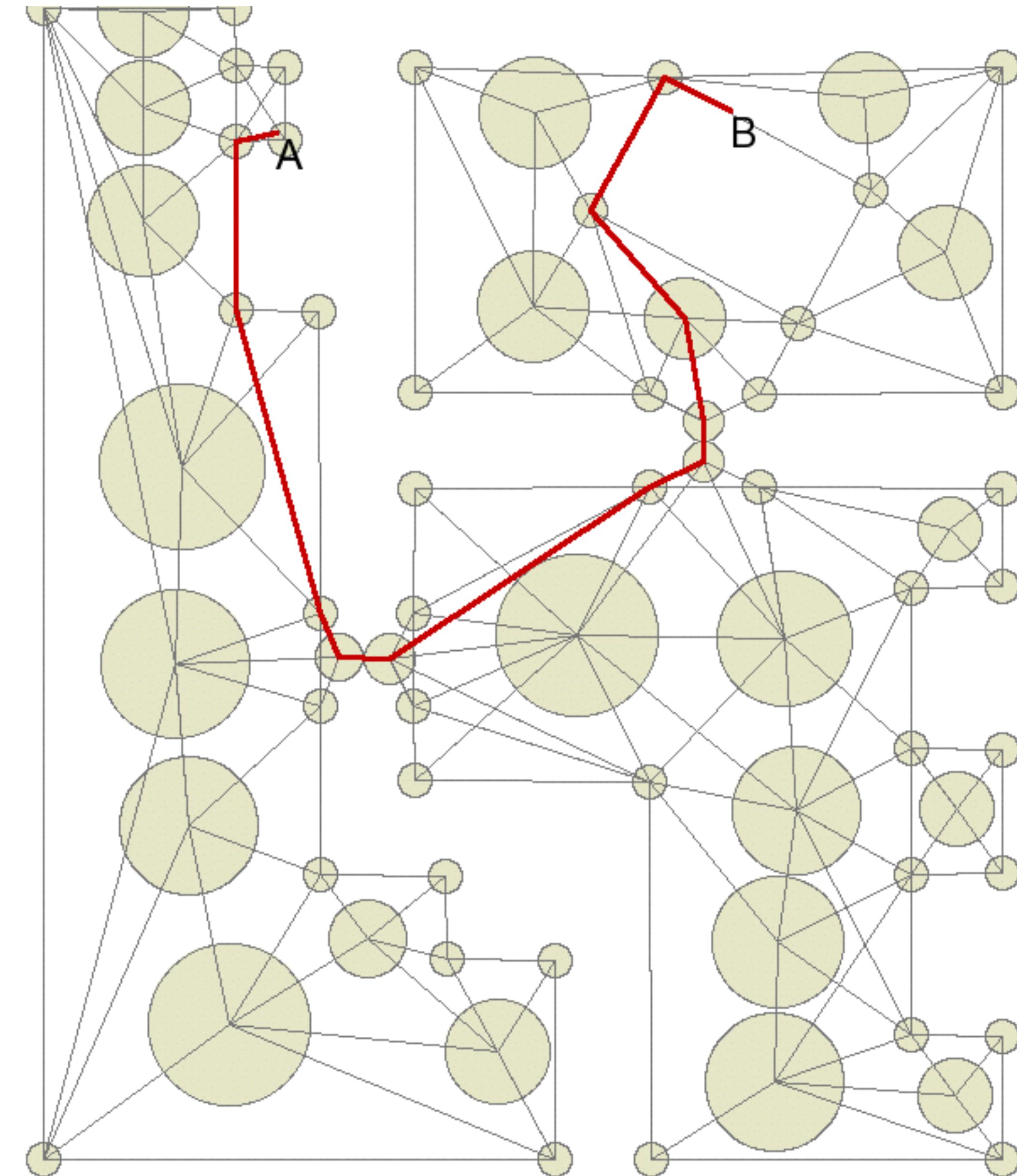
PATH: F,D,B

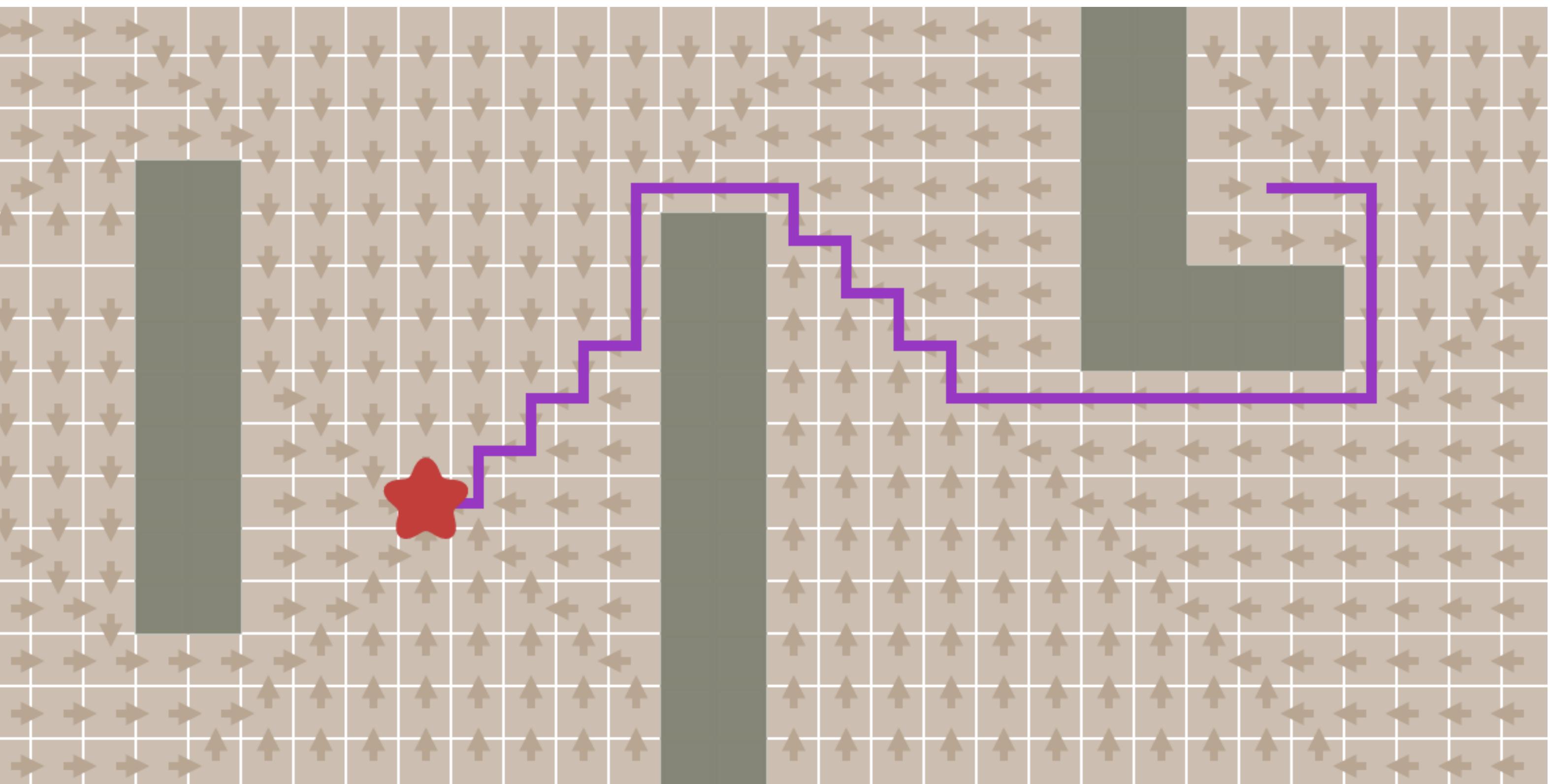
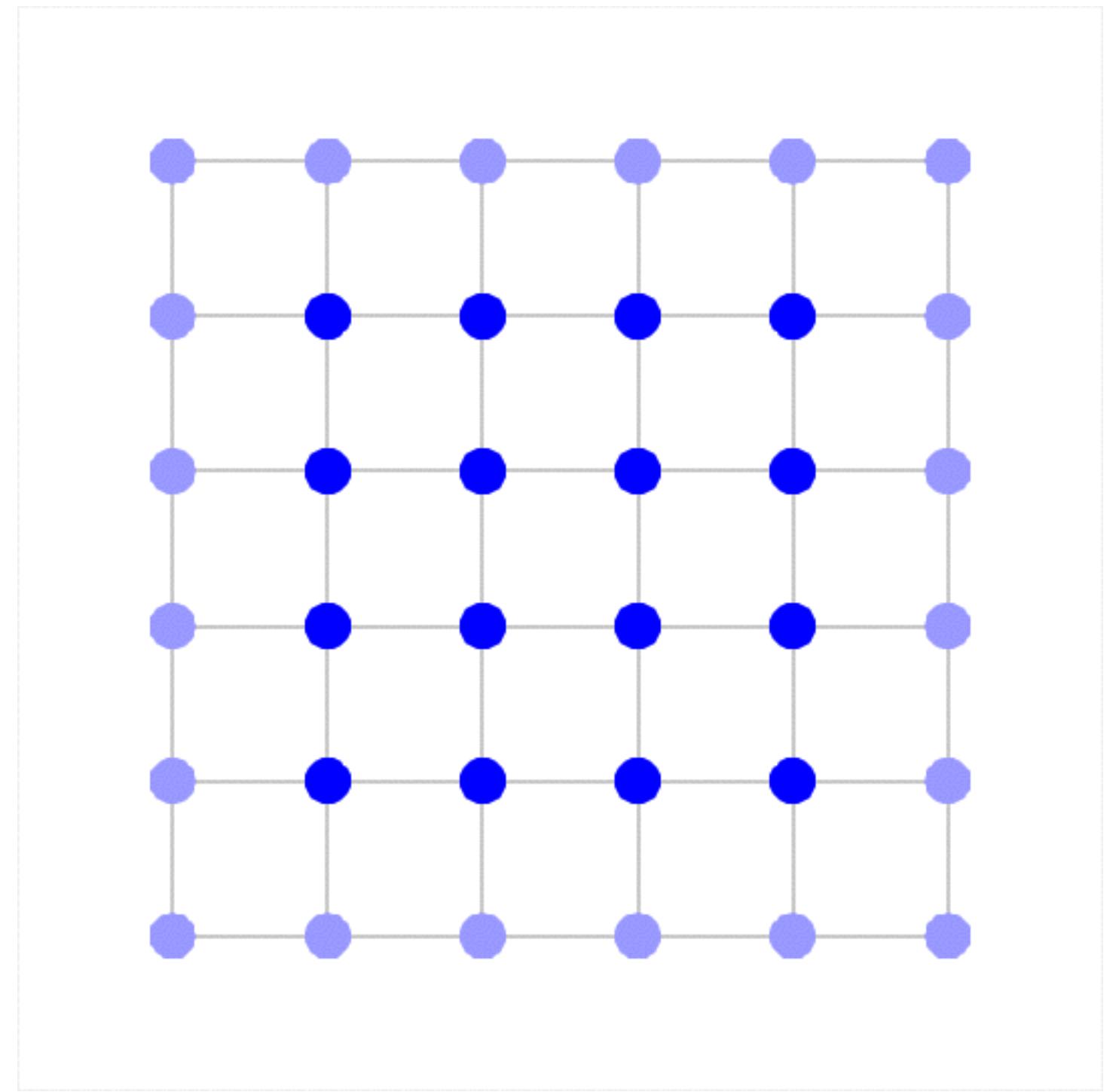


Now, starting at the goal node (F), look at the cameFrom nodes, adding them to a list of nodes until we hit the starting node.

CURRENT NODE: A A IS OUR STARTING NODE!

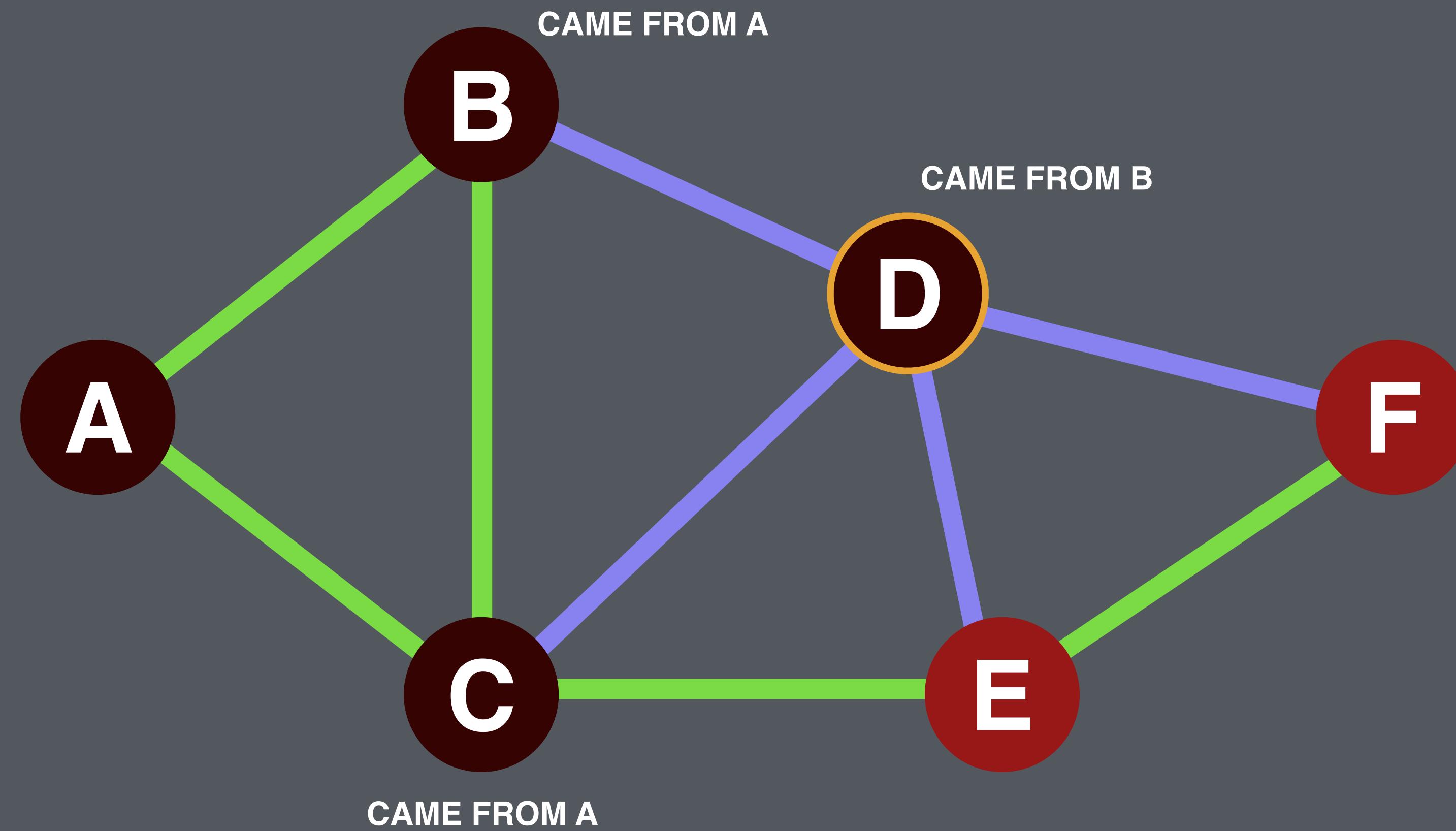
PATH: F,D,B,A



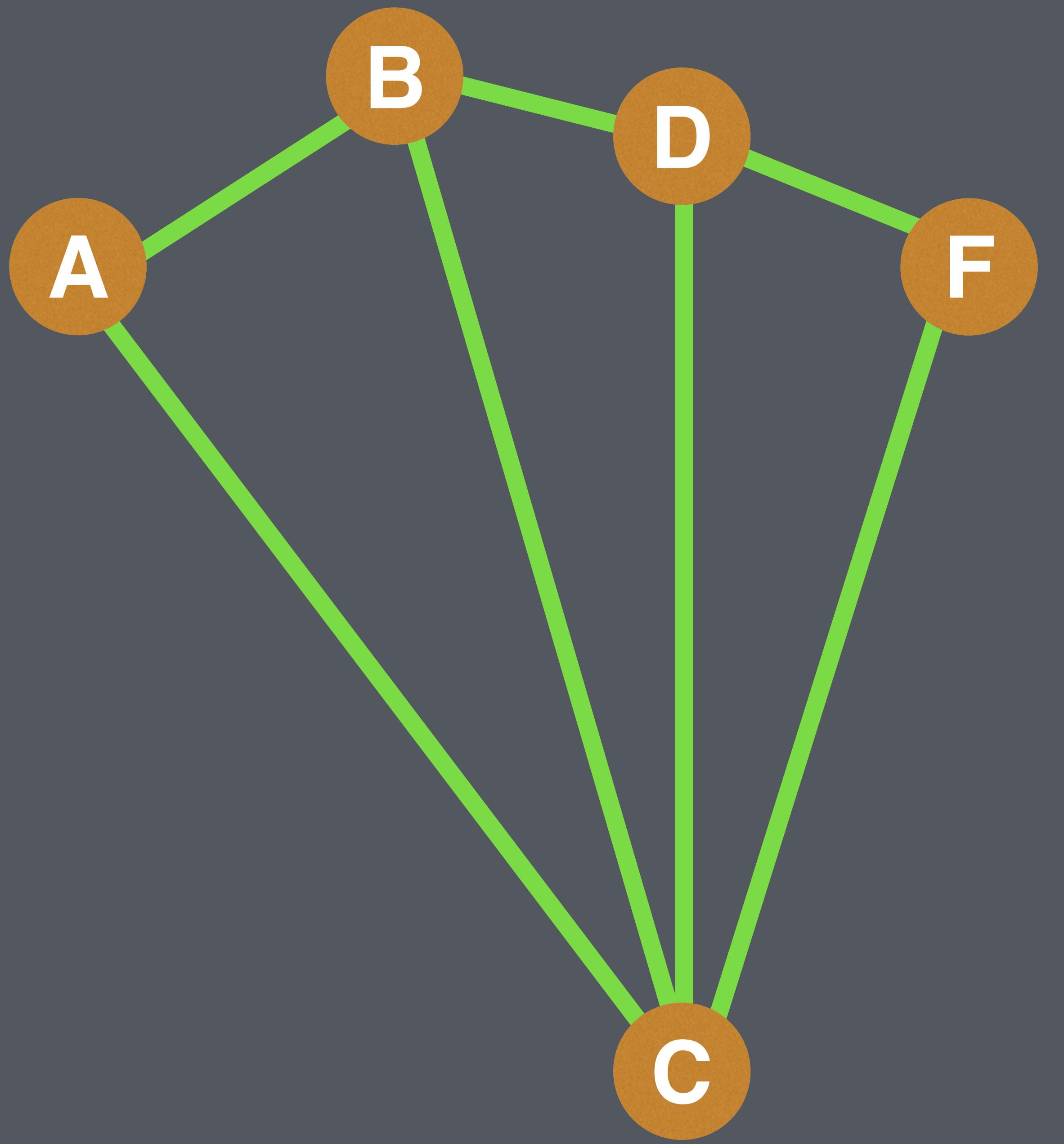


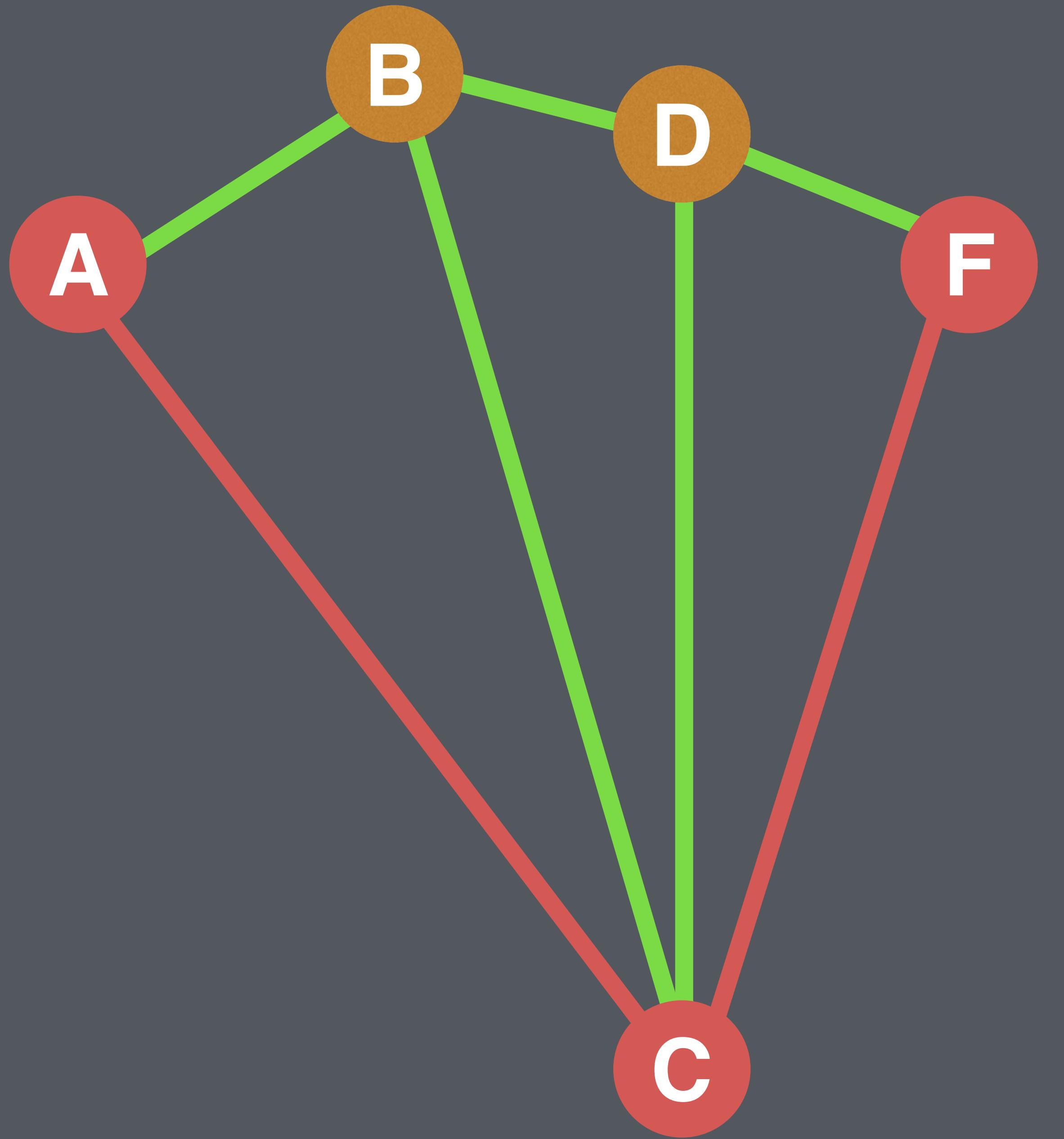
We can optimize our search by stopping cameFrom generation when we hit our goal node.

Path from A to D:

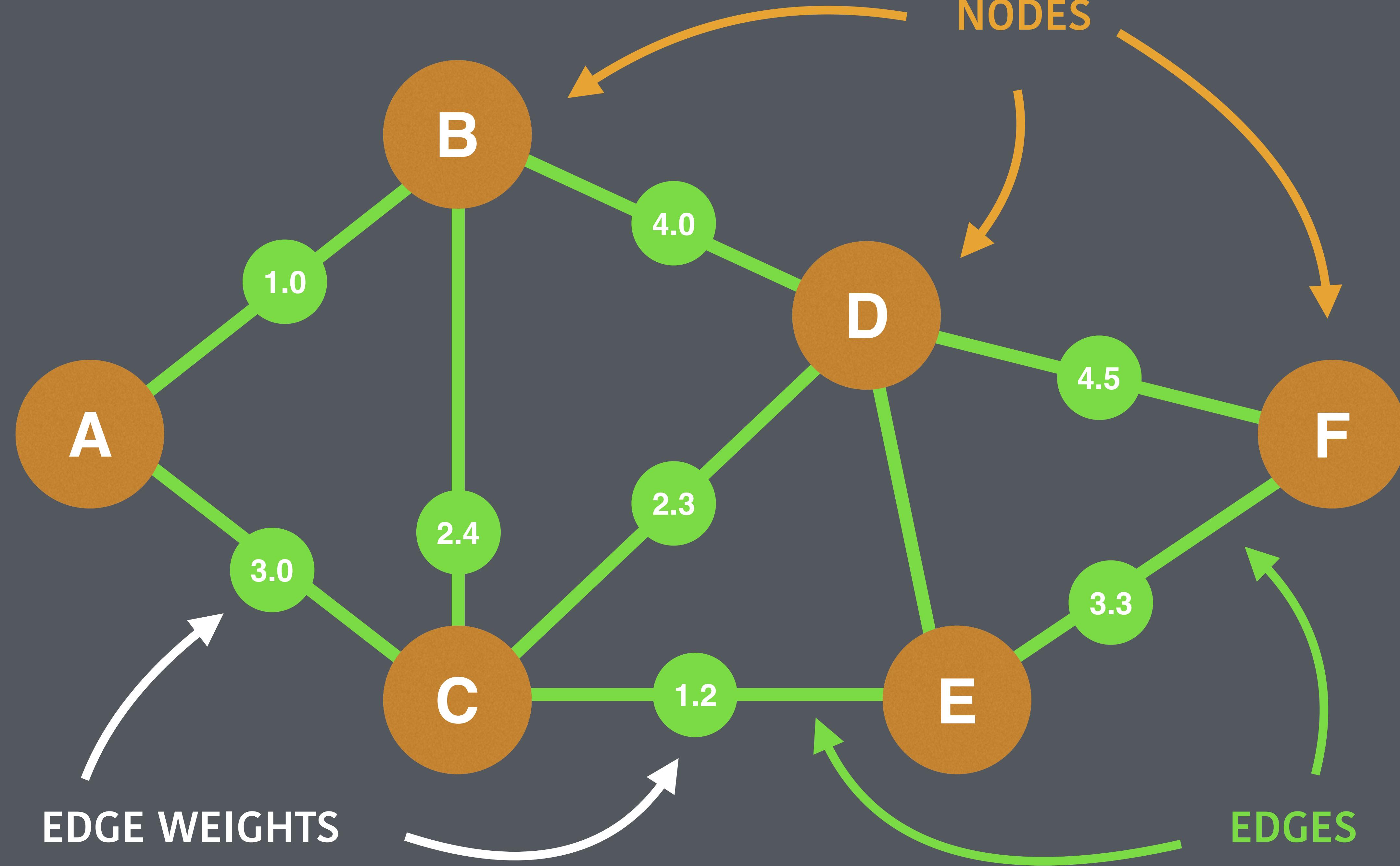


Distance

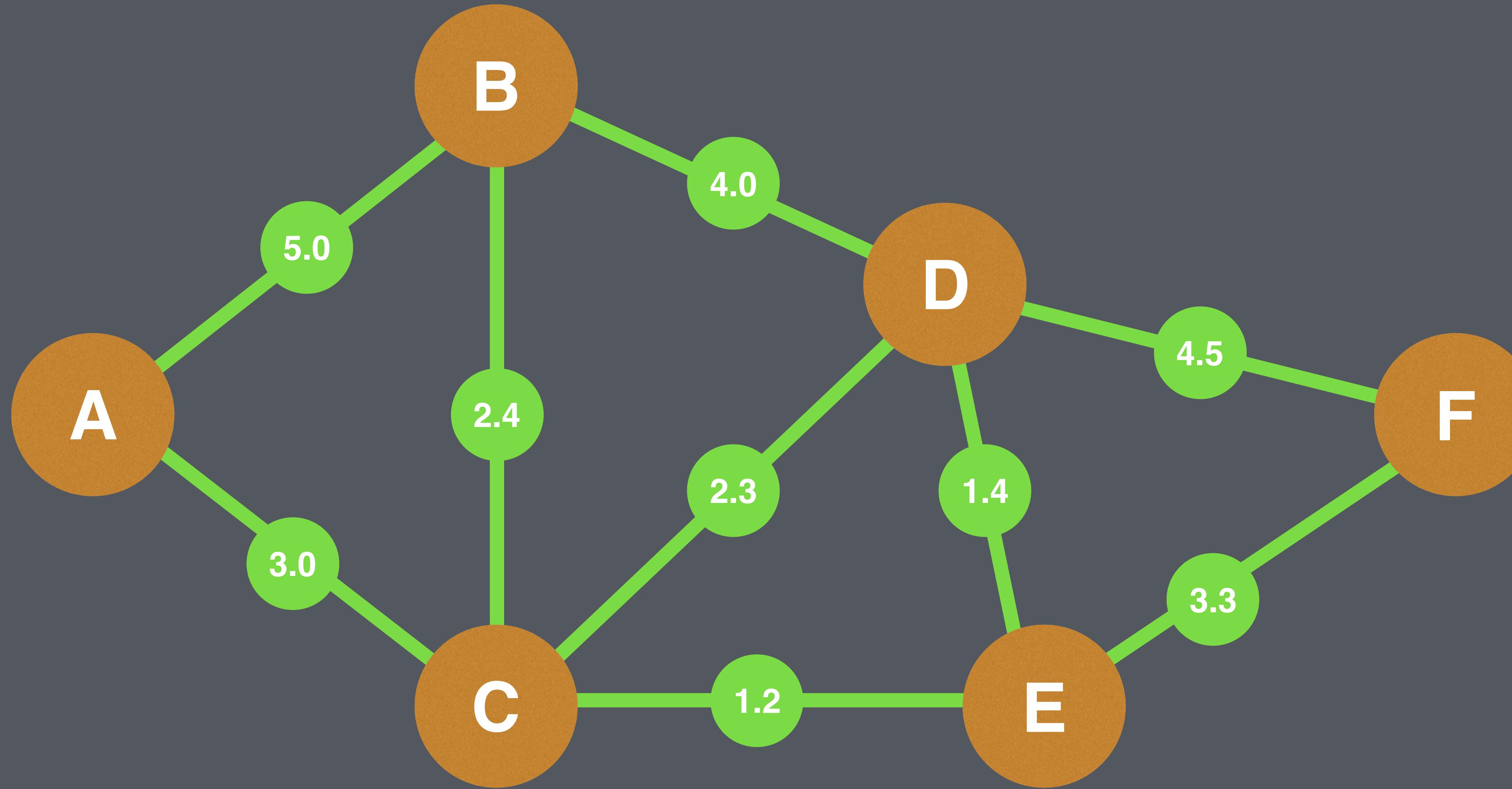




Weighted graphs



AI path nodes as **weighted graphs**.

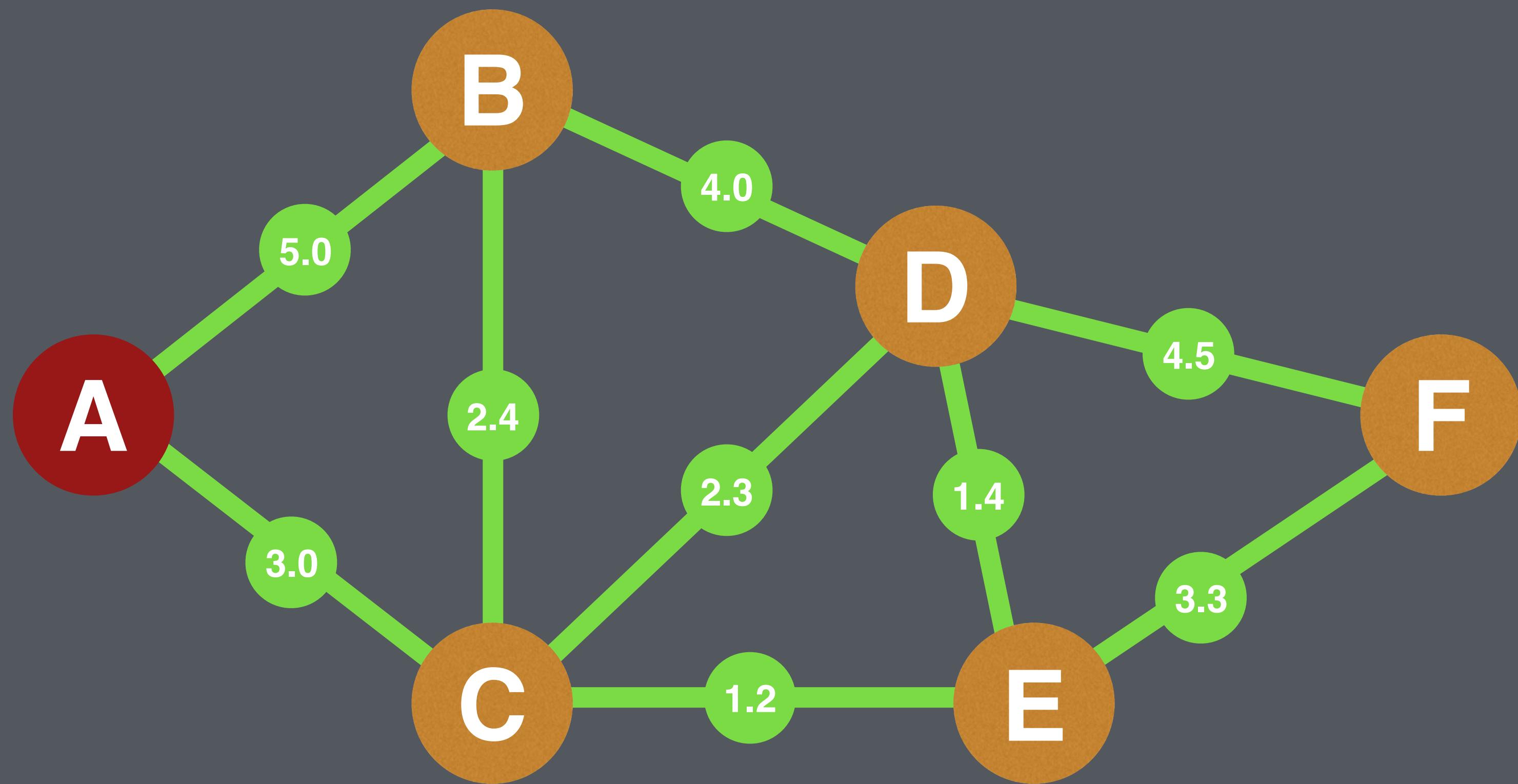


Dijkstra's algorithm.

```
class Node {  
public:  
    Node(float x, float y) : x(x), y(y){}  
    float x;  
    float y;  
    bool visited;  
    float cost;  
    Node *cameFrom;  
    std::vector<Node*> connected;  
};
```



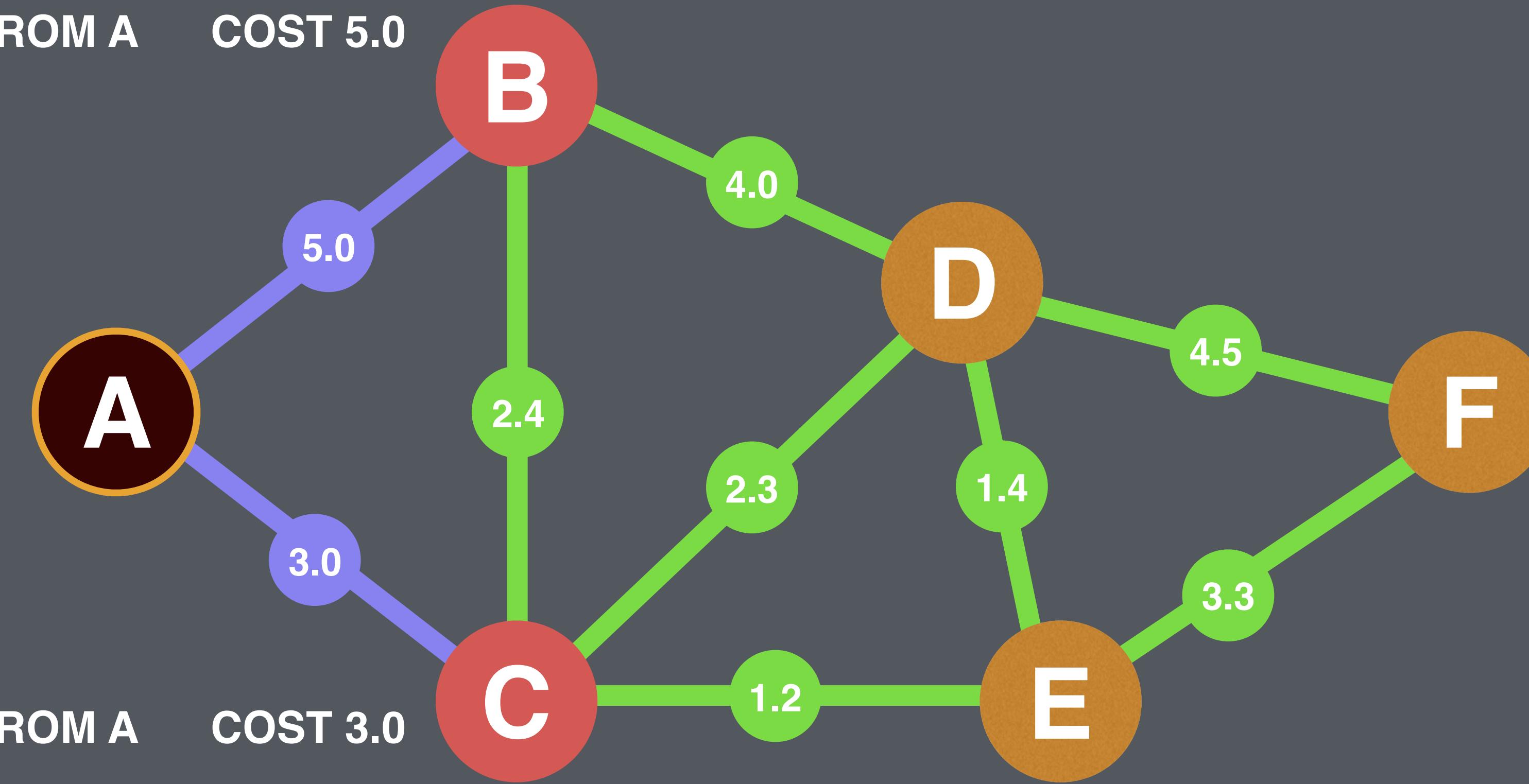
Priority queue



Add our starting node to the queue with cost 0

PRIORITY_QUEUE: A(0)

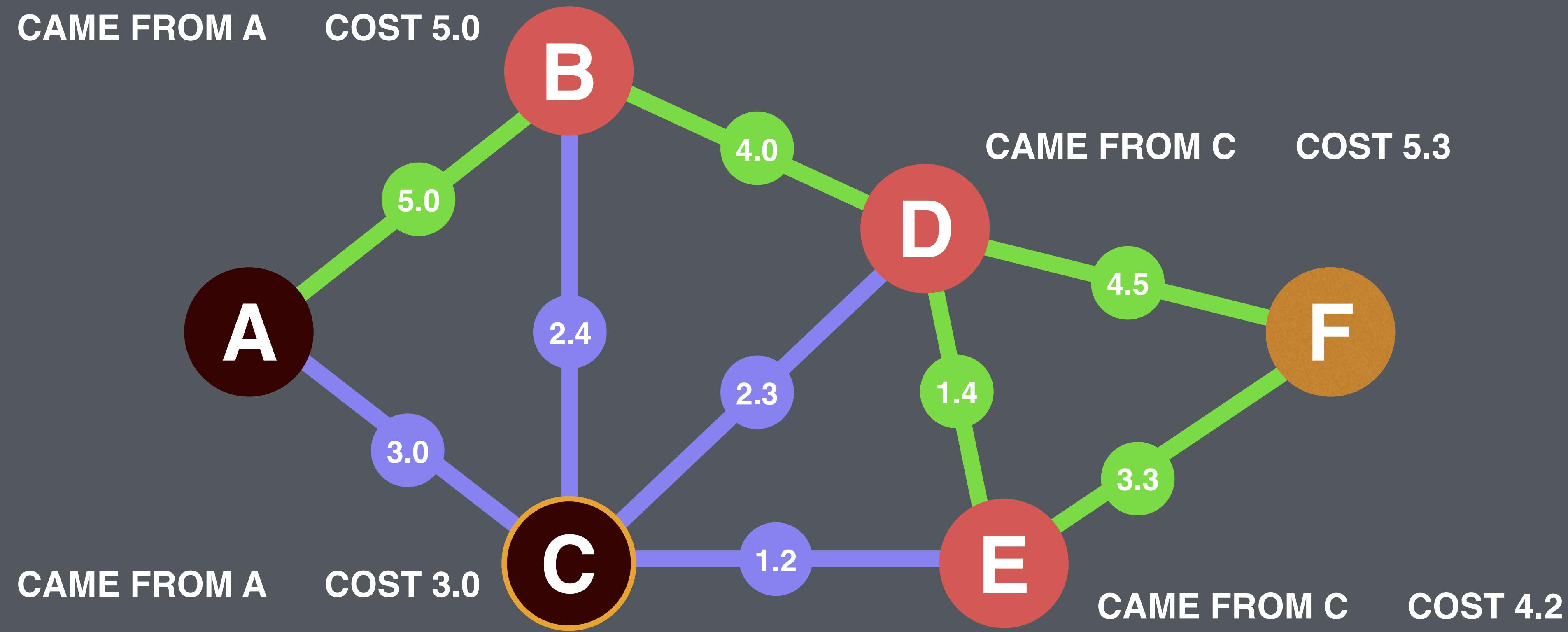
CAME FROM A COST 5.0



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited OR IF THE COST OF THE CURRENT NODE PLUS THE CONNECTION COST IS LESS THAN THE COST OF THAT NODE, mark them visited, set their "cameFrom" node to the node we popped from the queue and SET THEIR COST TO THE CURRENT NODE COST + CONNECTION COST.

CURRENT NODE: A

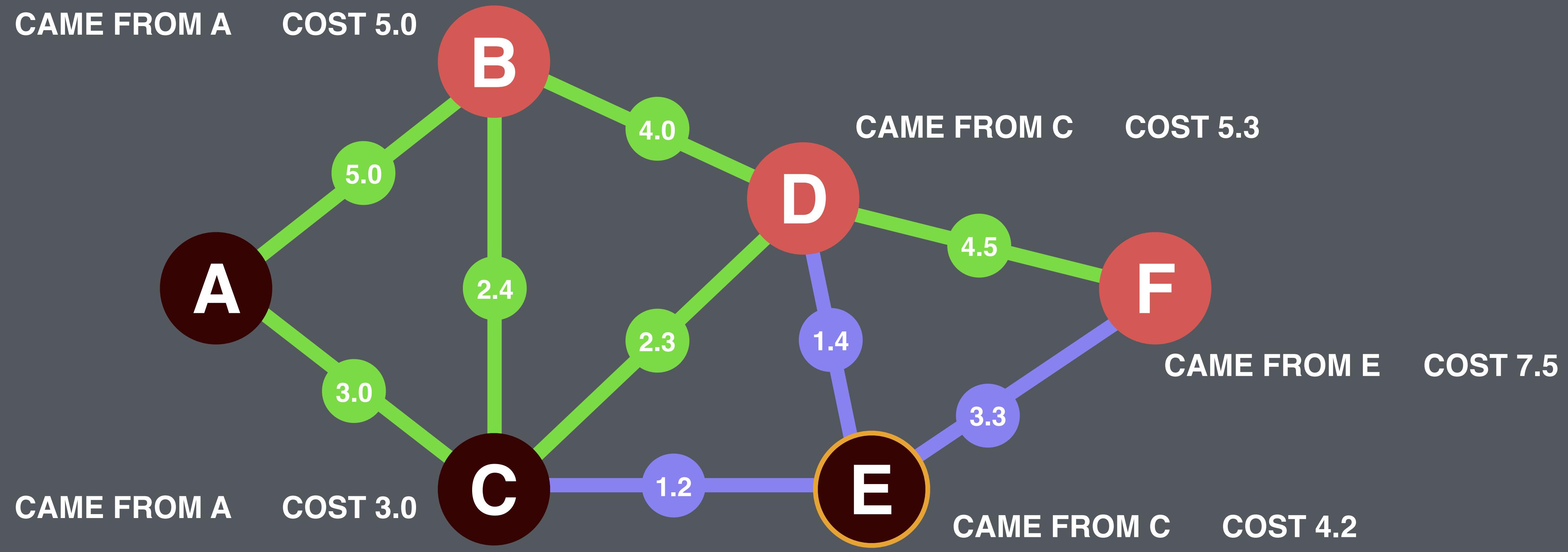
PRIORITY_QUEUE: C(3.0) B(5.0)



While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited OR IF THE COST OF THE CURRENT NODE PLUS THE CONNECTION COST IS LESS THAN THE COST OF THAT NODE, mark them visited, set their "cameFrom" node to the node we popped from the queue and SET THEIR COST TO THE CURRENT NODE COST + CONNECTION COST.

CURRENT NODE: C

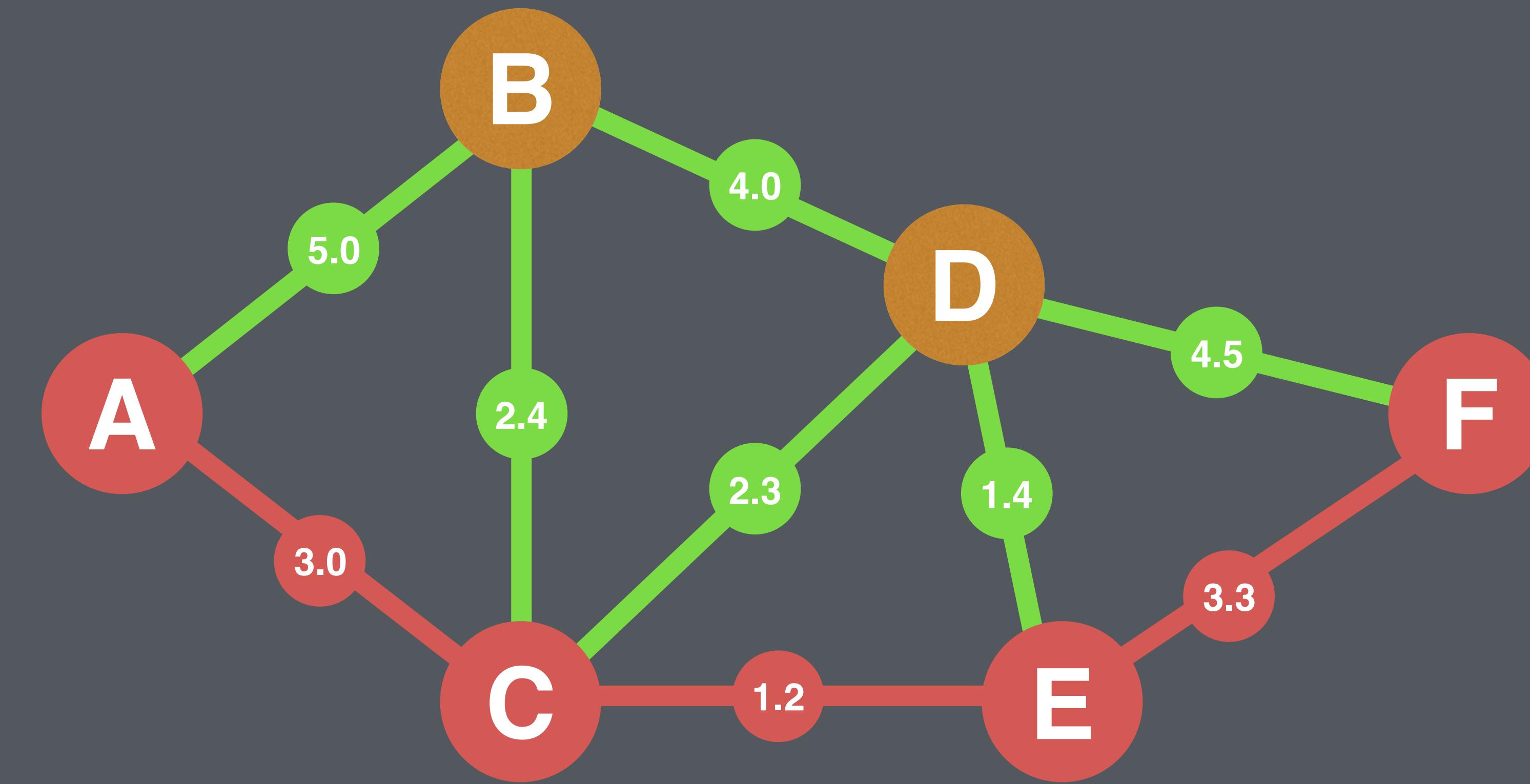
PRIORITY_QUEUE: E(4.2) B(5.0) D(5.3)

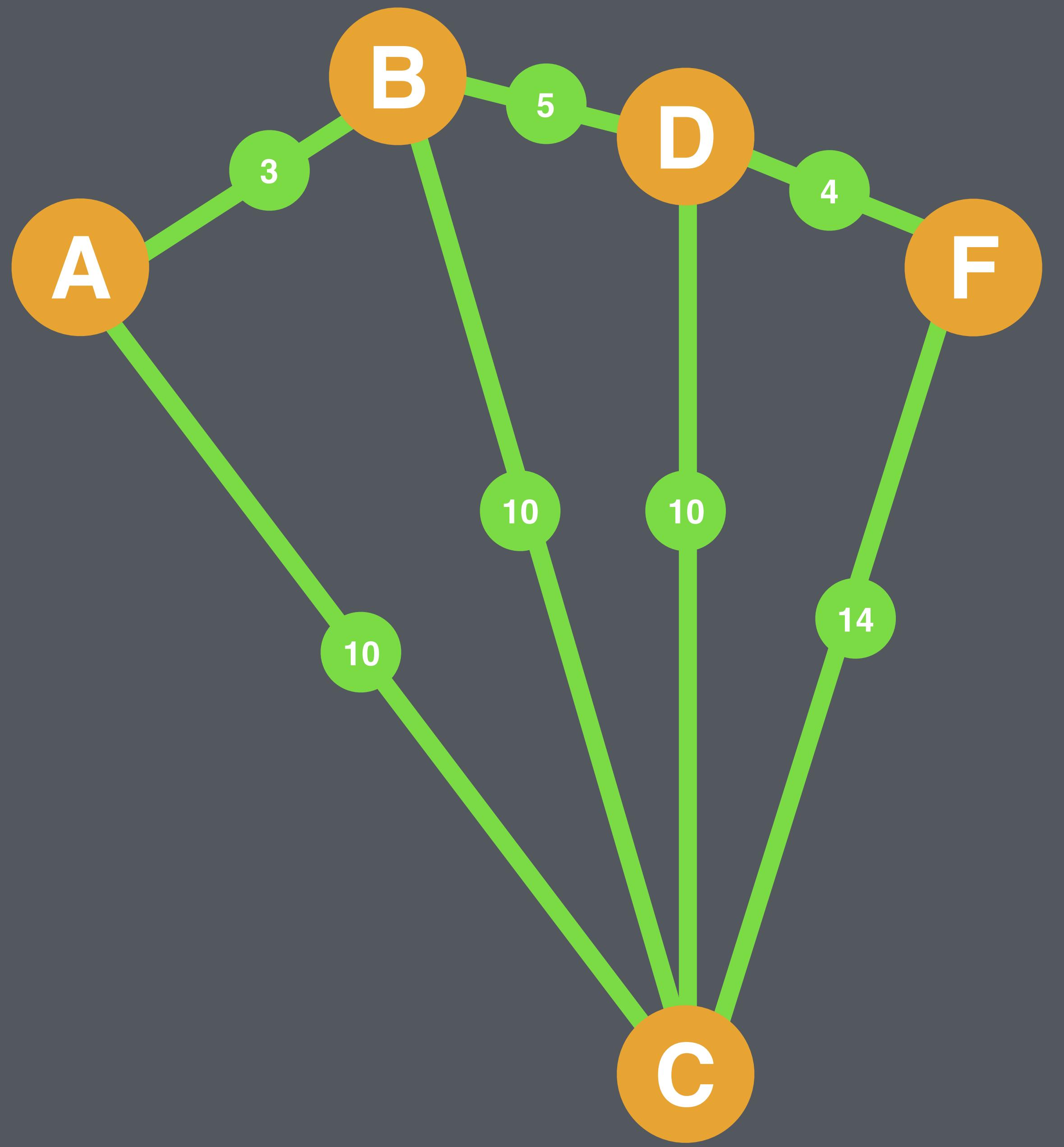


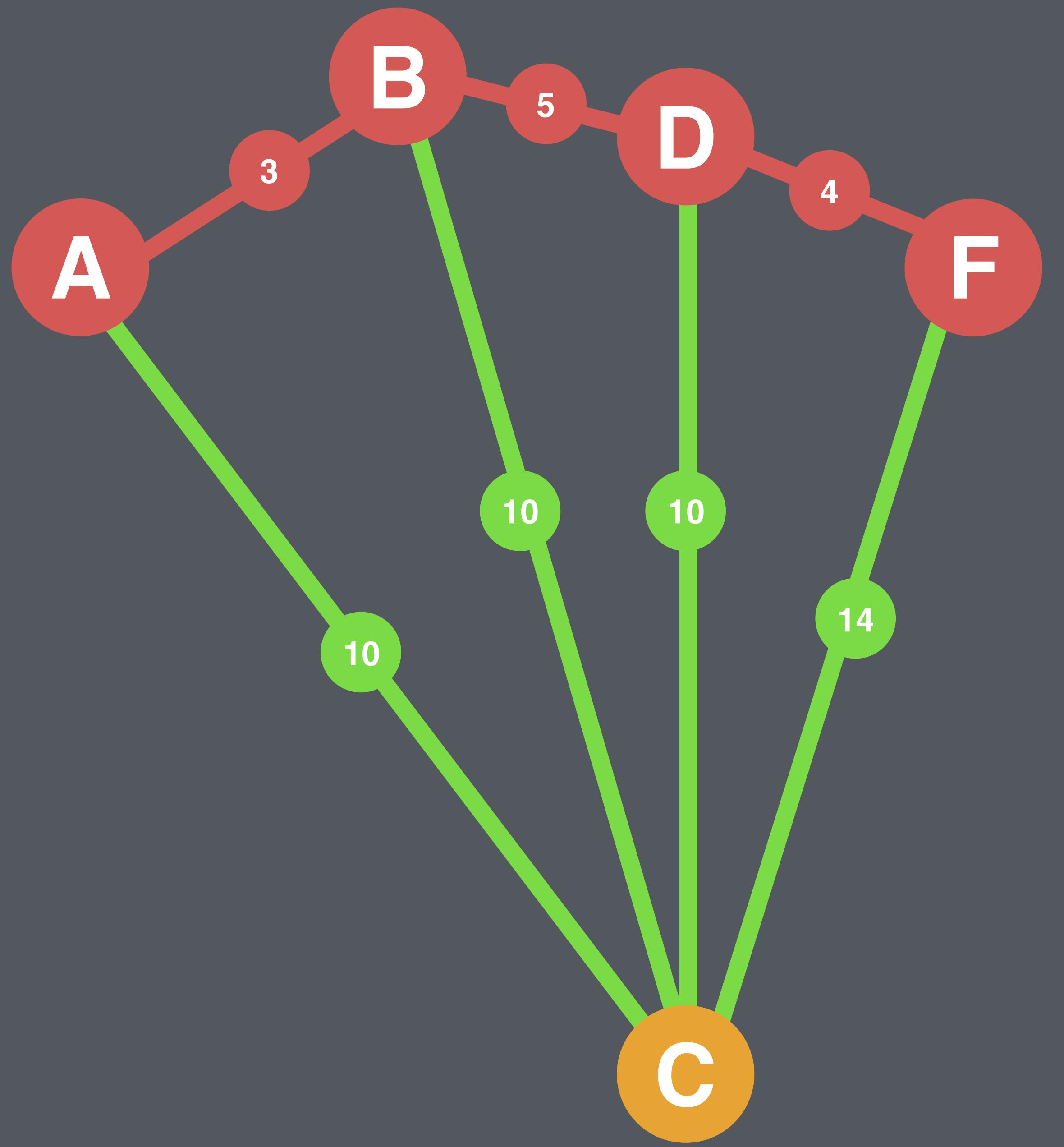
While queue has items in it, pop the front queue item, add its connected nodes to the queue if they haven't been visited OR IF THE COST OF THE CURRENT NODE PLUS THE CONNECTION COST IS LESS THAN THE COST OF THAT NODE, mark them visited, set their "cameFrom" node to the node we popped from the queue and SET THEIR COST TO THE CURRENT NODE COST + CONNECTION COST.

CURRENT NODE: E

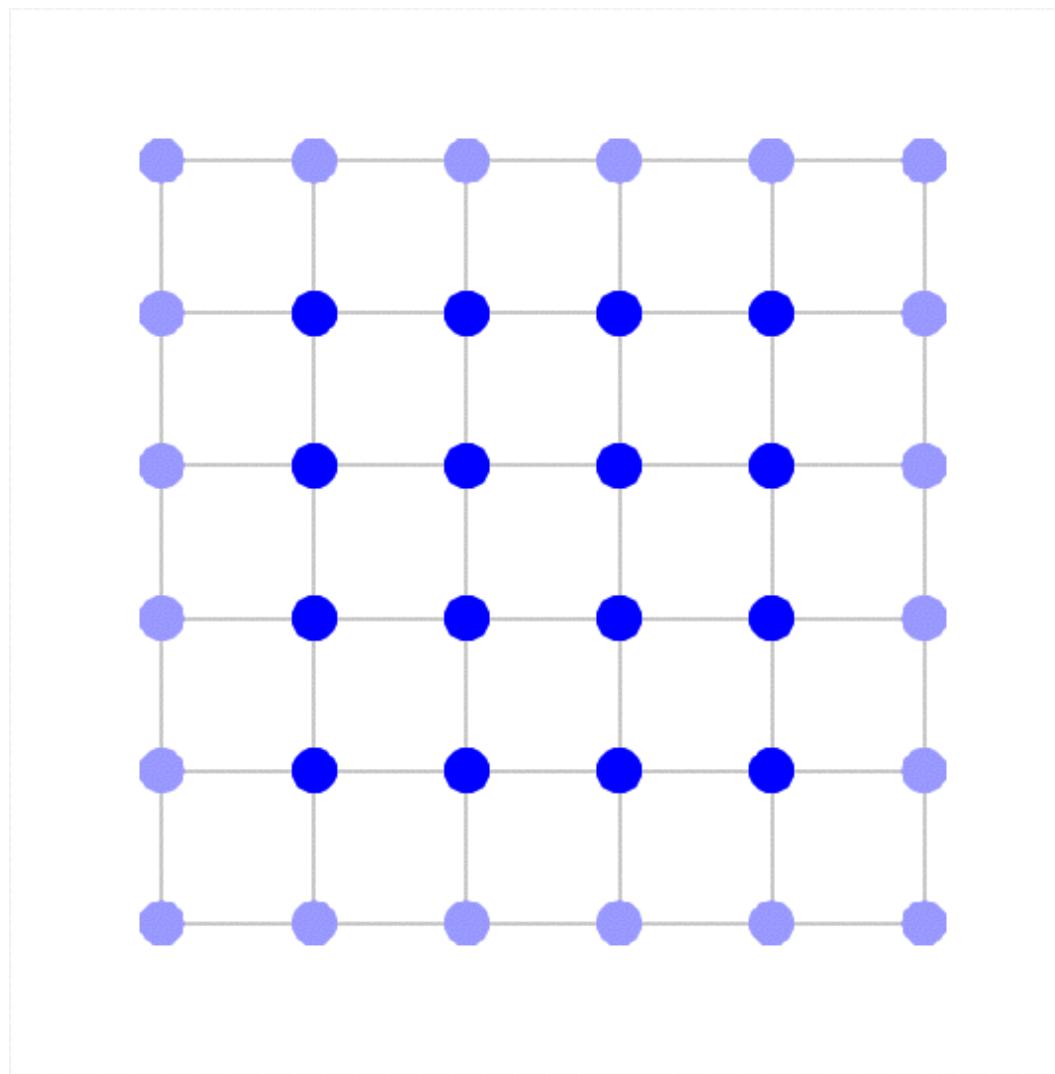
PRIORITY_QUEUE: B(5.0) D(5.3) F(7.5)



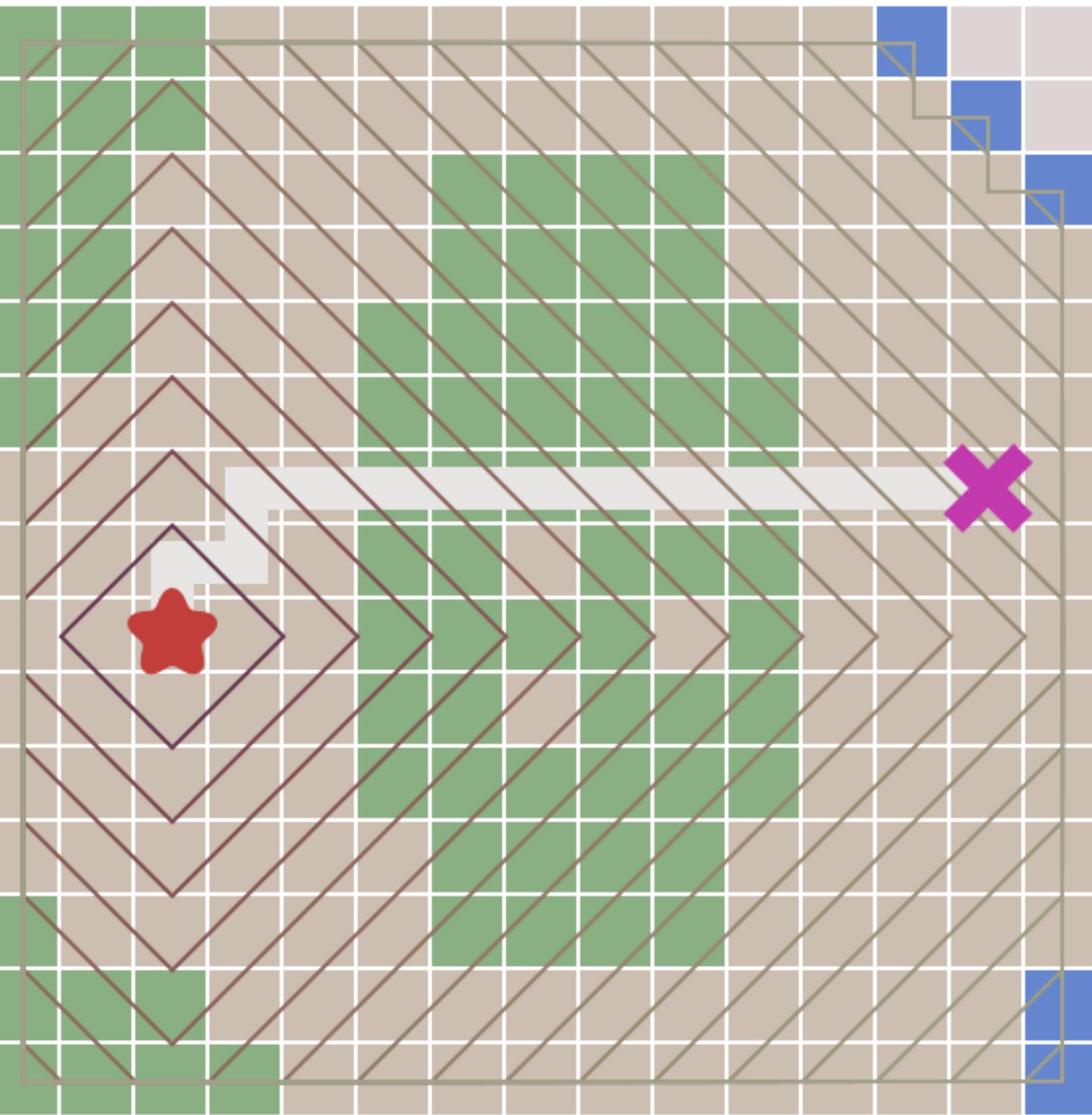




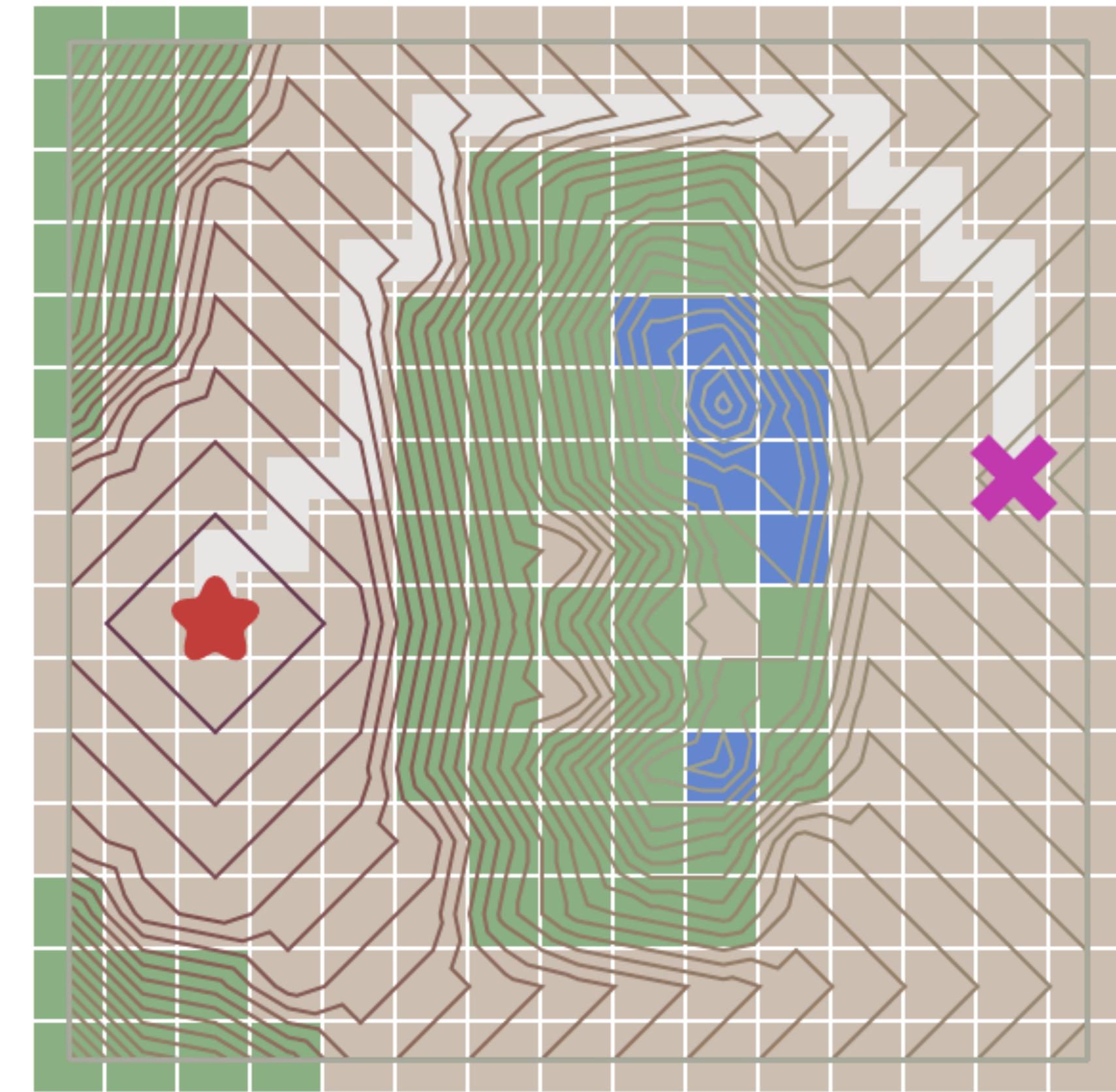




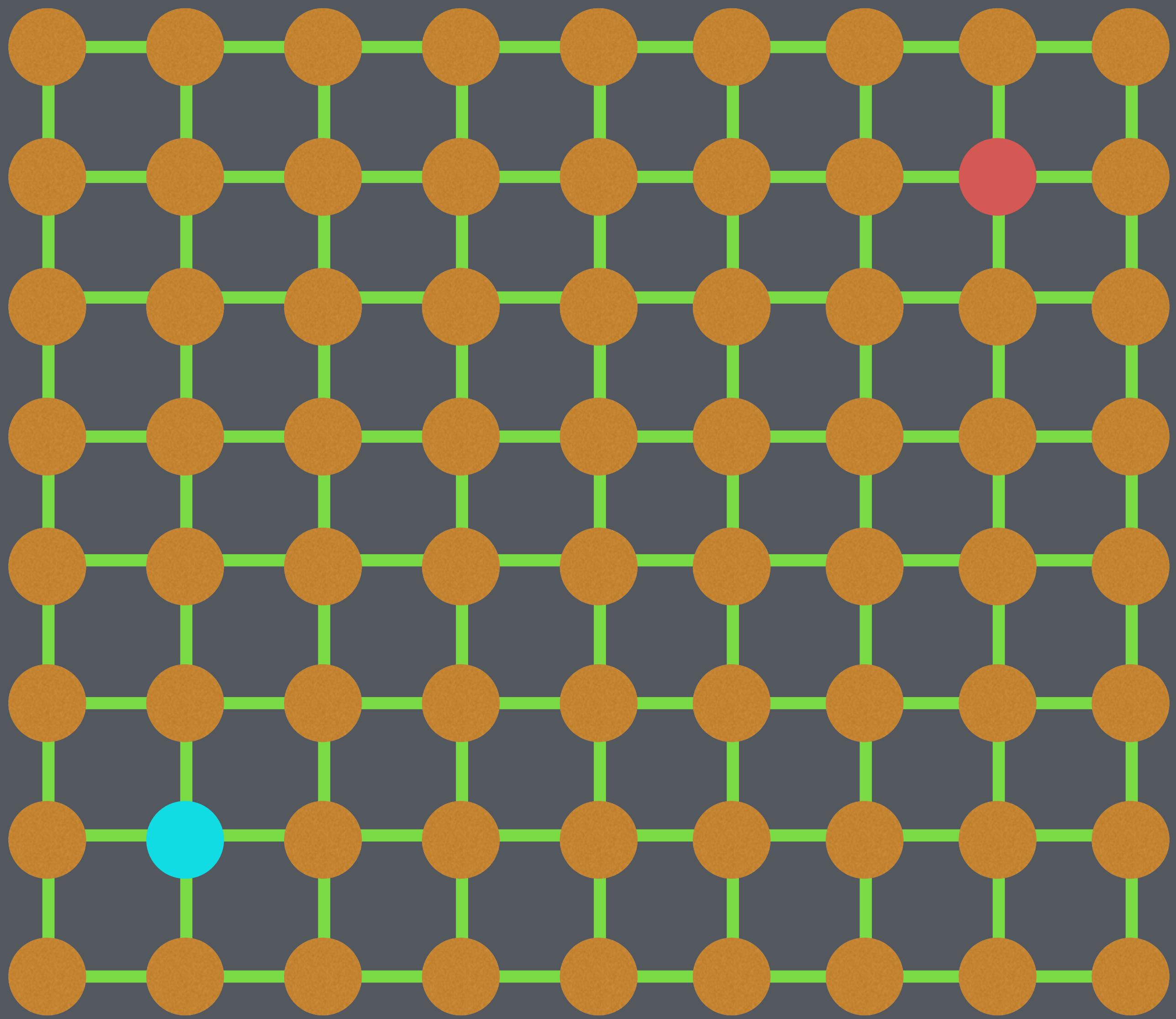
Breadth First Search



Dijkstra's Algorithm



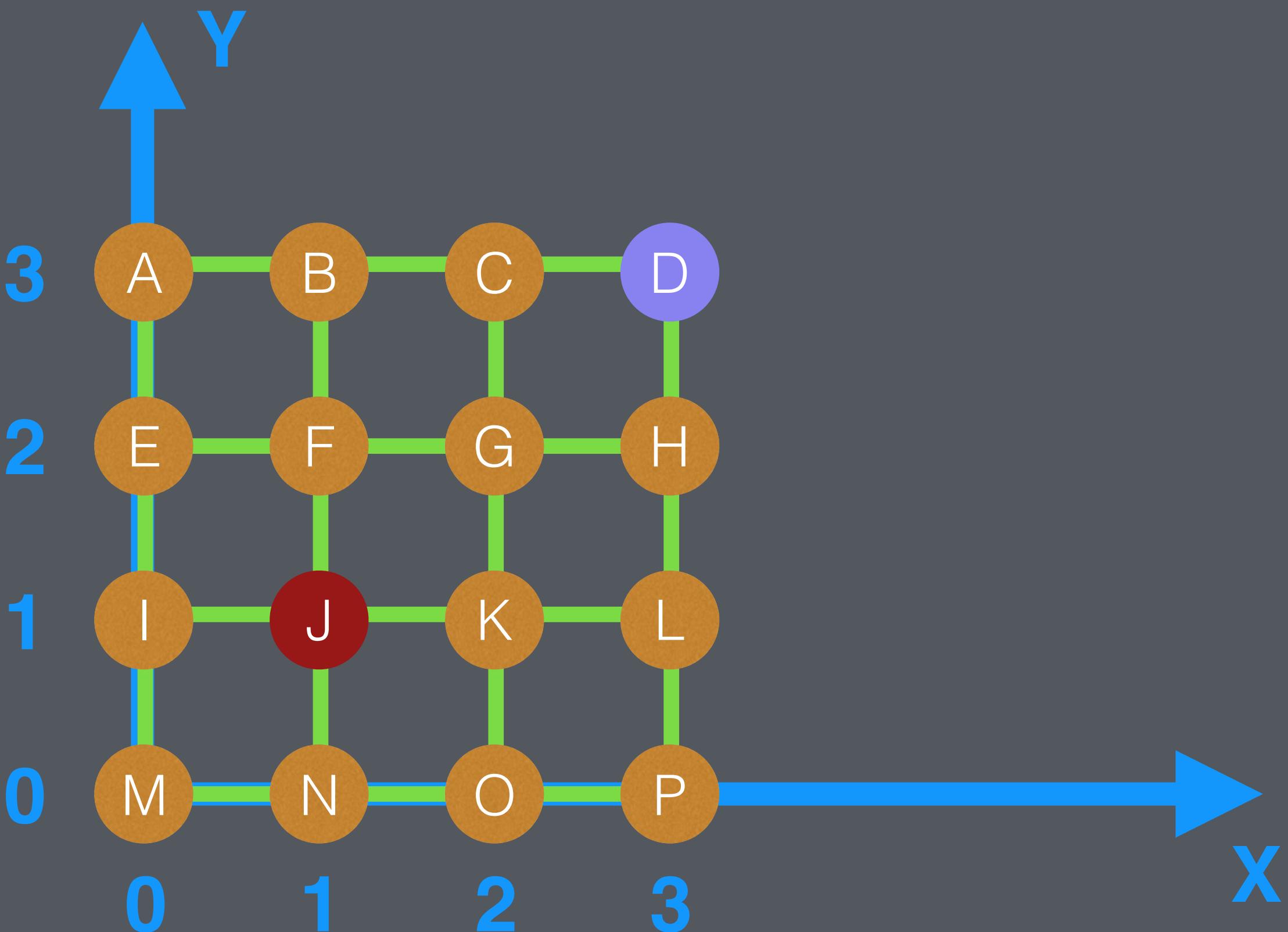
Optimizing using a **heuristic**.



Greedy Best First Search

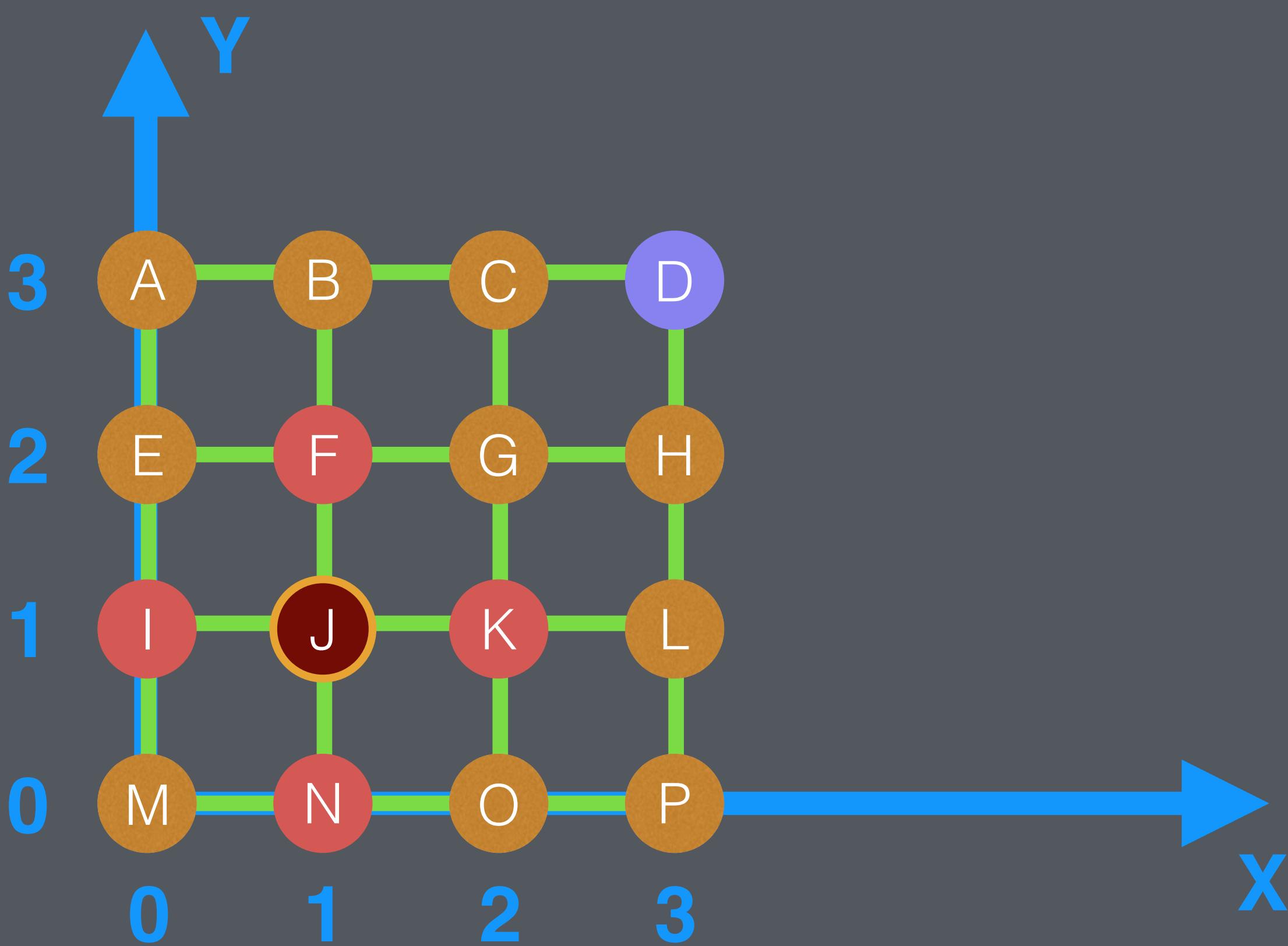
```
class Node {  
public:  
    Node(float x, float y) : x(x), y(y){}  
    float x;  
    float y;  
    bool visited;  
    float distanceFromGoal;  
    Node *cameFrom;  
    std::vector<Node*> connected;  
};
```





Add our starting node to the queue with priority 0

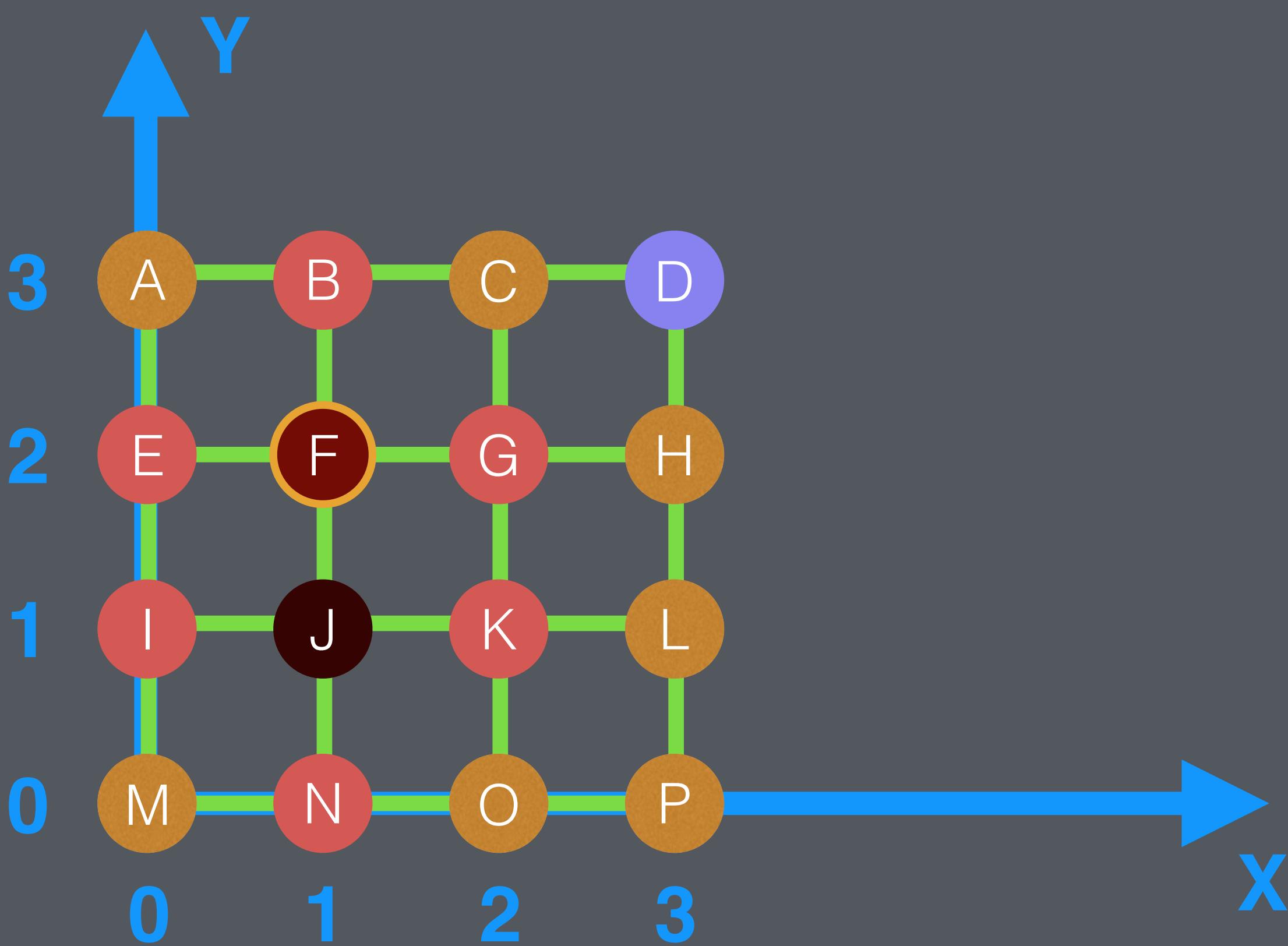
PRIORITY_QUEUE: J(0)



While queue has items in it, pop the front queue item, add its connected nodes to the queue (using their distance from the goal as queue priority) if they haven't been visited, mark them visited, set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: J

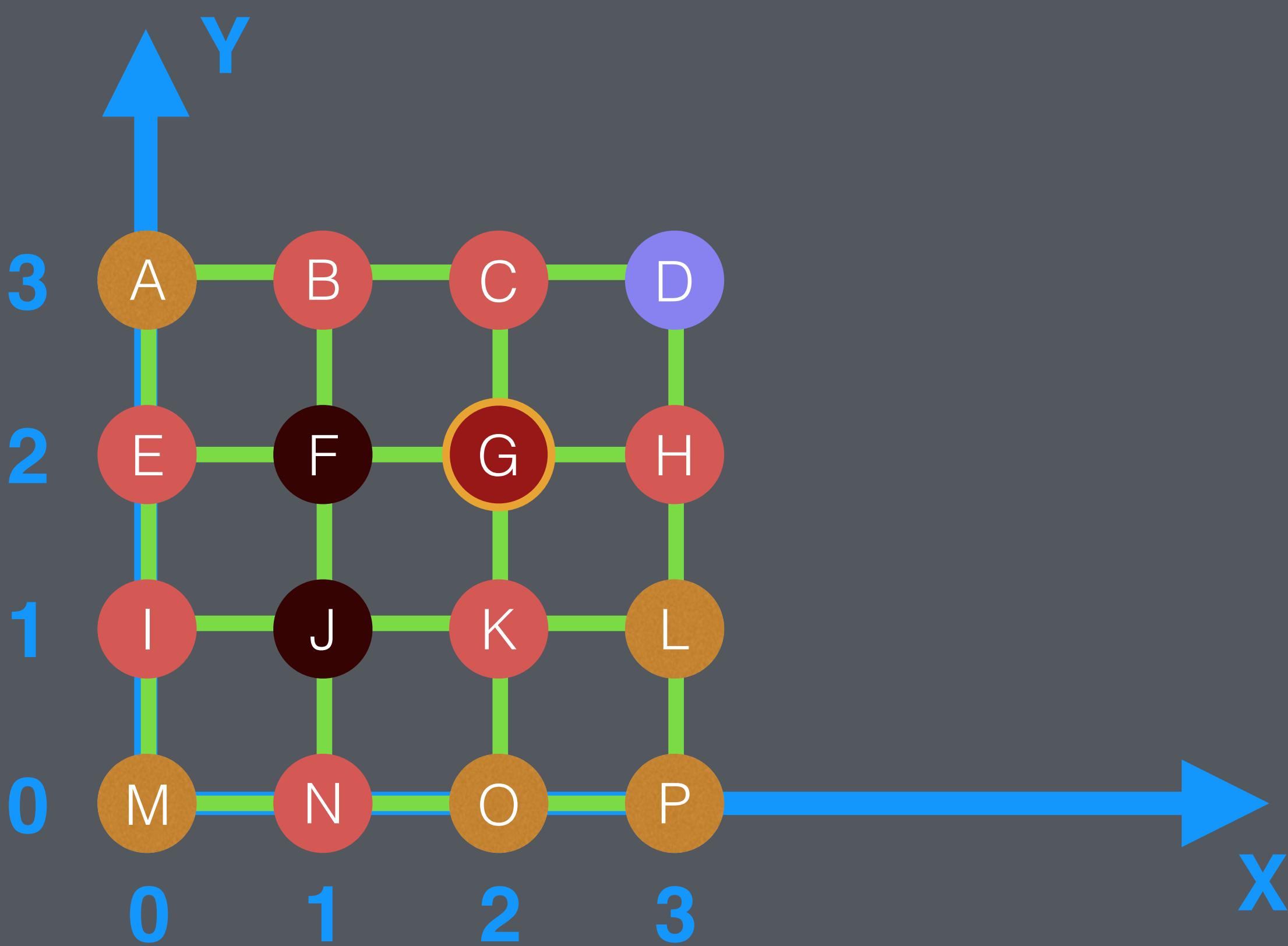
PRIORITY_QUEUE: F K I N



While queue has items in it, pop the front queue item, add its connected nodes to the queue (using their distance from the goal as queue priority) if they haven't been visited, mark them visited, set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: F

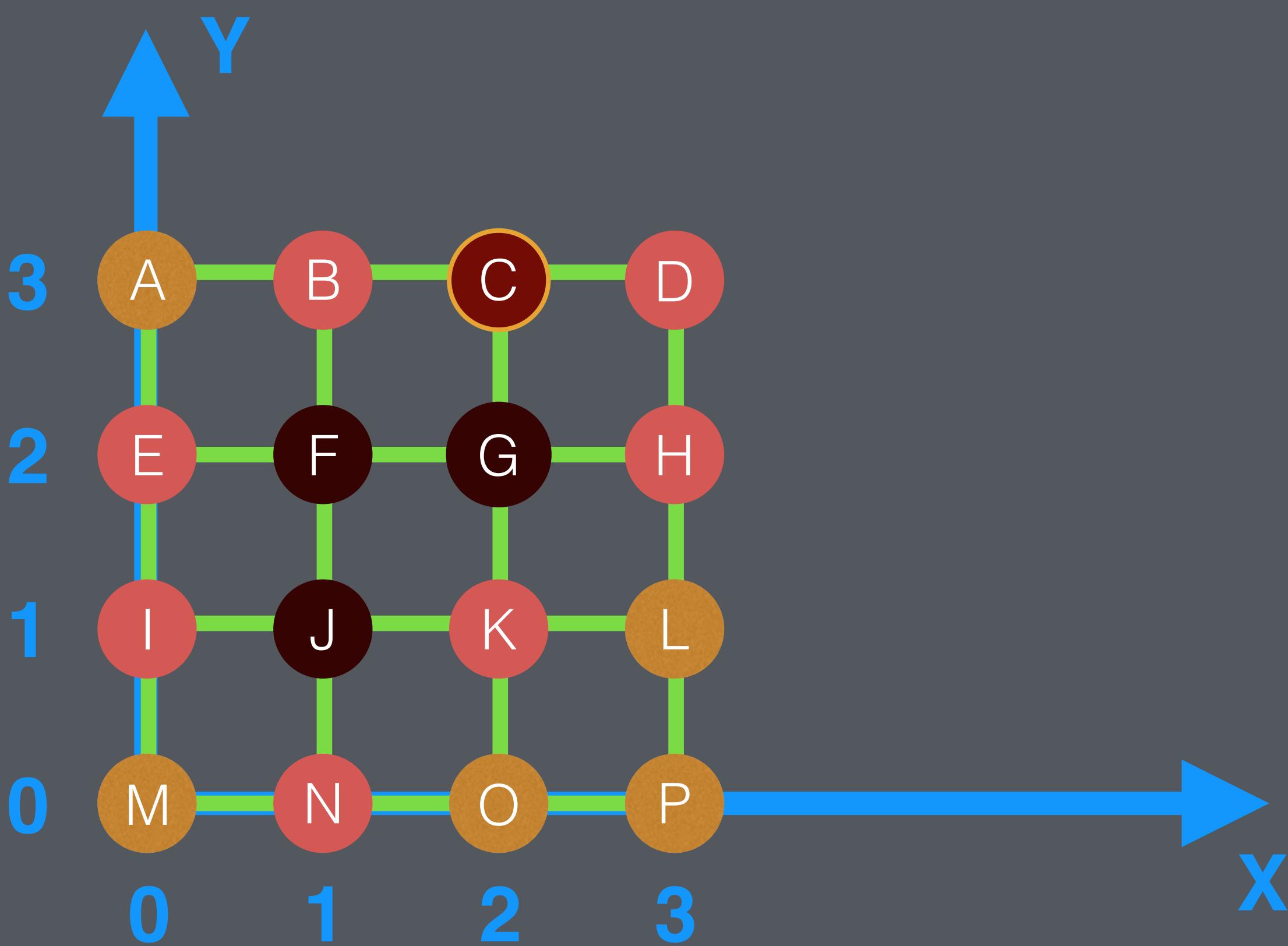
PRIORITY_QUEUE: G B K E I N



While queue has items in it, pop the front queue item, add its connected nodes to the queue (using their distance from the goal as queue priority) if they haven't been visited, mark them visited, set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: G

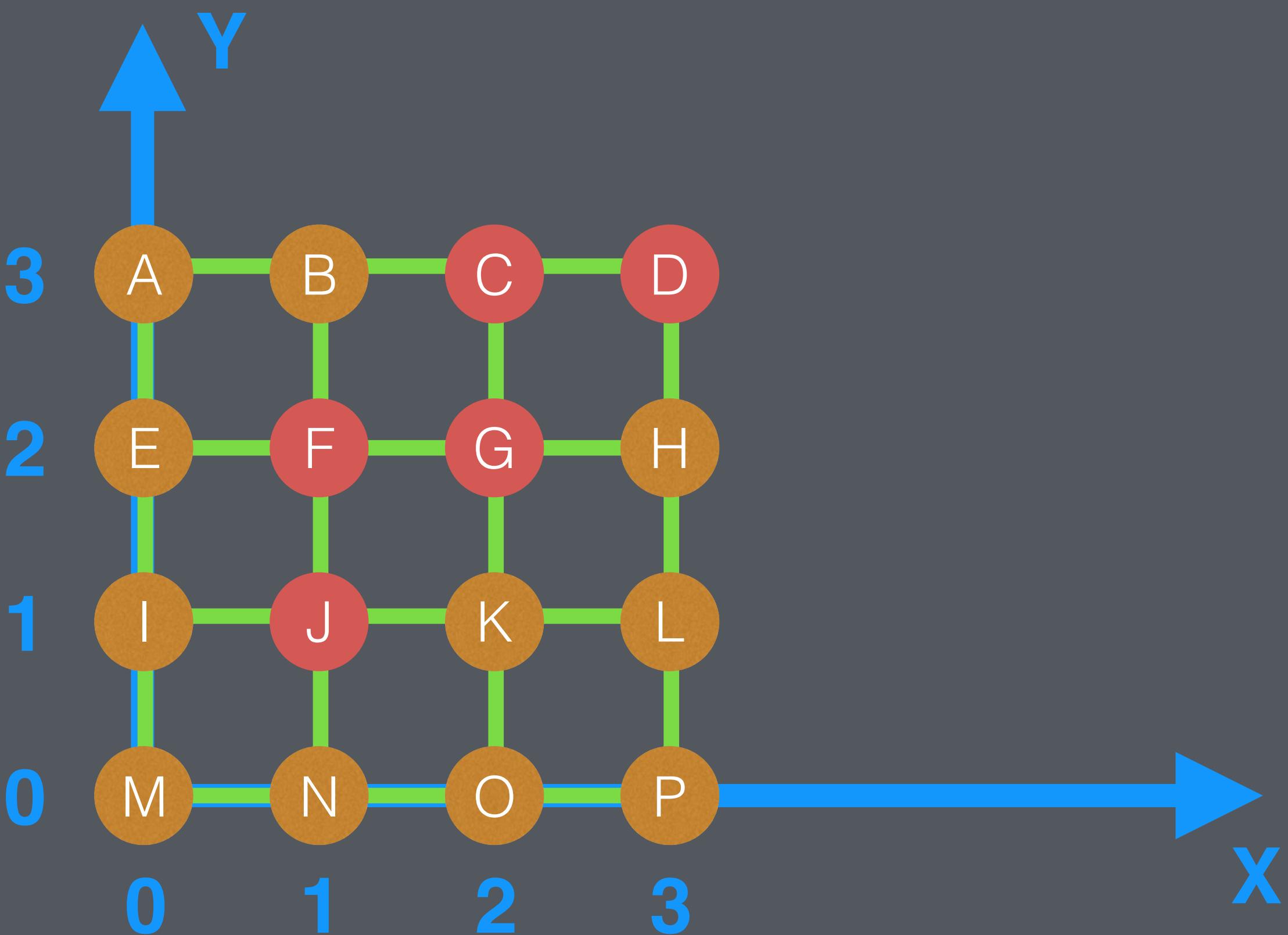
PRIORITY_QUEUE: C H B K E I N



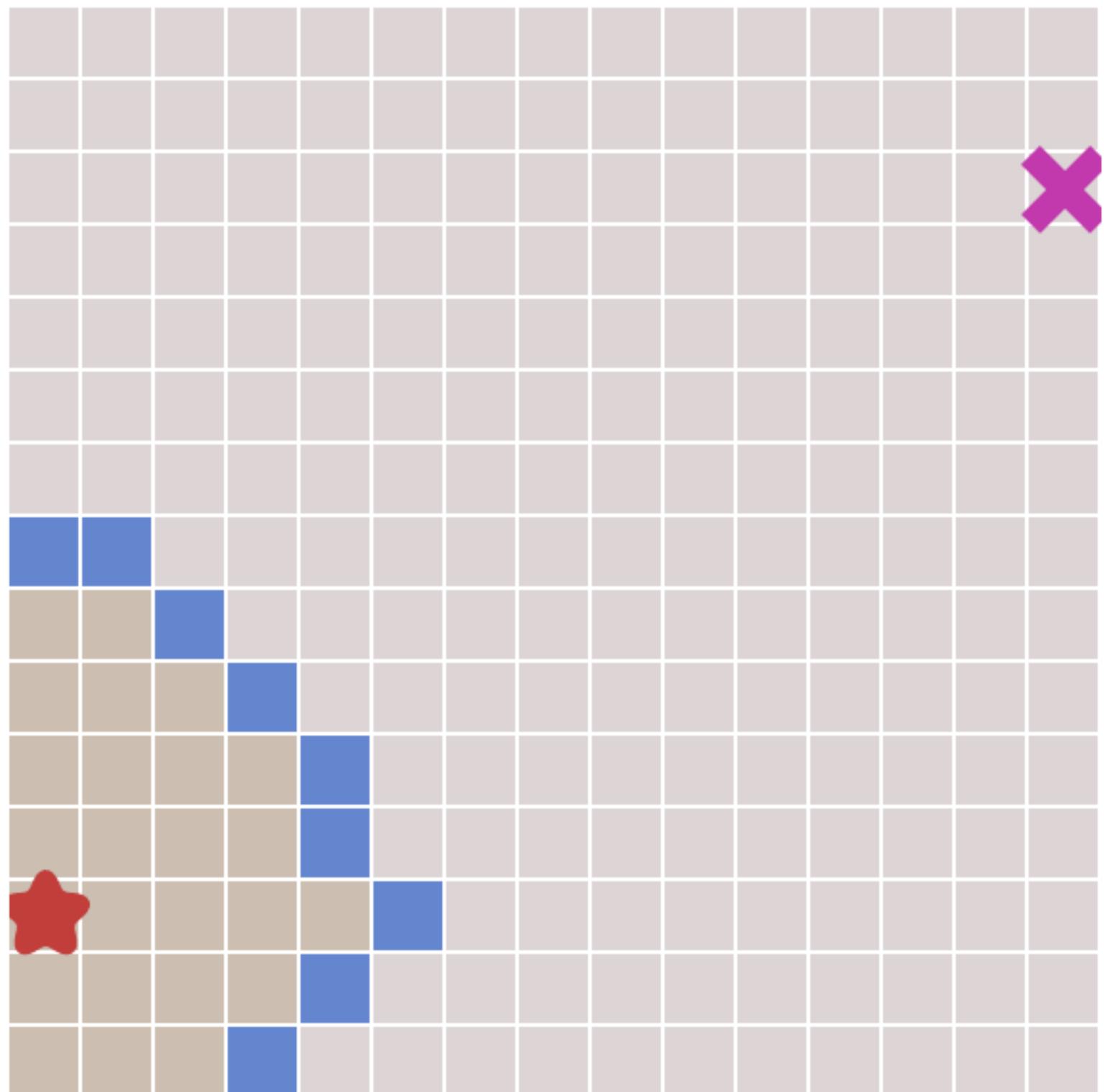
While queue has items in it, pop the front queue item, add its connected nodes to the queue (using their distance from the goal as queue priority) if they haven't been visited, mark them visited, set their "cameFrom" node to the node we popped from the queue.

CURRENT NODE: C

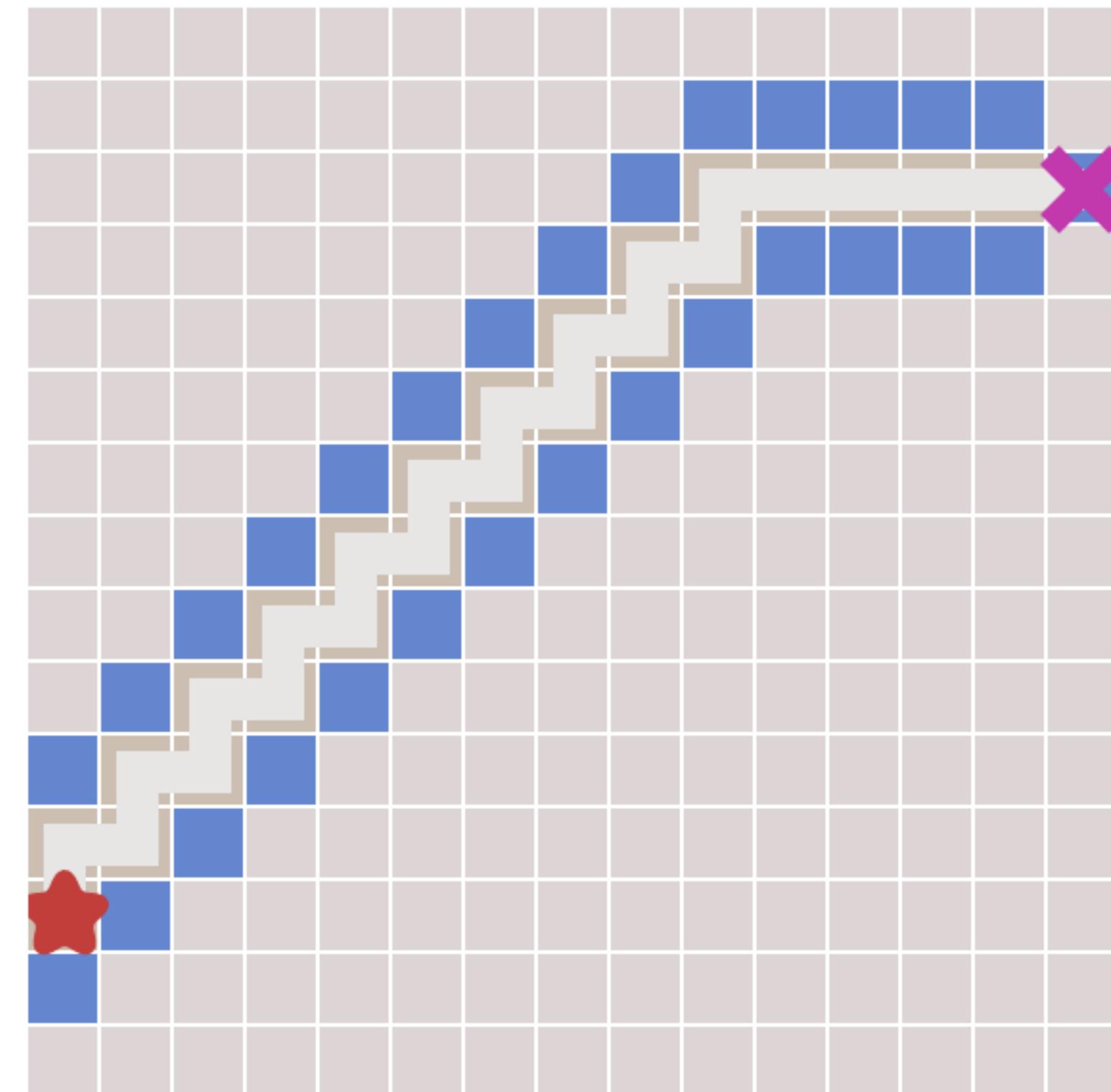
PRIORITY_QUEUE: D H B K E I N



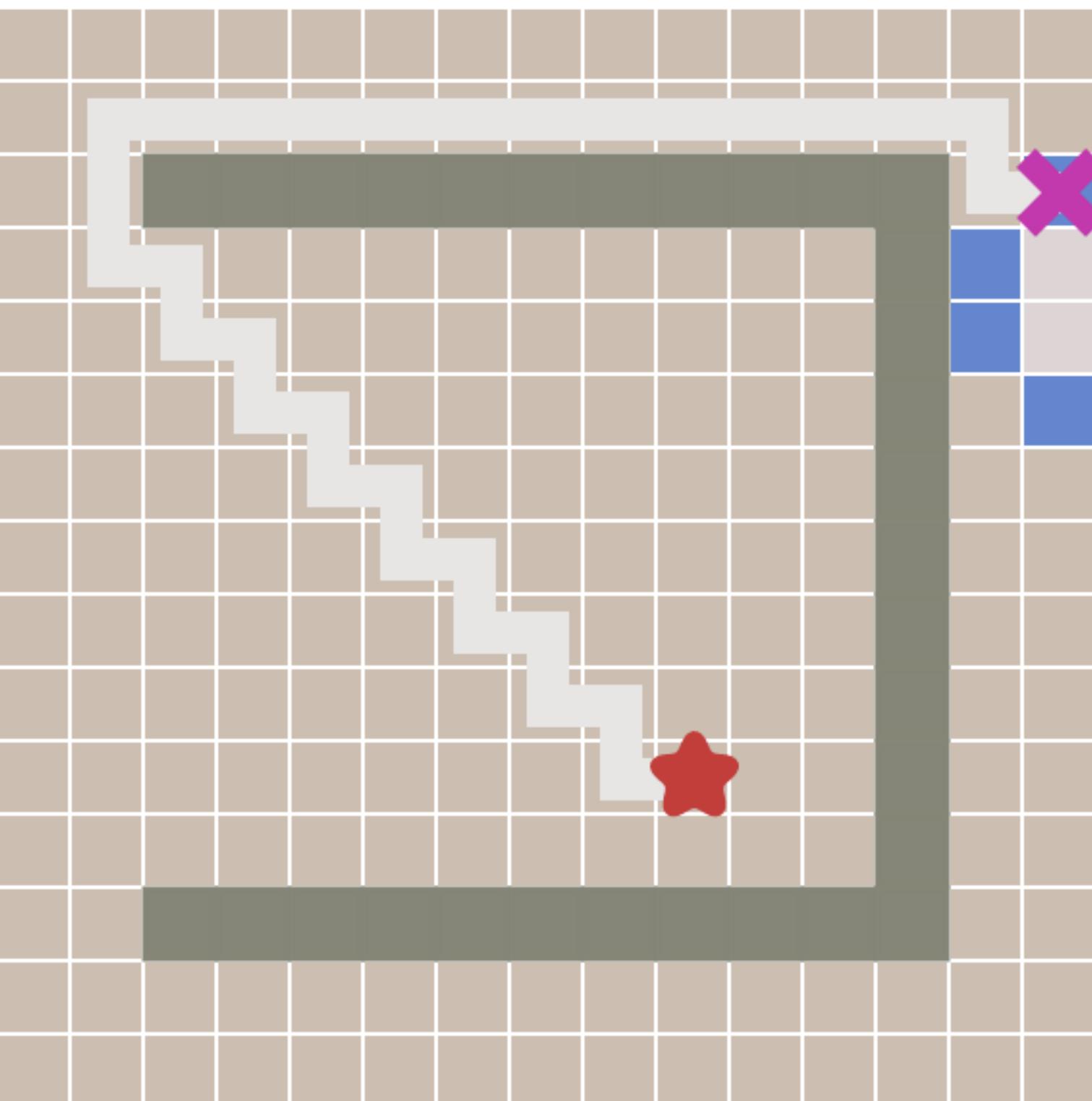
Breadth First Search



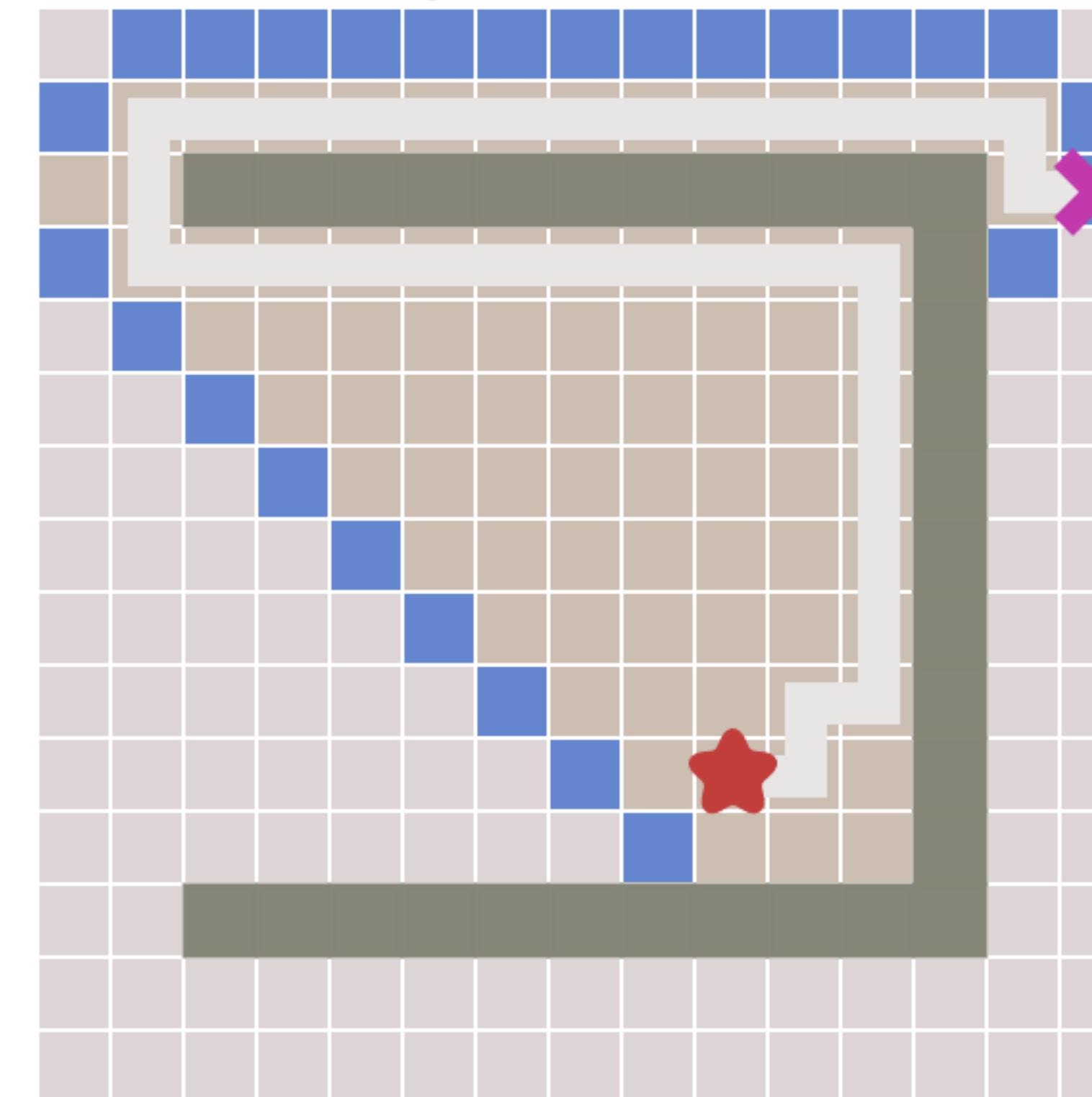
Greedy Best-First Search



Breadth First Search



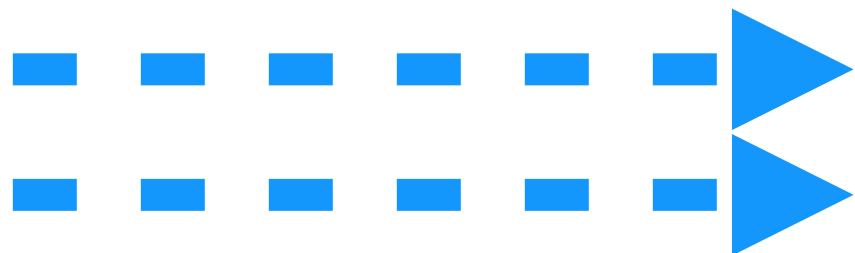
Greedy Best-First Search



A* algorithm

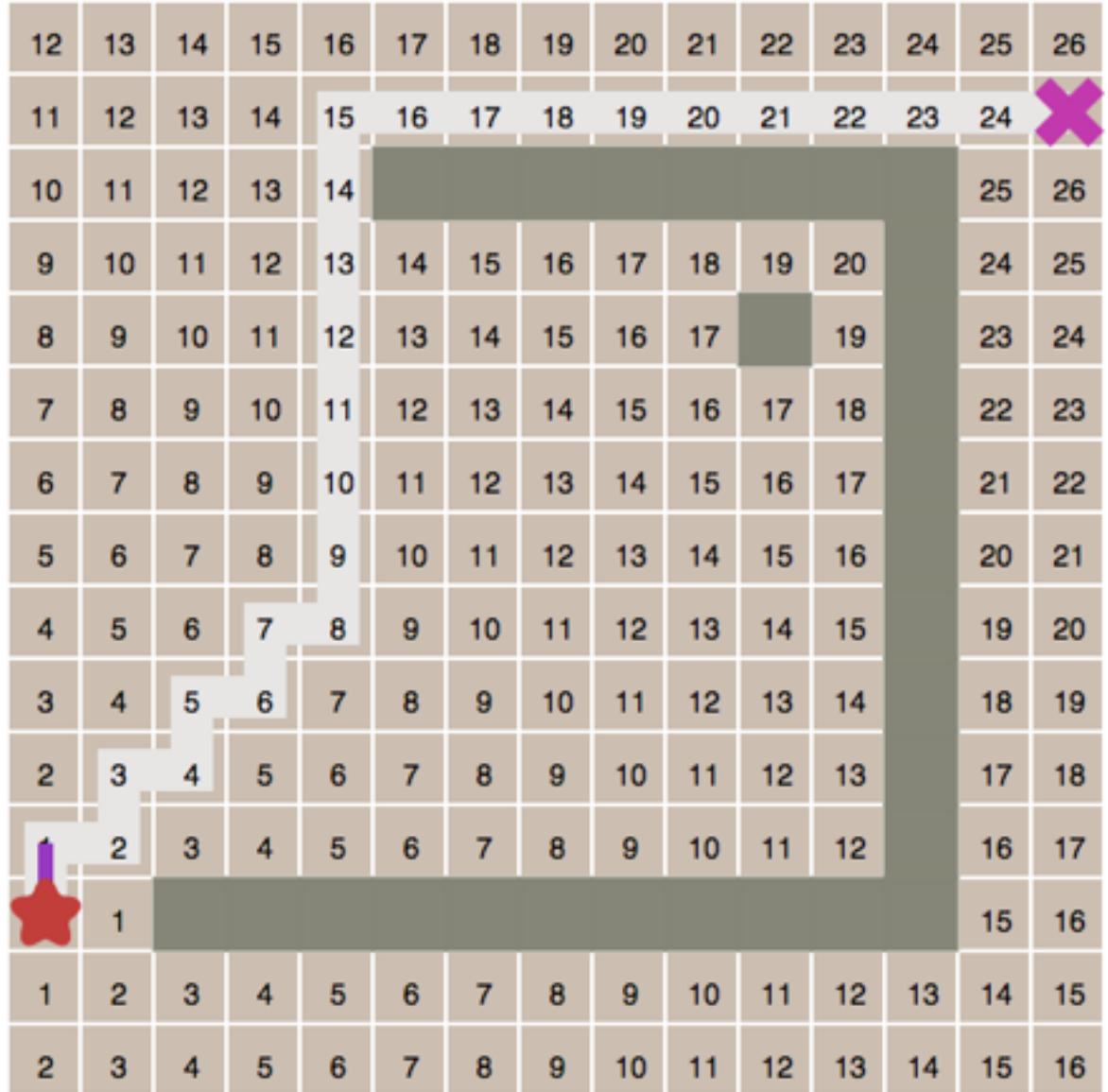
Dijkstra's algorithm + Greedy Best First search

```
class Node {  
public:  
    Node(float x, float y) : x(x), y(y){}  
    float x;  
    float y;  
    bool visited;  
    float cost;  
    float distanceFromGoal;  
    Node *cameFrom;  
    std::vector<Node*> connected;  
};
```

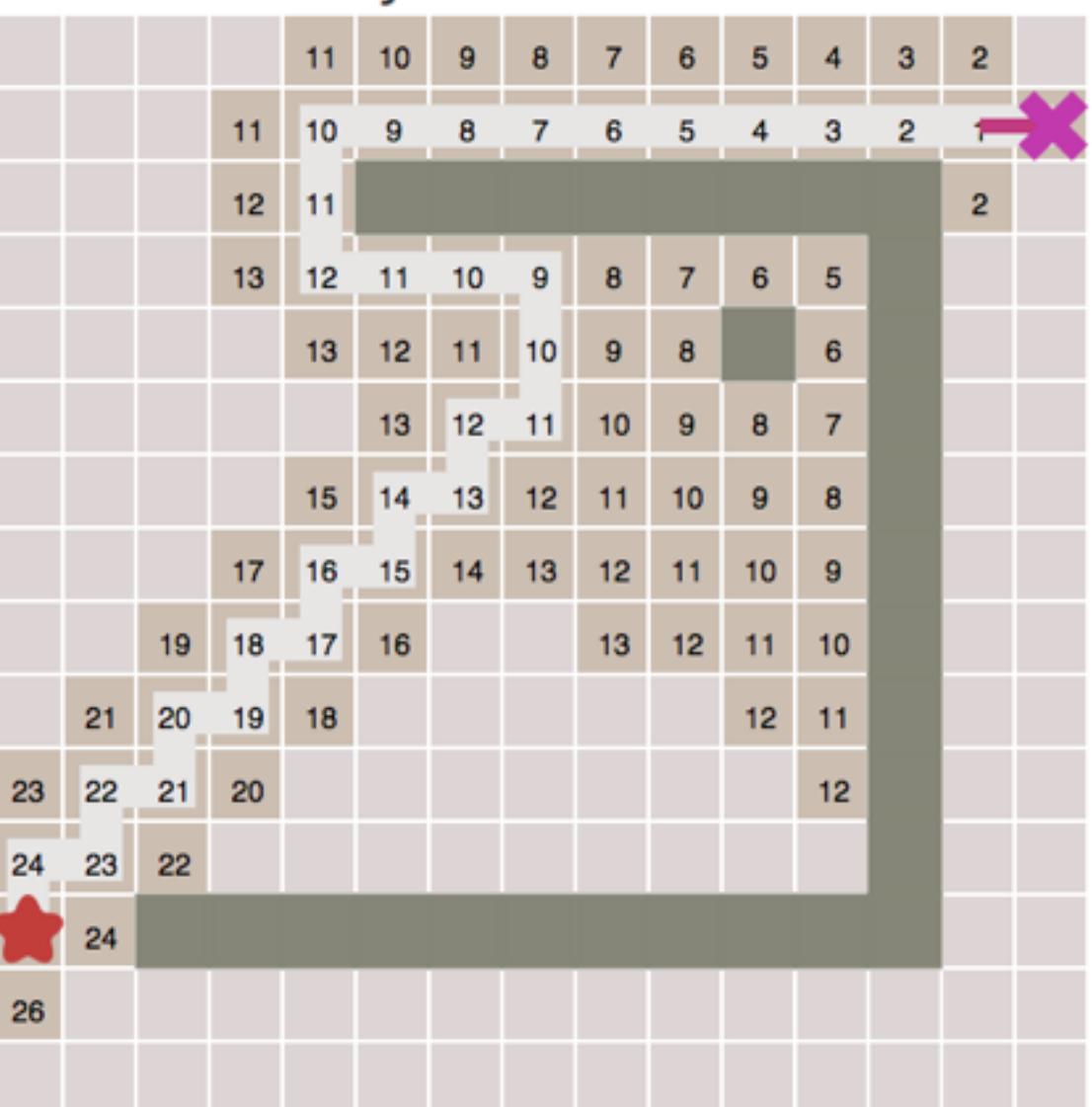


While queue has items in it, pop the front queue item, add its connected nodes to the queue (**USING THEIR COST+DISTANCE FROM GOAL AS PRIORITY**) if they haven't been visited OR IF THE COST OF THE CURRENT NODE PLUS THE CONNECTION COST IS LESS THAN THE COST OF THAT NODE, mark them visited, set their “cameFrom” node to the node we popped from the queue and SET THEIR COST TO THE CURRENT NODE COST + CONNECTION COST

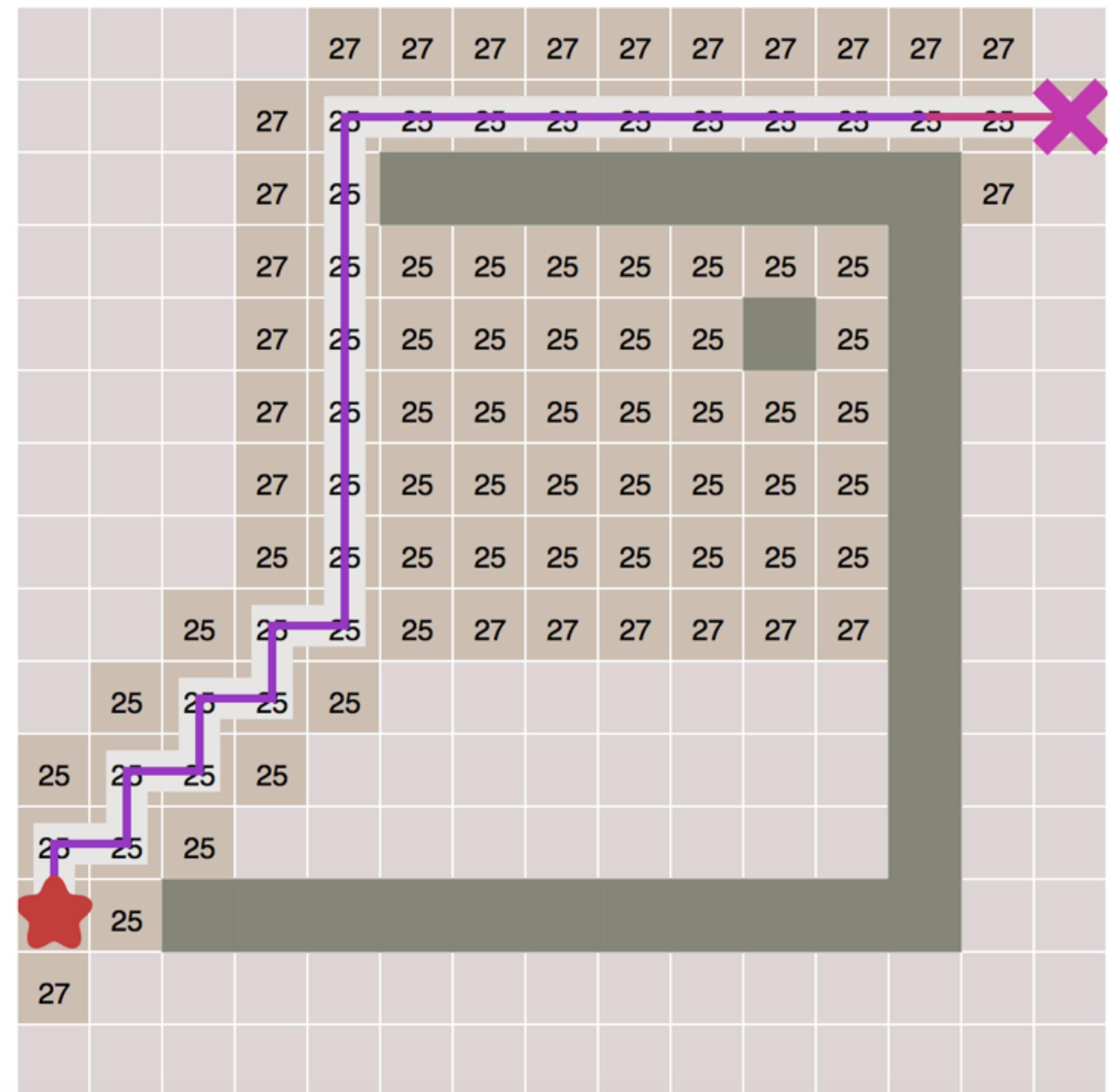
Dijkstra's Algorithm



Greedy Best-First Search

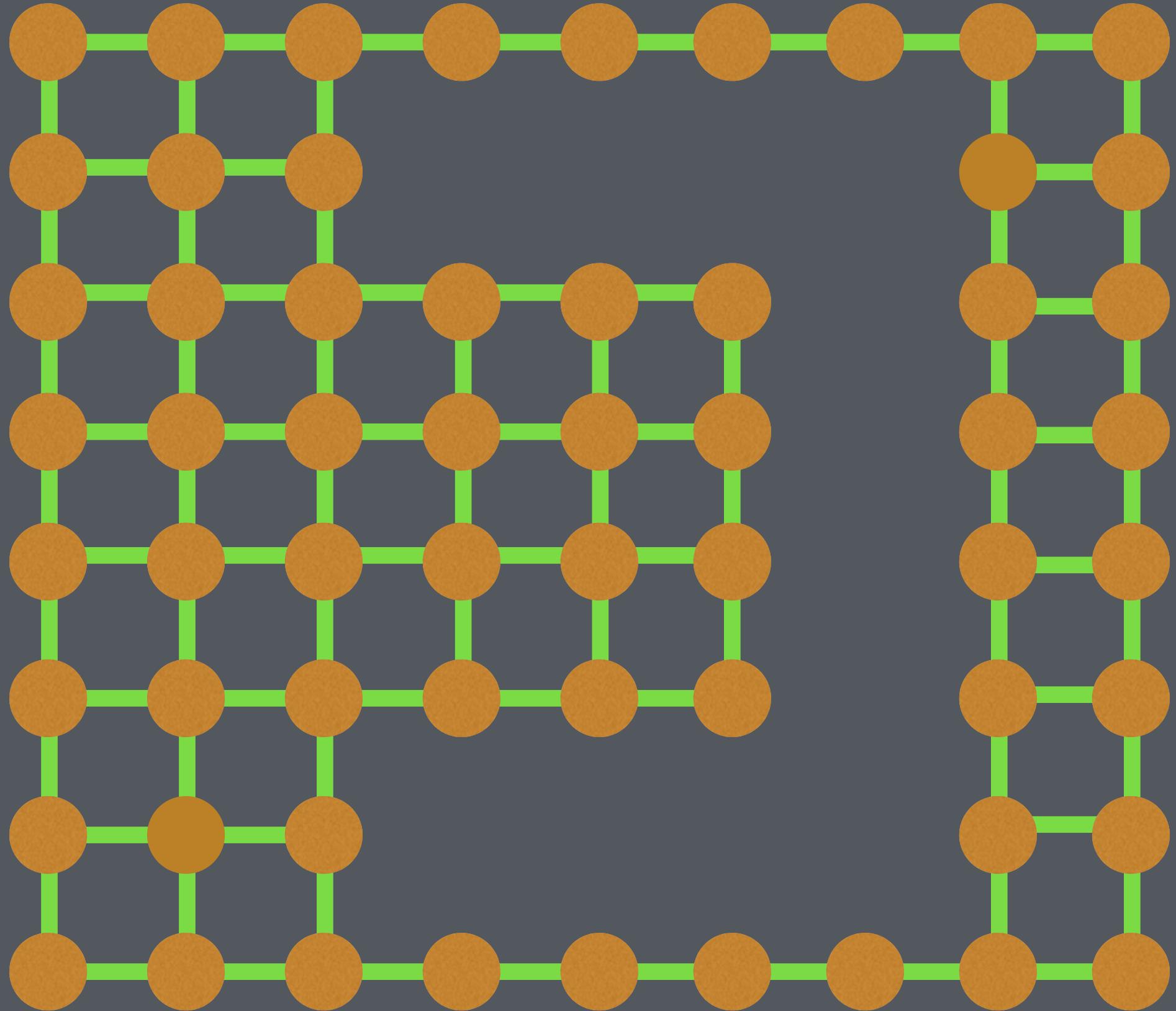
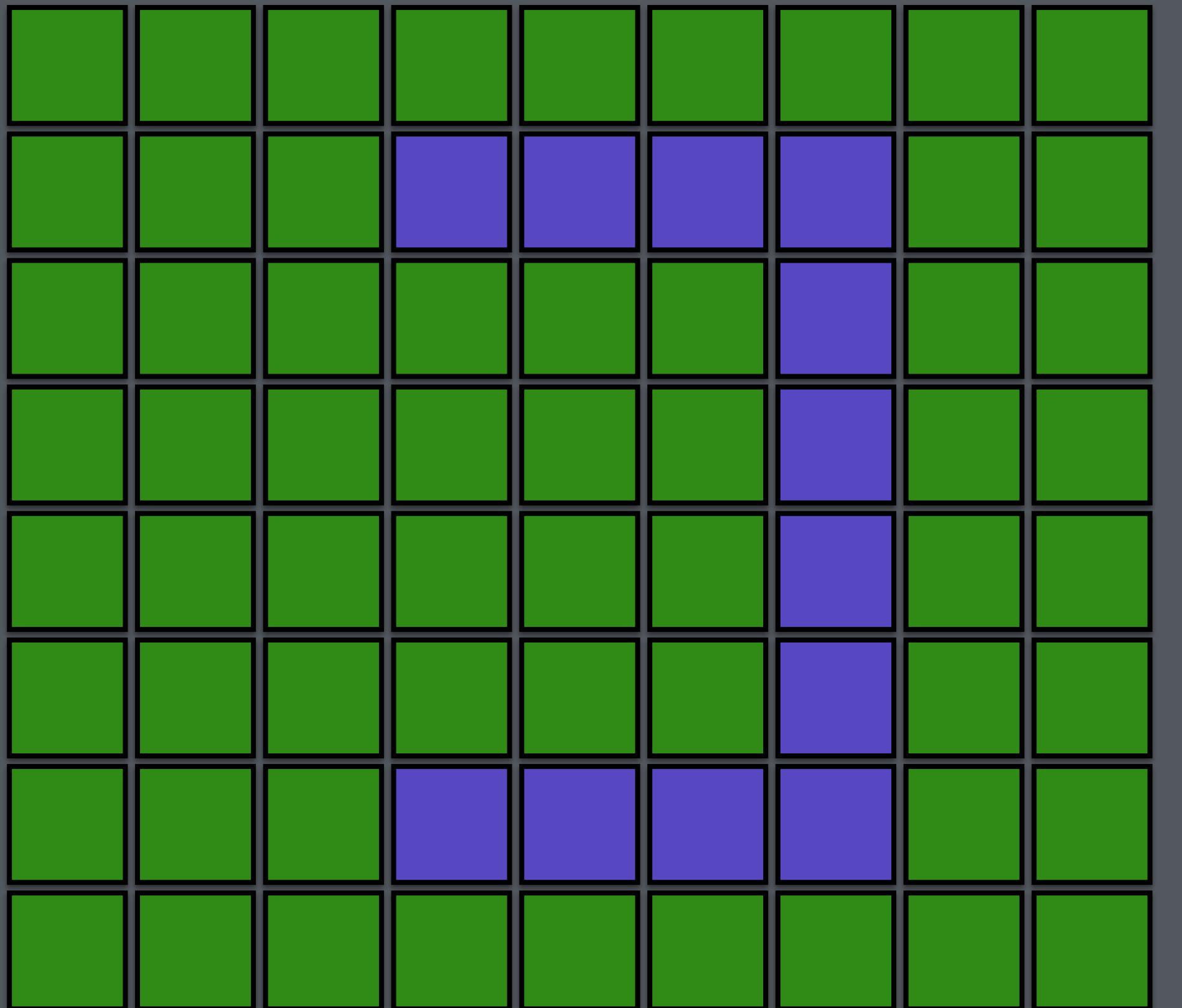


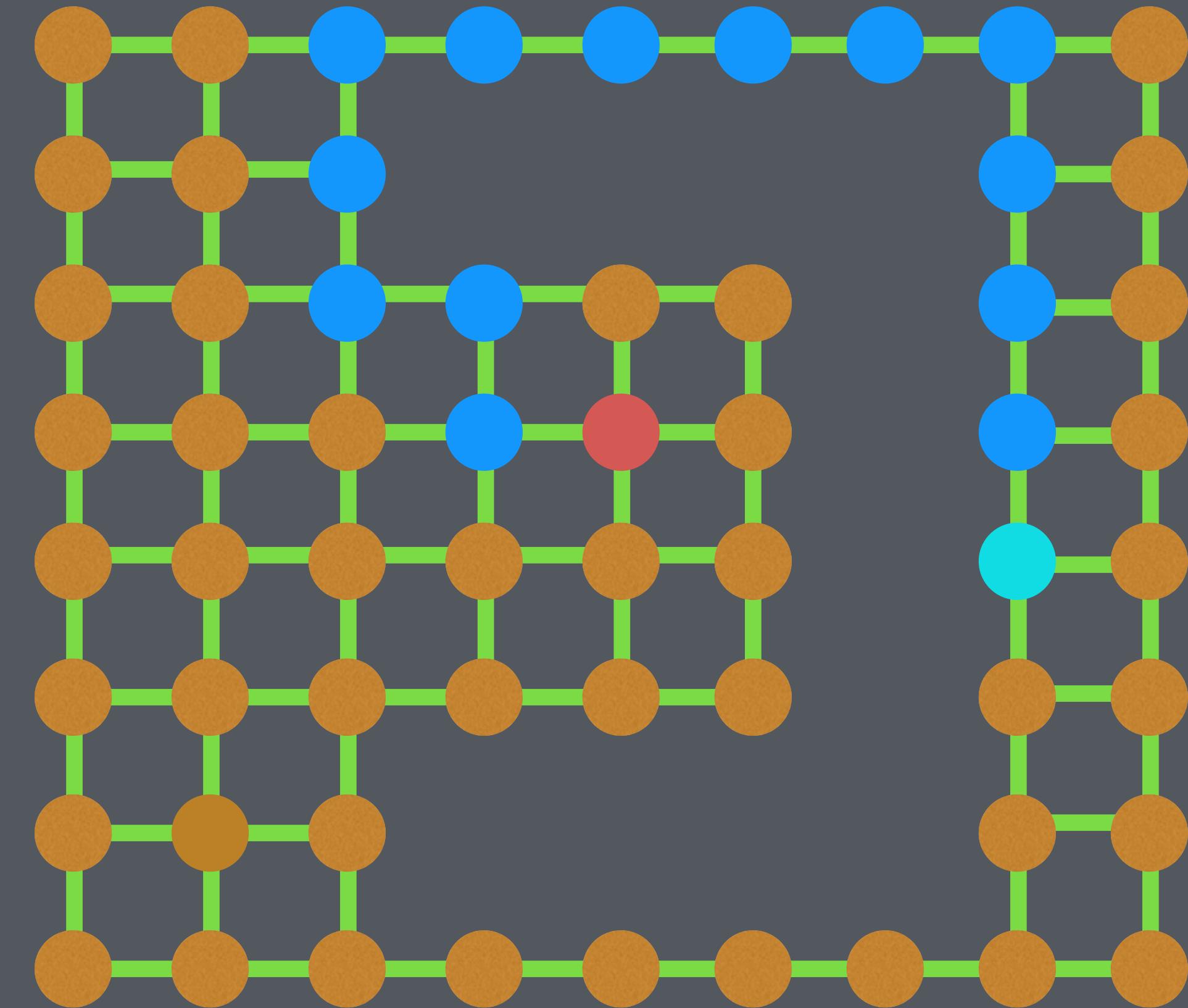
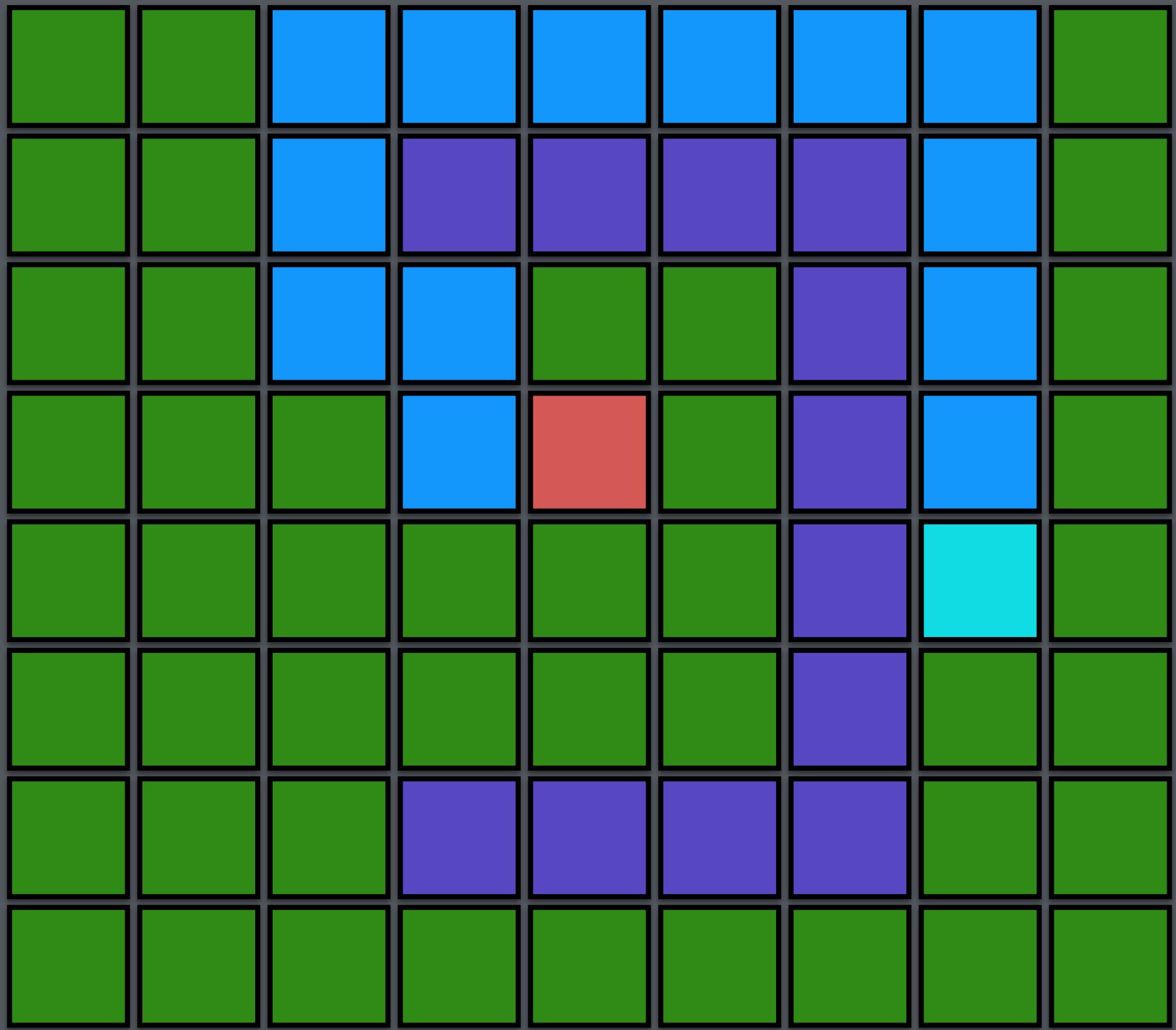
A* Search



Creating our path nodes.

Grid based maps.

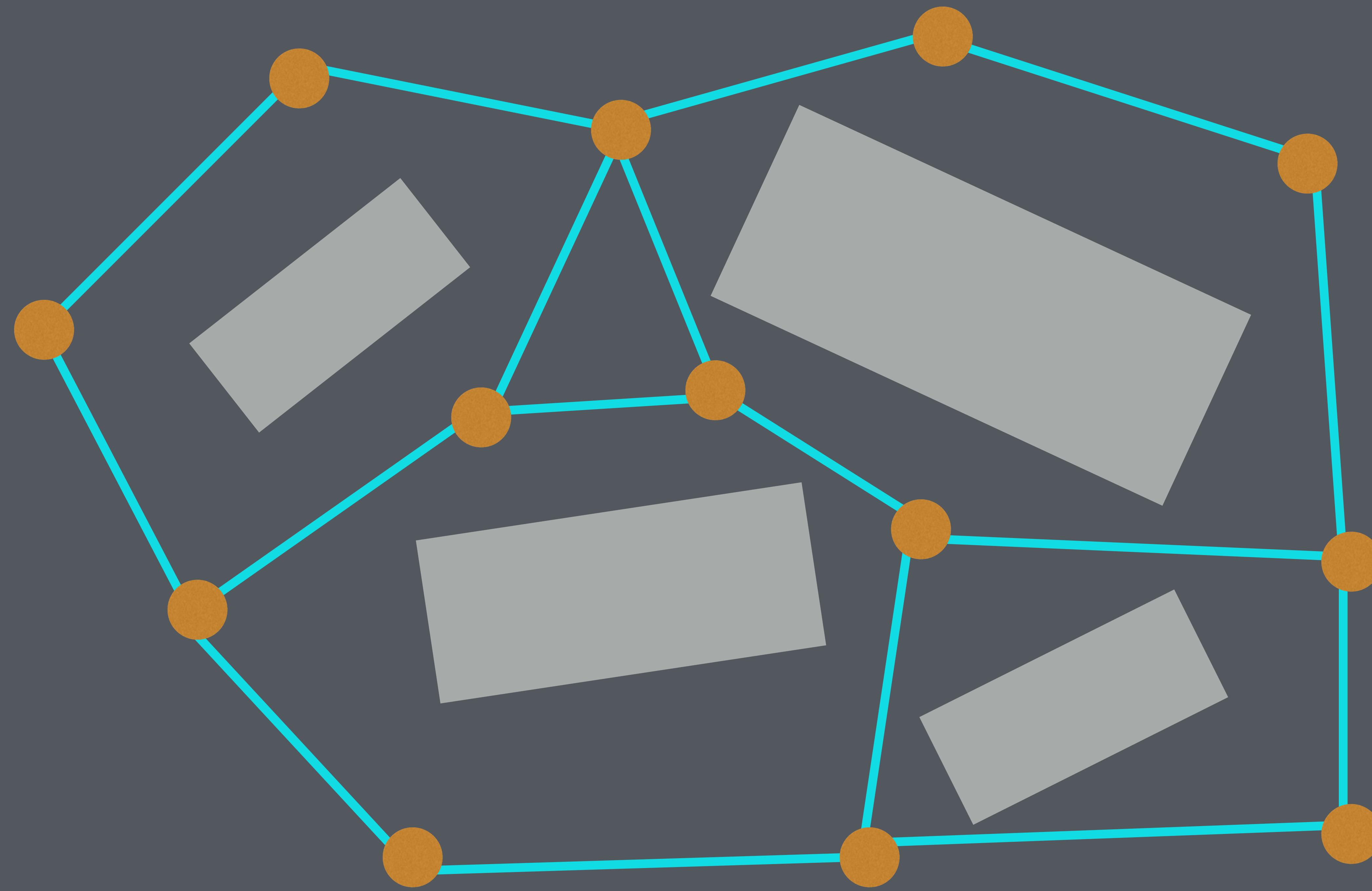




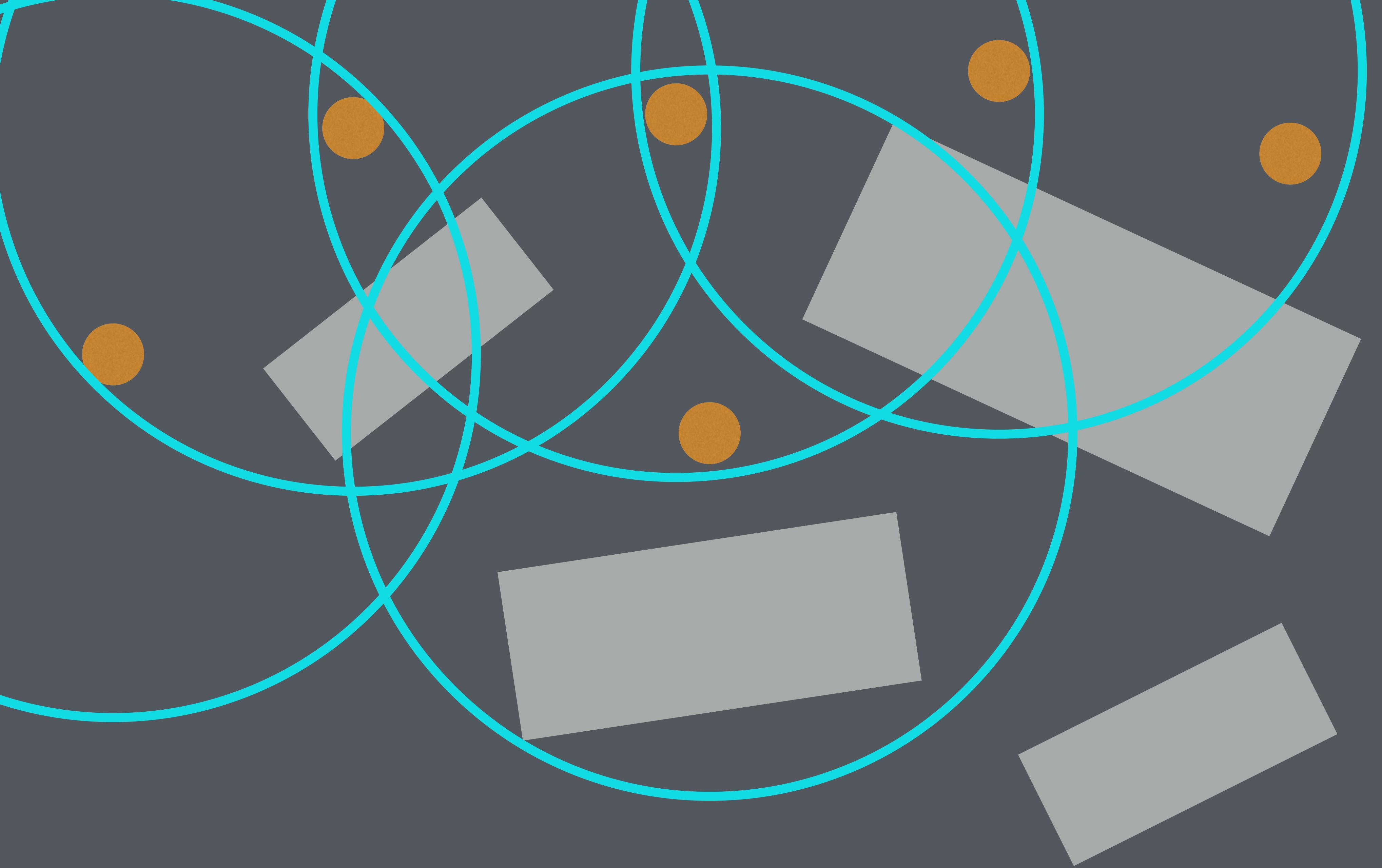
Use larger connection weights for tiles that are harder to pass.

Free-form maps.

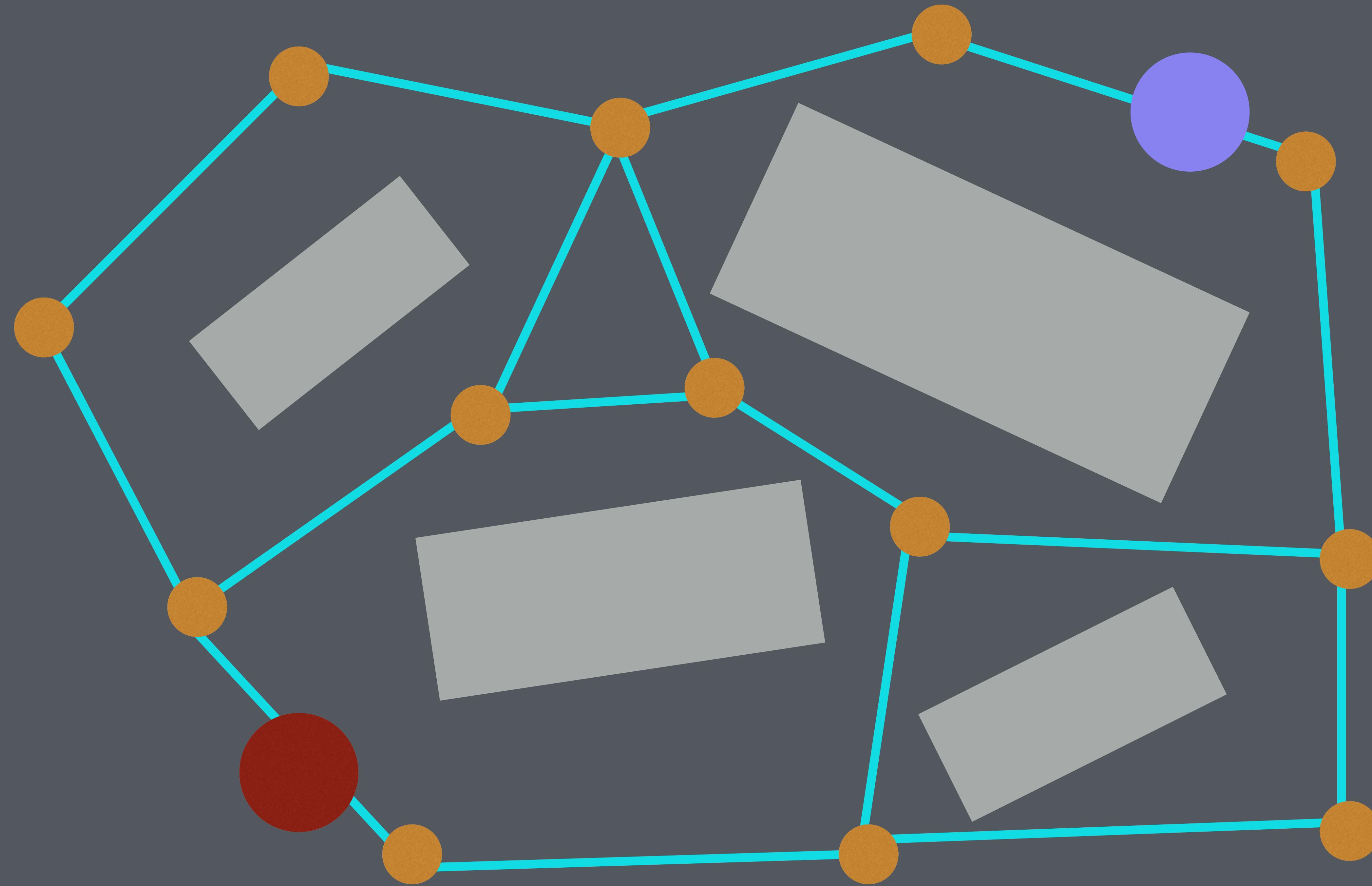
Manually place and connect AI nodes so that it is possible to reach one node from another in a straight line.



You can connect nodes automatically
based on distance, but you'll have to be careful
where you place them.



Traversing a path.

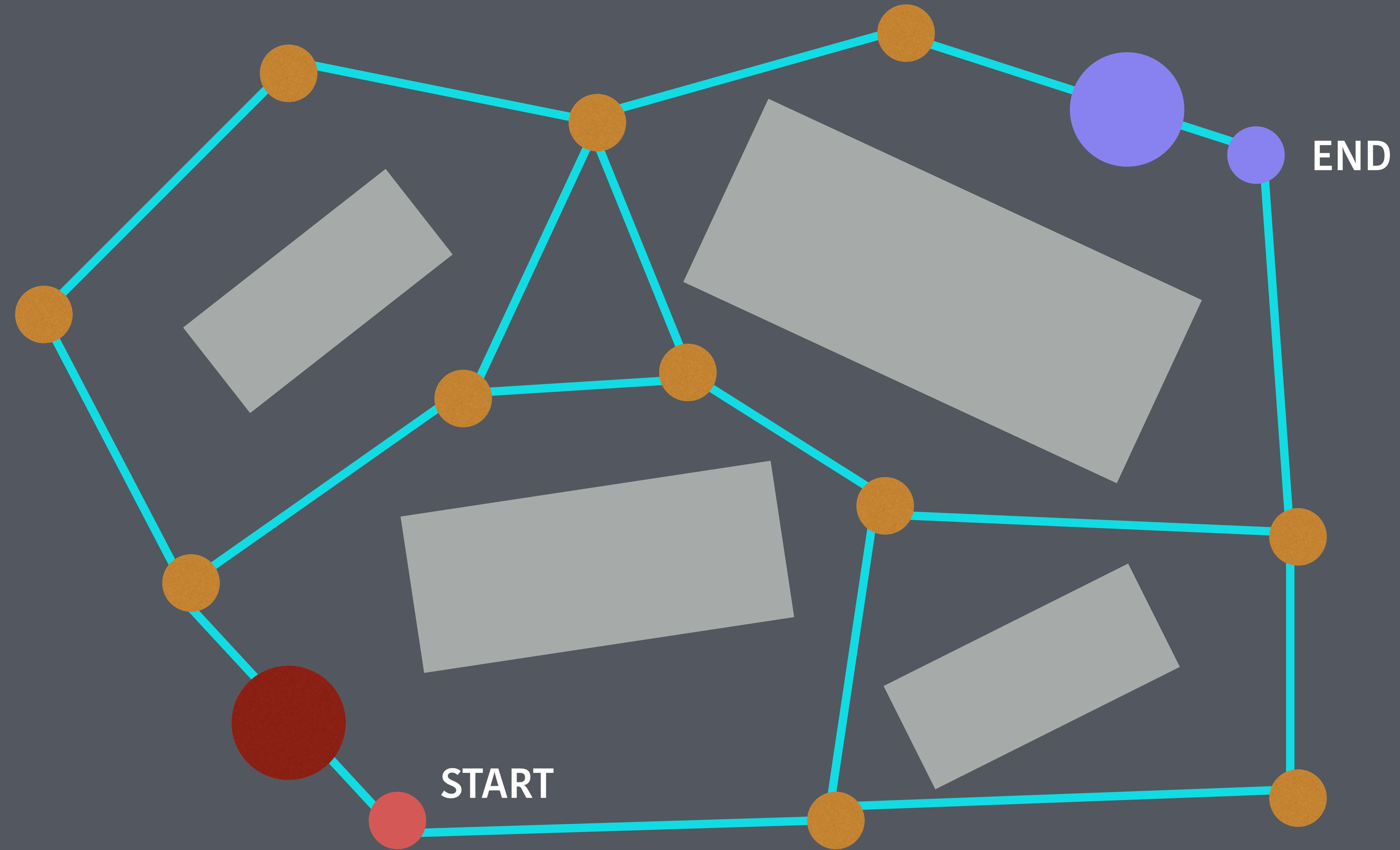


Get the **closest** node to the AI's position.

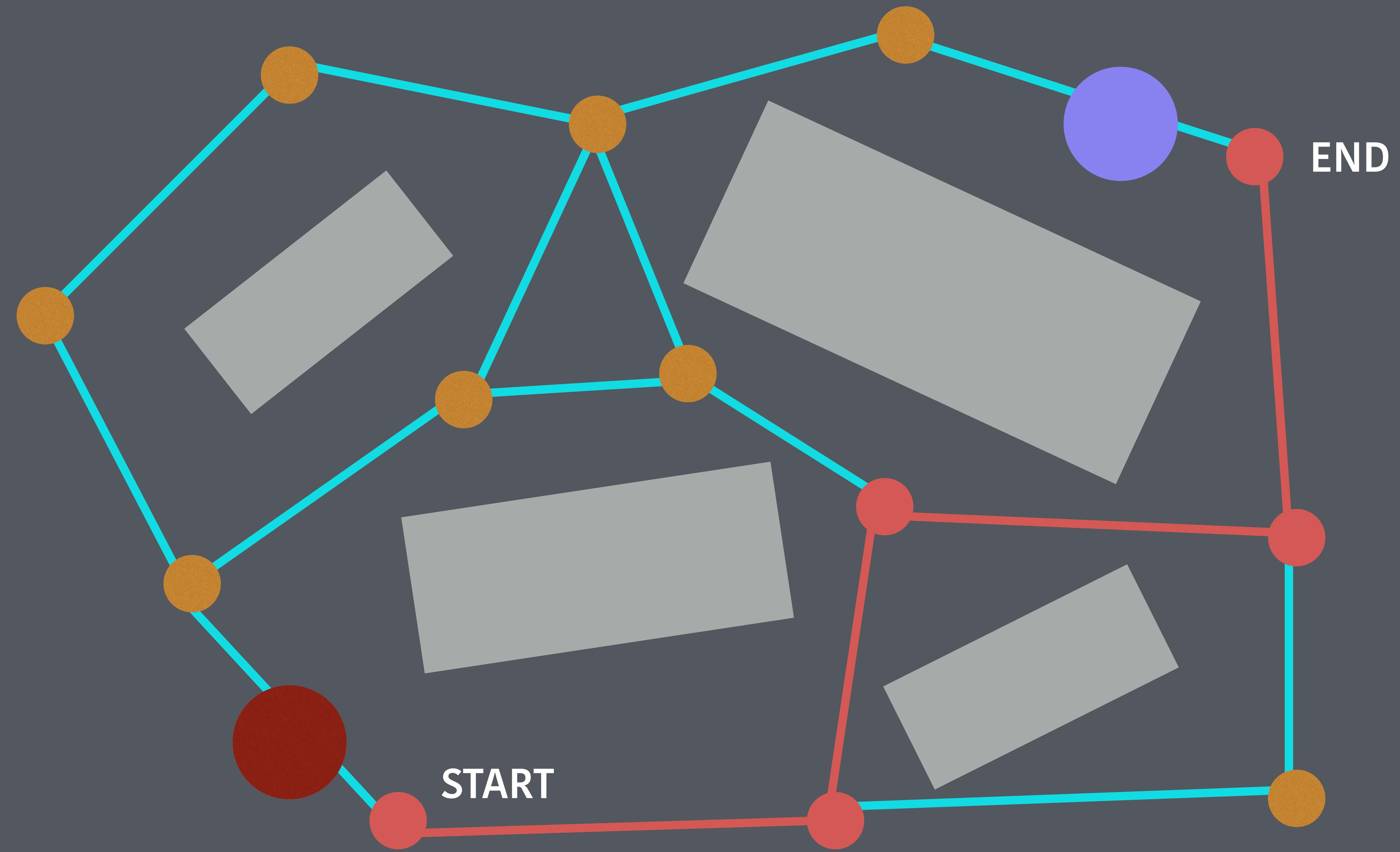
This will be the **start** node.

Get the **closest** node to the target's position.

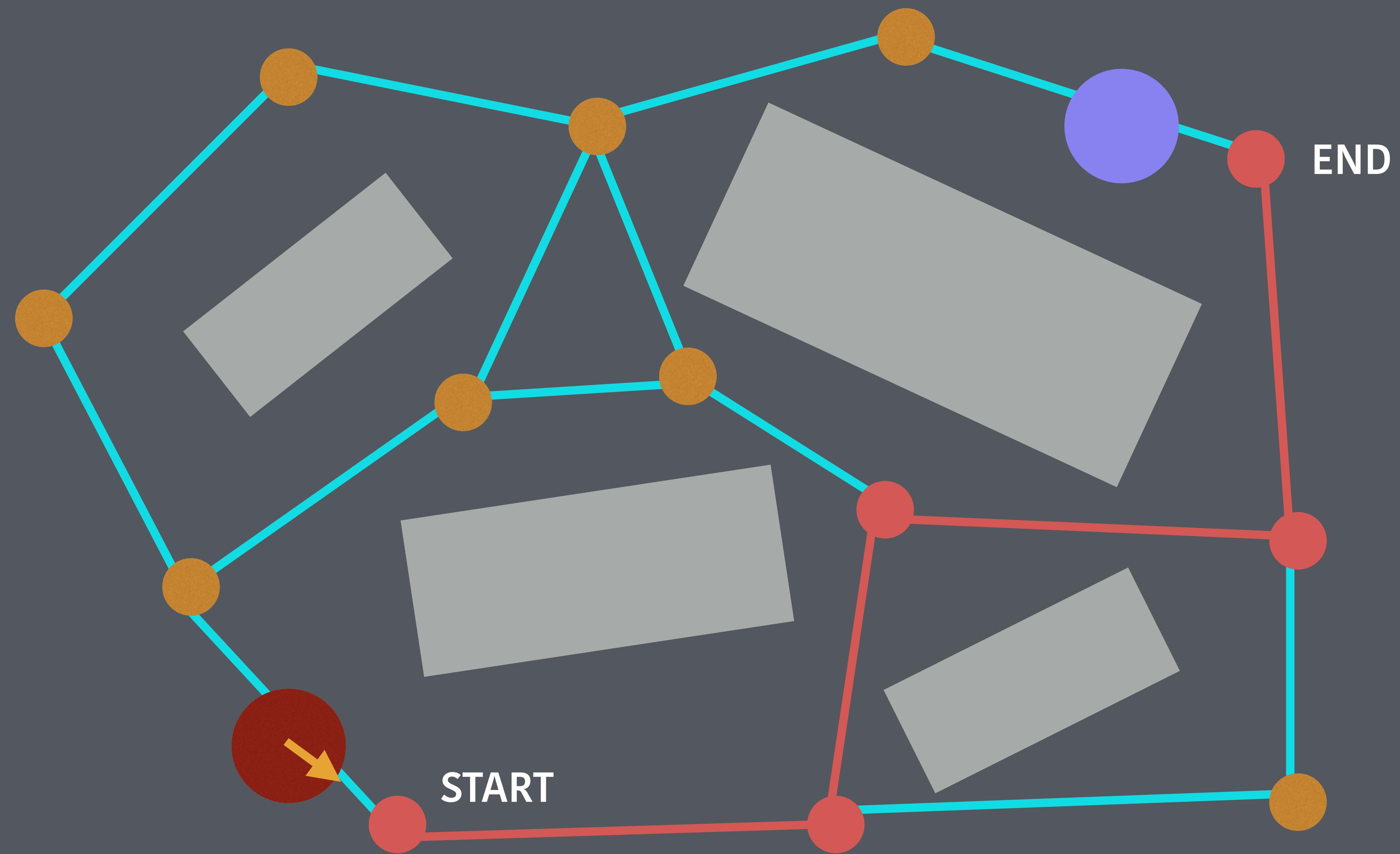
This will be the **end** node.



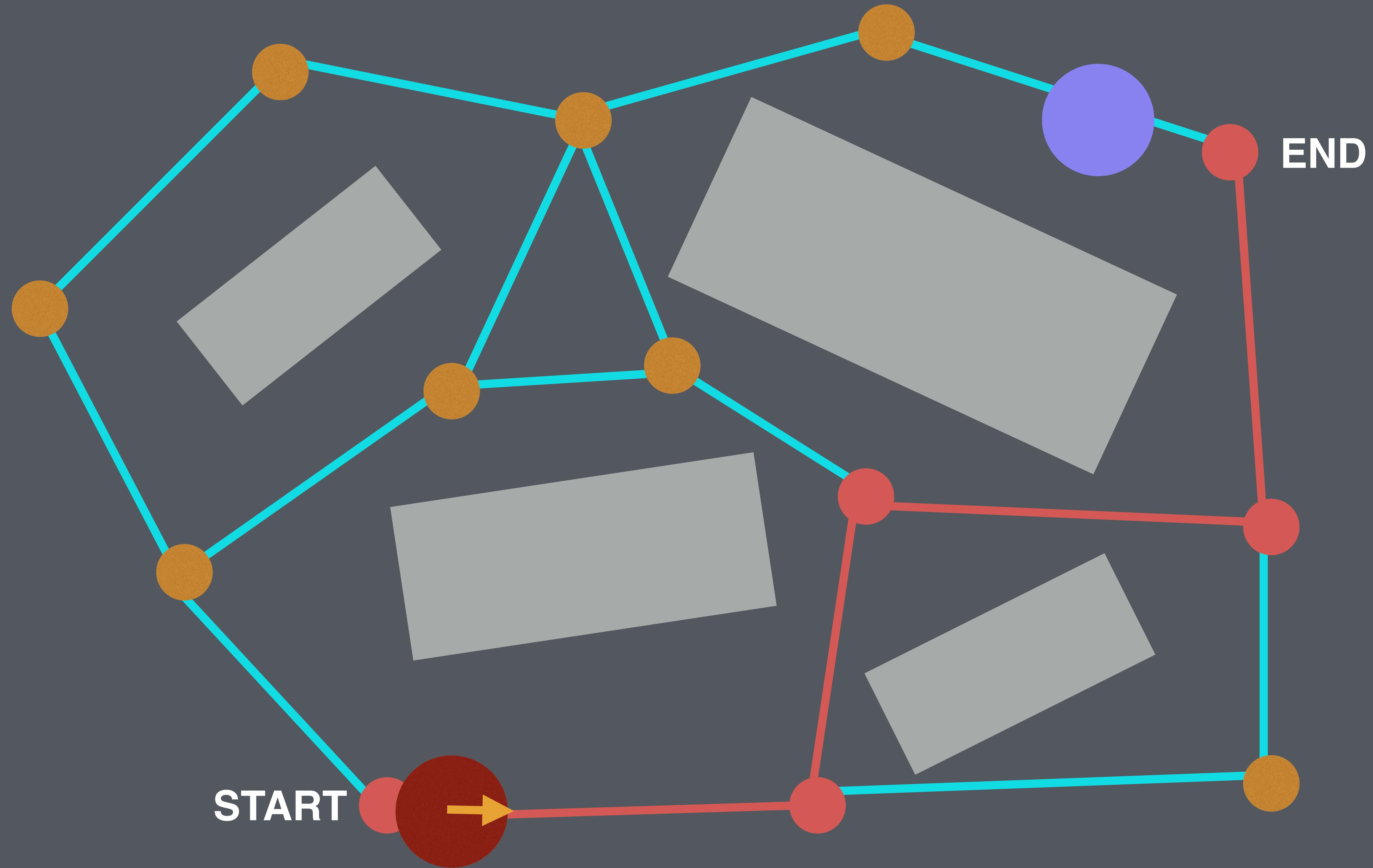
Calculate the best path using A*.



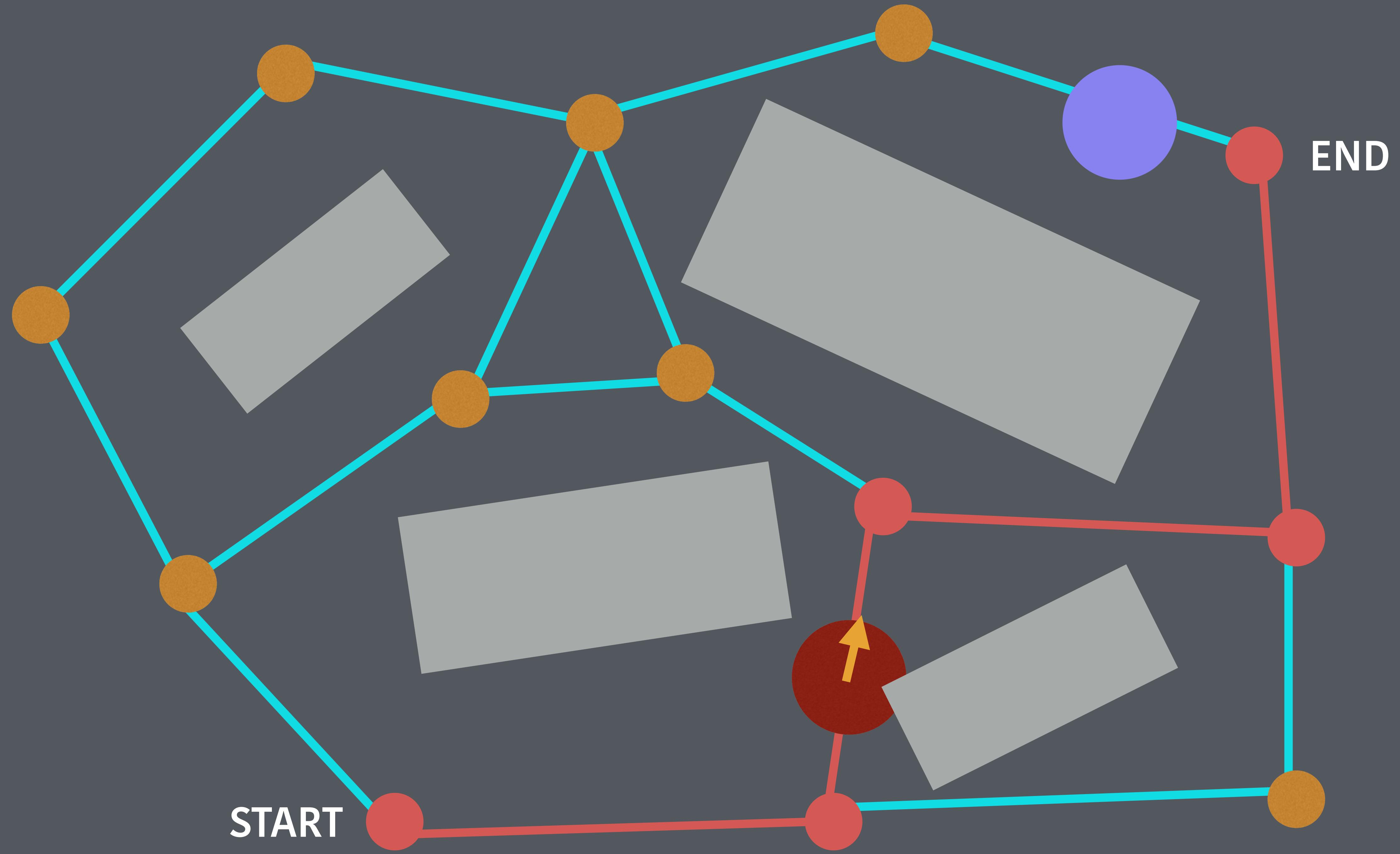
Put the path in a vector and set its first entry as the AI destination (**move towards that point on every frame**).

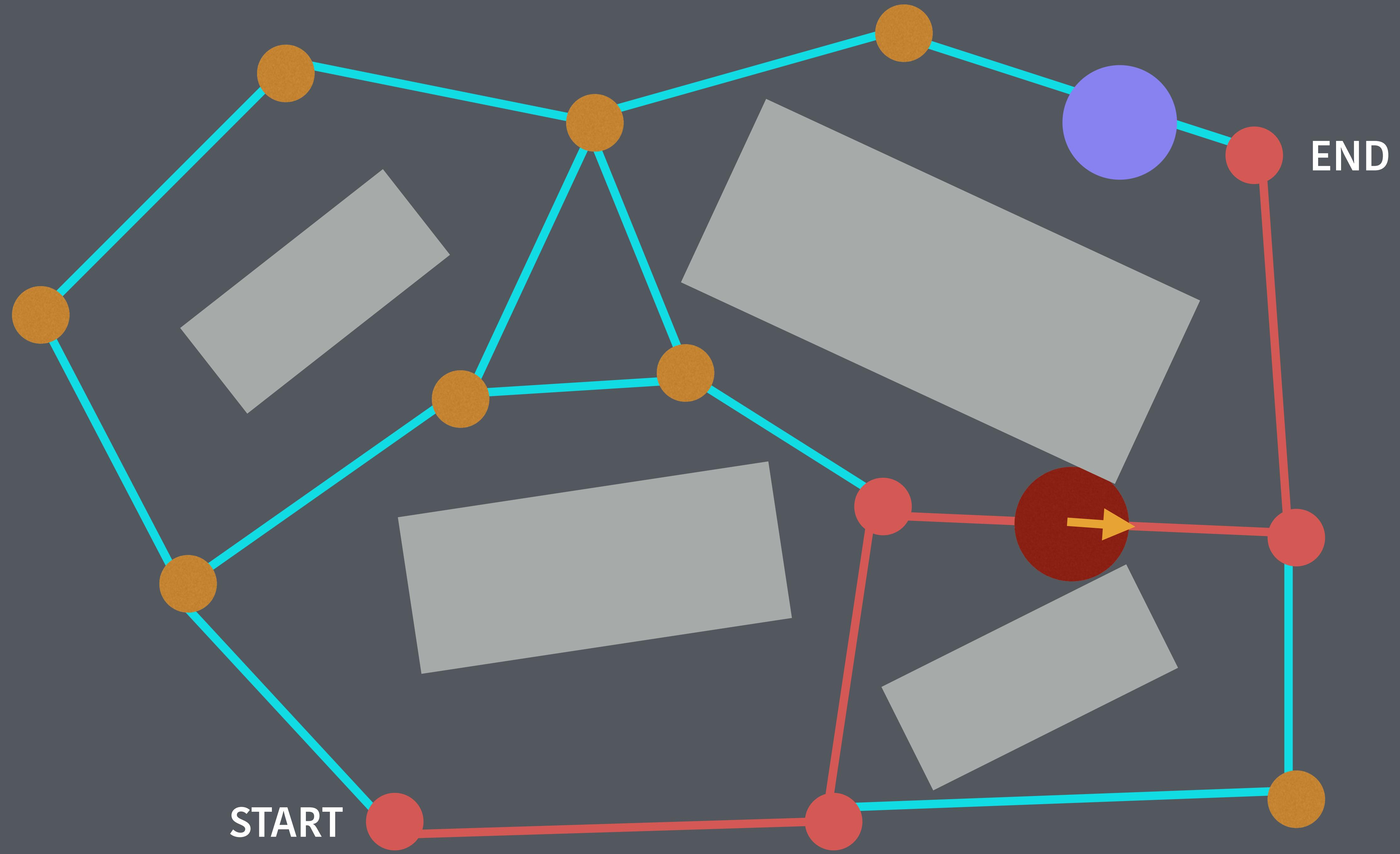


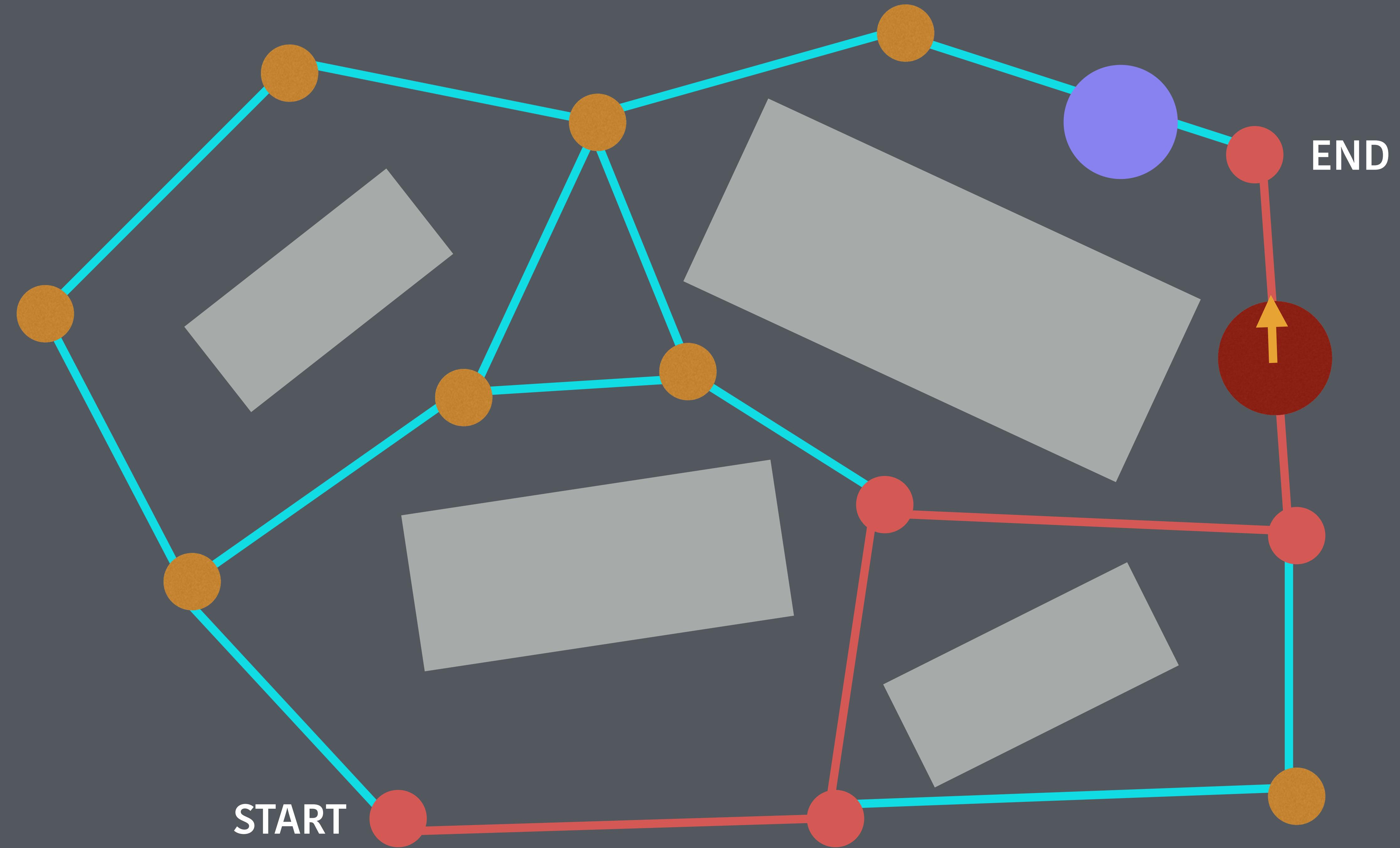
When the destination is reached (distance from AI to it is less than a certain amount), set the goal as the next node in the path.



Repeat this until you reach the final node.







You can recalculate the path on every frame or on a certain interval so you can readjust your path if the **target is moving**.