CT255
NGT2

Week 9
[2D Games in Java]

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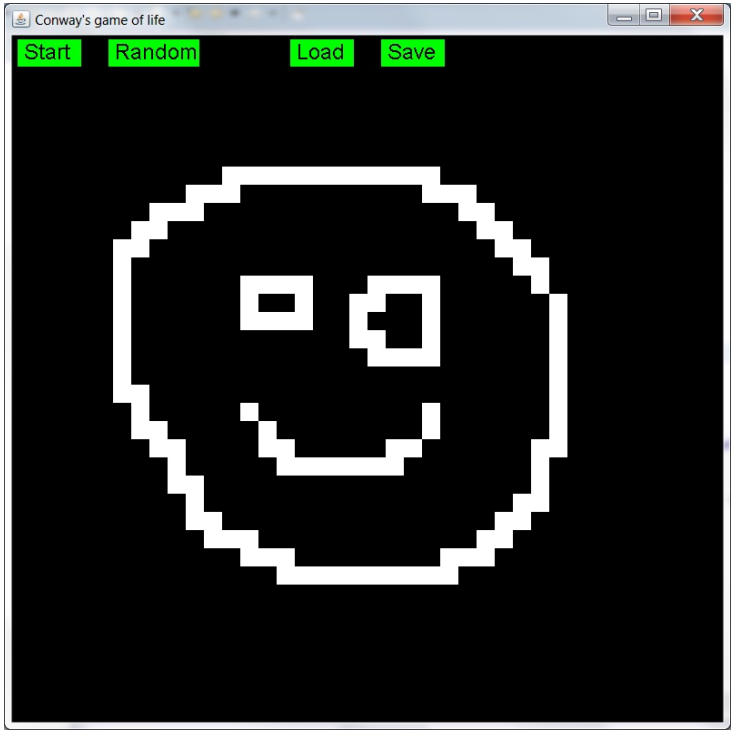
Last week's assignment [Conway's Game of Life]

- Implement mouse dragging for game state setup
- Implement game state loading and saving (via 'buttons' as before)
- Read the following A* webpage for next week!



http://www.psychicsoftware.com/AStarForBeginners.html

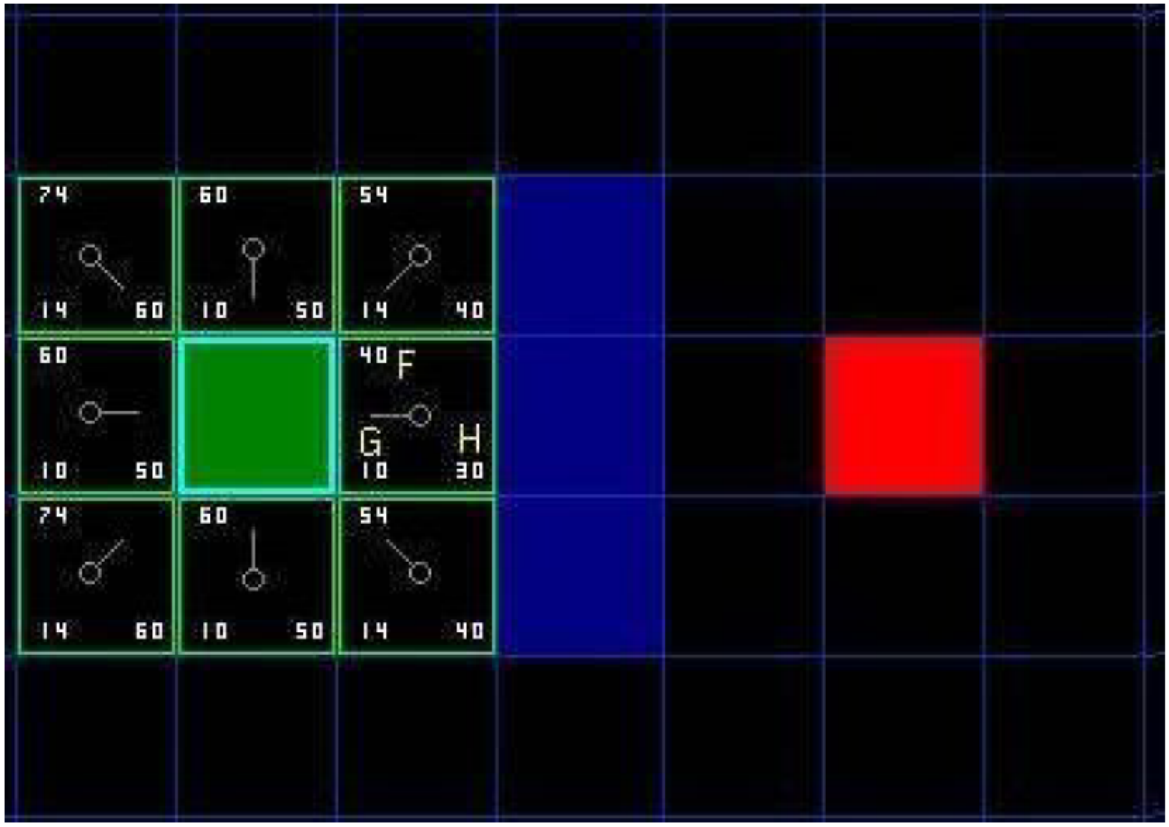
A* Pathfinding

- 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.



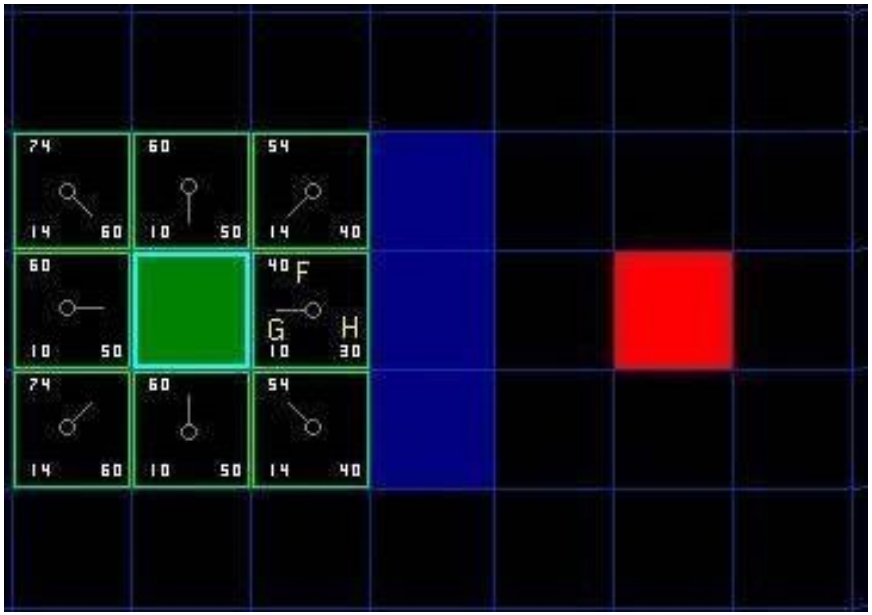
known cost from start to this node

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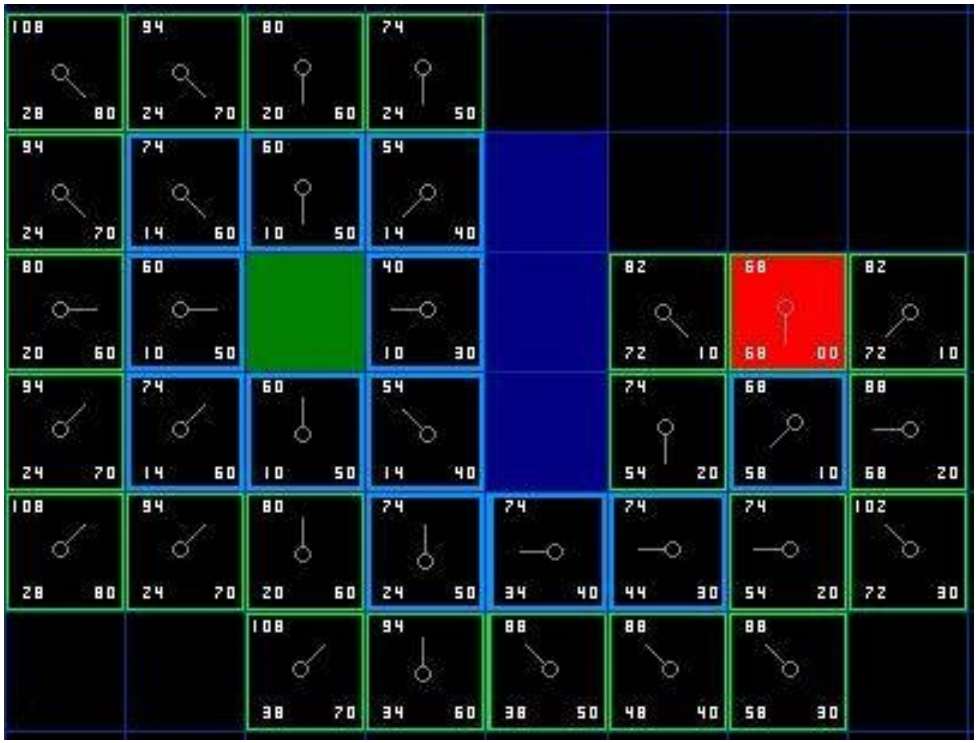
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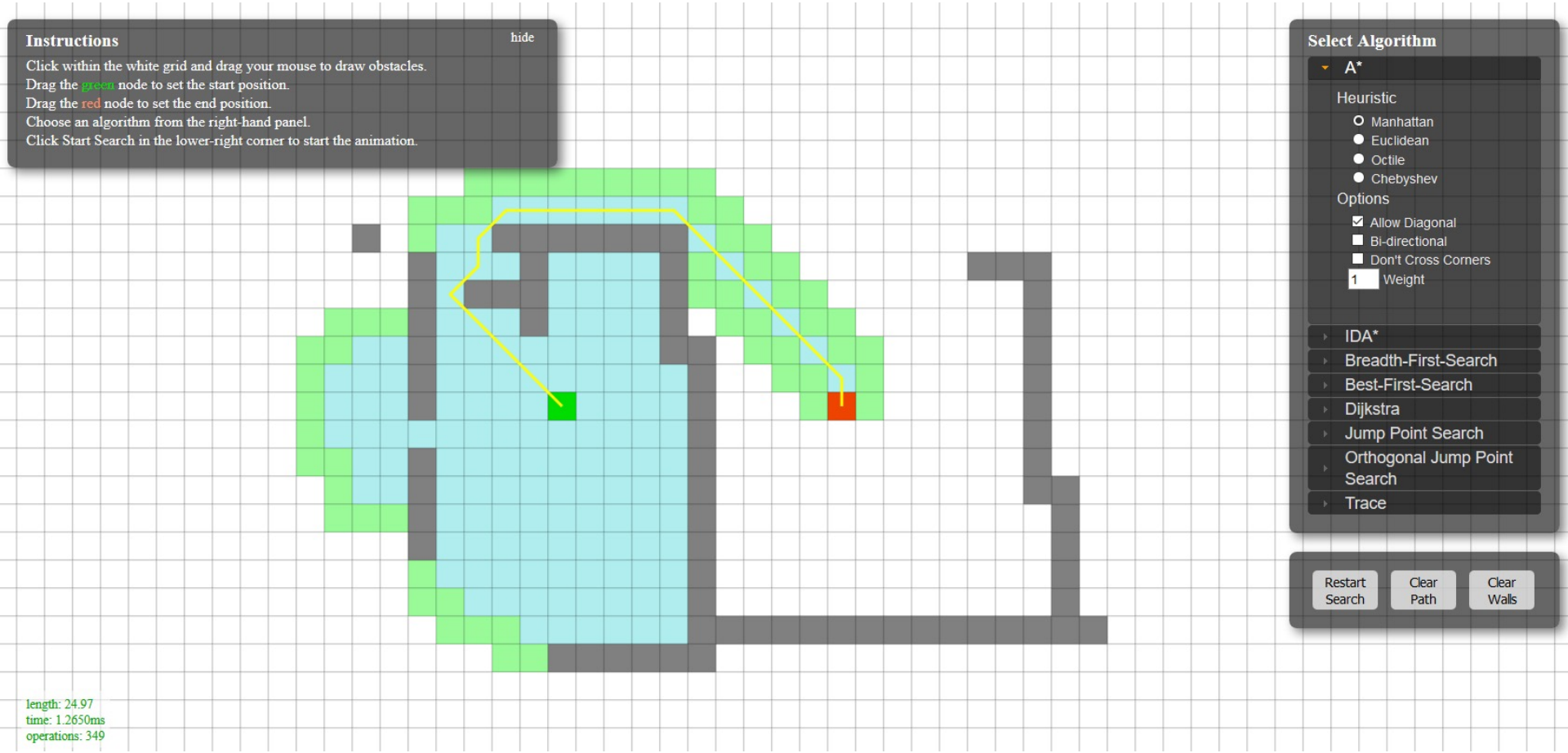
https://qiao.github.io/PathFinding.js/visual/



(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 board (2D array of nodes)
  - Walkable/unwalkable map (i.e. our original 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 the **starting node** and set to ‘open’

Implementing A* Pathfinding..

- What is the initial algorithmic step?
- What is the general algorithmic step?
  - Find open node with lowest f (call it X)
  - EXPAND: 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

Data for A*

- It makes sense to define a ‘node’ class, and to store nodes in specific kinds of data structures. I suggest:
  - a 2D array covering the whole game area (quick to find based on x,y)
  - a linked-list for the Open List (quick to add/remove members)
  - a stack storing the calculated path to follow (good for reversing order via LIFO)
- Of course, each node instance can happily exist in multiple data structures, since they're actually only storing pointers to it
- The nature of the A* algorithm means that we obtain our calculated path in the reverse order to how we need it
  - use a **2D array** to store all possible node cells during calculations, then when the target is found:
  - use a **stack** to store the path that a ‘badguy’ will follow, as this is a handy way to reverse the order of data
- The **linked list** is not strictly required, but since only a subset of all nodes will be Open at any given time, it's more efficient to store these in a separate data structure rather than have to search all nodes to find the best Open node to expand next

Stack

'Last in First Out' (LIFO)

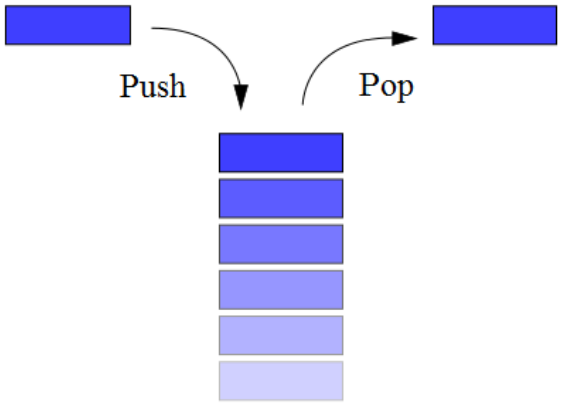
- In Java, use the Stack class:

```
import java.util.Stack;
```

Use the `push` and `pop` methods of this class

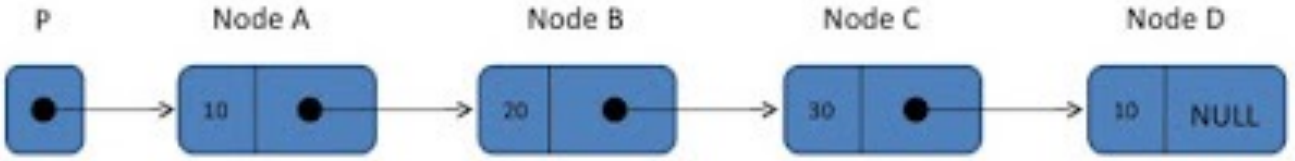
```
myStack.push(myObject);
myObject = (myClass)myStack.pop();
```

You can push any object you like onto a stack (e.g. our node object) and when popping it you must cast it to its correct data type



Linked List

- A list implemented by each item having a link to the next item.
- Head points to the first node.
- Last node points to NULL.



- Very efficient for insertion and deletion
- Can only be iterated sequentially (i.e. not random access)

```java
import java.util.*;
public class LinkedListDemo {

   public static void main(String args[]) {
      // create a linked list
      LinkedList ll = new LinkedList();

      // add elements to the linked list
      ll.add("F");
      ll.add("B");
      ll.add("D");
      ll.add("E");
      ll.add("C");
      ll.addLast("Z");
      ll.addFirst("A");
      ll.add(1, "A2");
      System.out.println("Original contents of ll: " + ll);

      // remove elements from the linked list
      ll.remove("F");
      ll.remove(2);
      System.out.println("Contents of ll after deletion: " + ll);

      // remove first and last elements
      ll.removeFirst();
      ll.removeLast();
      System.out.println("ll after deleting first and last: " + ll);

      // get and set a value
      Object val = ll.get(2);
      ll.set(2, (String) val + " Changed");
      System.out.println("ll after change: " + ll);
   }
}
```

This will produce the following result –

Output

```
Original contents of ll: [A, A2, F, B, D, E, C, Z]
Contents of ll after deletion: [A, A2, D, E, C, Z]
ll after deleting first and last: [A2, D, E, C]
ll after change: [A2, D, E Changed, C]
```

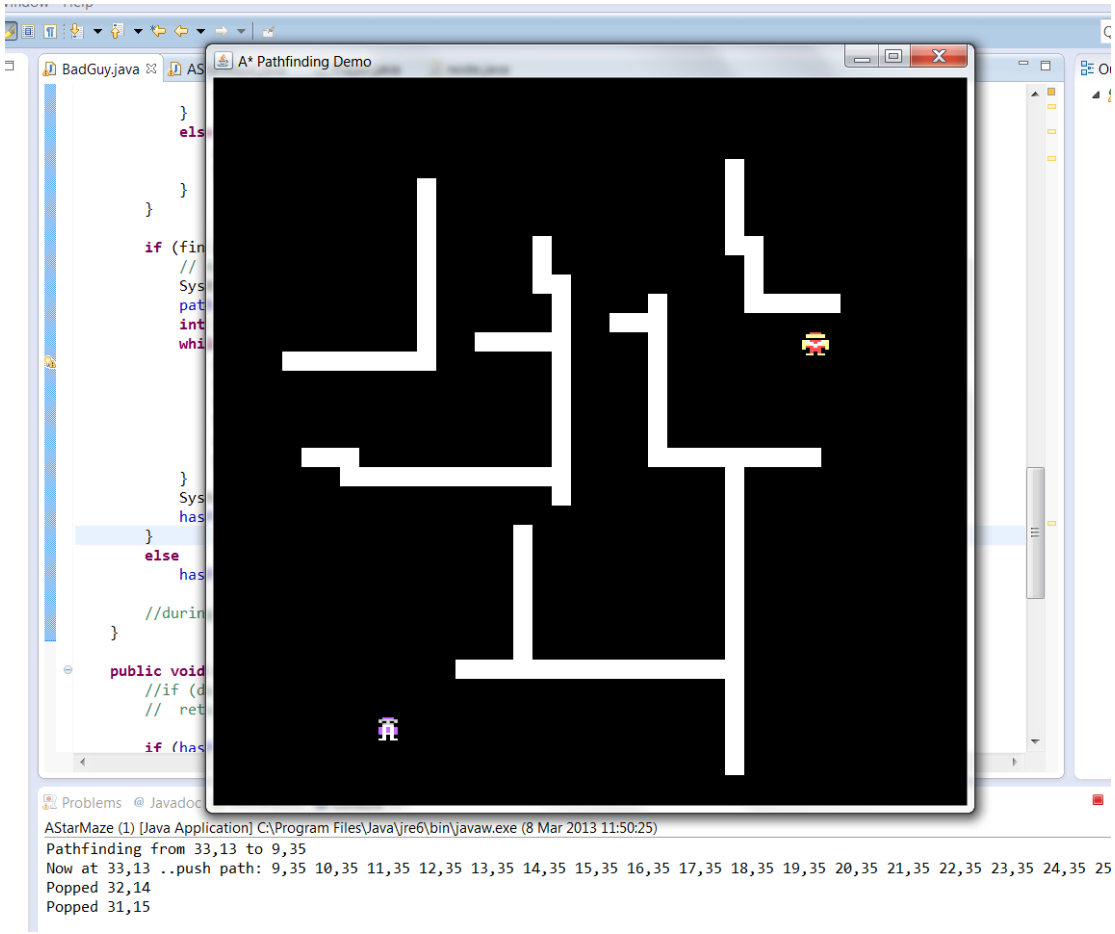
Iteration:

```
Iterator i = ll.iterator();
while (i.hasNext()) {
  string s = (String)i.next();
}
```

From: https://www.tutorialspoint.com/java/java_linkedlist_class.htm

Assignment

- Download base code for ‘badguy chases the player’ game
- This provides maze drawing, loading, saving
- It also moves the player with arrow keys, and badguy moves according to a dumb ‘straight line’ chase path – stops at walls
- Your goal is to implement A* pathfinding to make the badguy chase more effectively
- The A* path should be recalculated whenever the player moves or the maze is modified



Base code:

AStarDemoBaseCode.zip

(posted on Blackboard)

Debugging

- I'd recommend using **System.*out.print*** to debug the A* calculations and path following code