Traveler Problem

How did I do it?

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Problem Statement

For example, for a 4x4 one, here is a solution

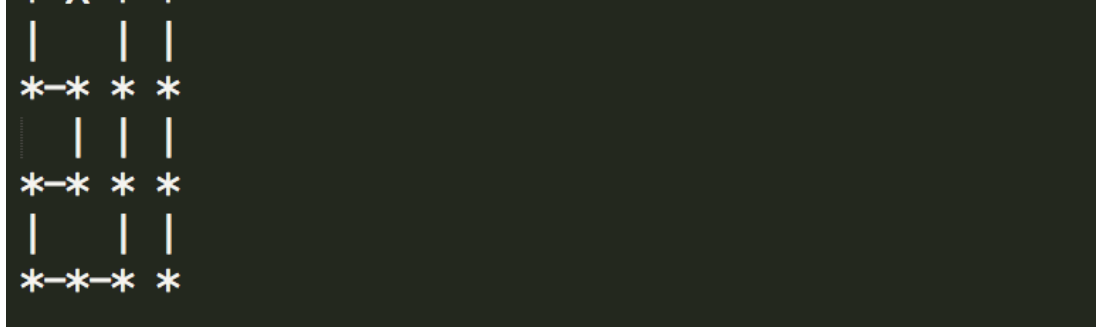
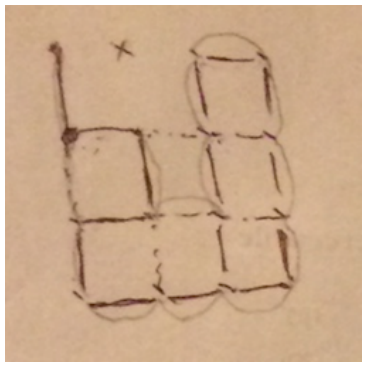
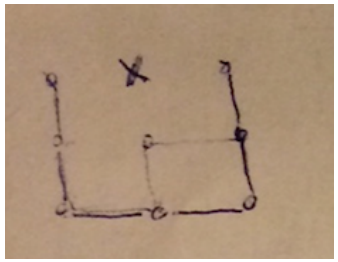


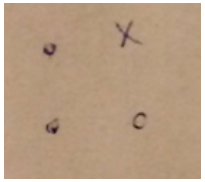
Figure out a travel plan to go through each and every city exactly once with only horizontal and vertical moves but no diagonal ones. The X should be excluded.

Use **good examples** to figure out a solution

- 5x5 grid is too complex, and it does not seem to have solutions. Not a good example for figuring out solutions.
- Use 4x4 grid instead, which has obvious solutions.
- Even 3x3.
- Even 2x2.

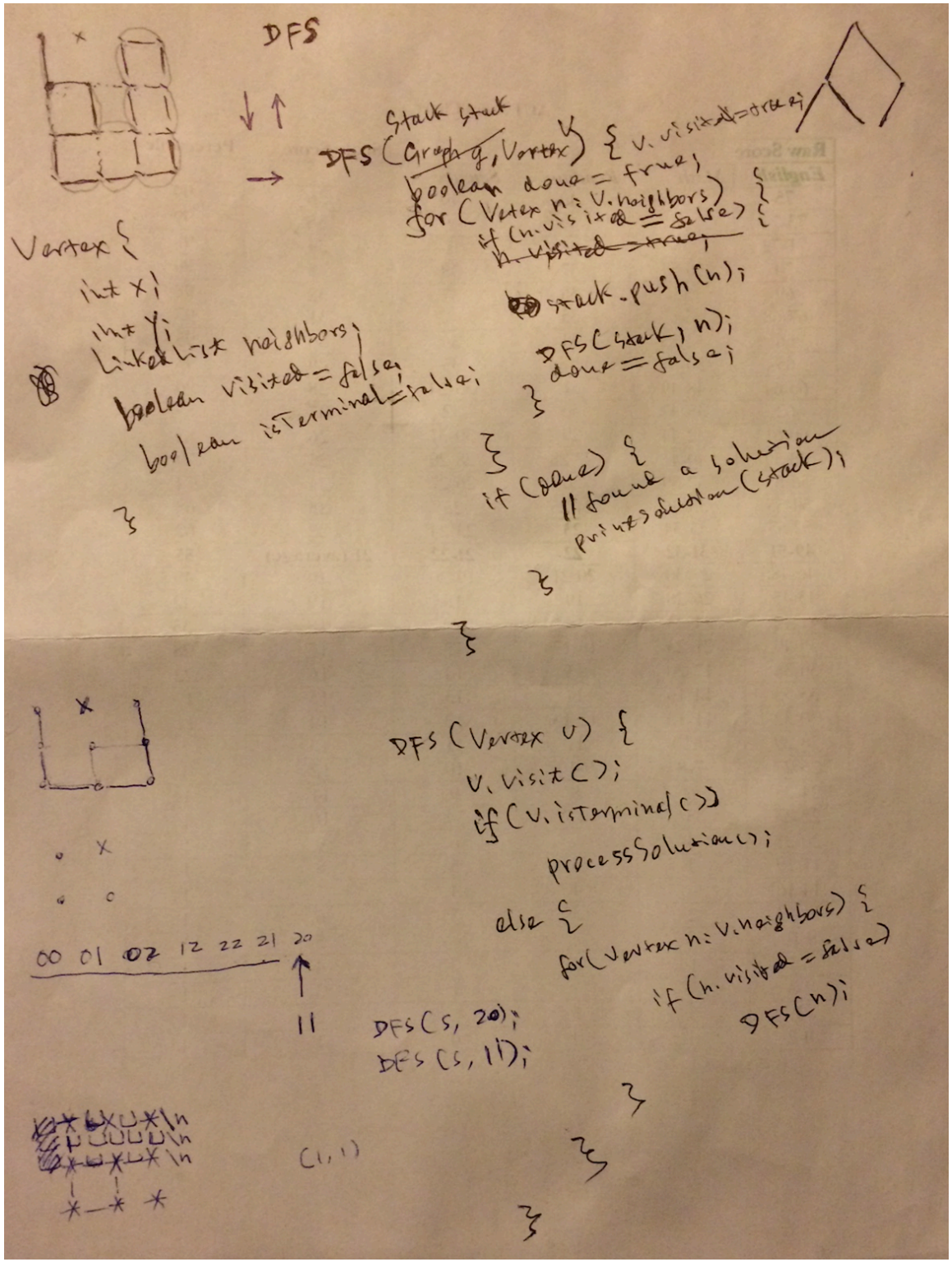






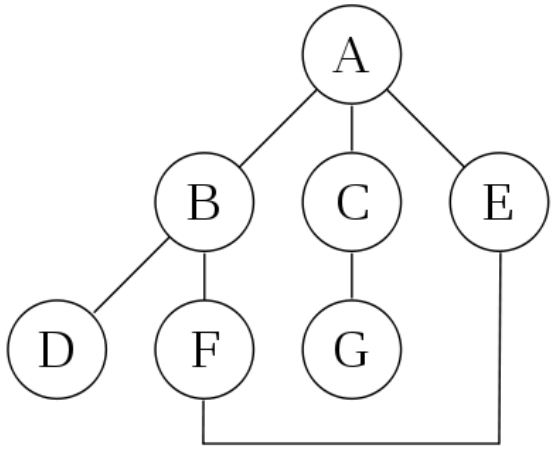
Use **paper and pencil** to figure out a solution.

- Do NOT use a computer until you have found the solution.
- Always use specific examples (good examples) to figure out the algorithm. Abstraction does not work.
- After finding a solution, try it with other examples. Think abstraction.



Reference known algorithms

- DFS seems relevant.
- https://en.wikipedia.org/wiki/Depth-first_search



Pseudocode [edit]

Input: A graph *G* and a vertex *v* of G

Output: All vertices reachable from *v* labeled as discovered

A recursive implementation of DFS:[5]

```
1  procedure DFS(G,v):
2      label v as discovered
3      for all edges from v to w in G.adjacentEdges(v) do
4          if vertex w is not labeled as discovered then
5              recursively call DFS(G,w)
```

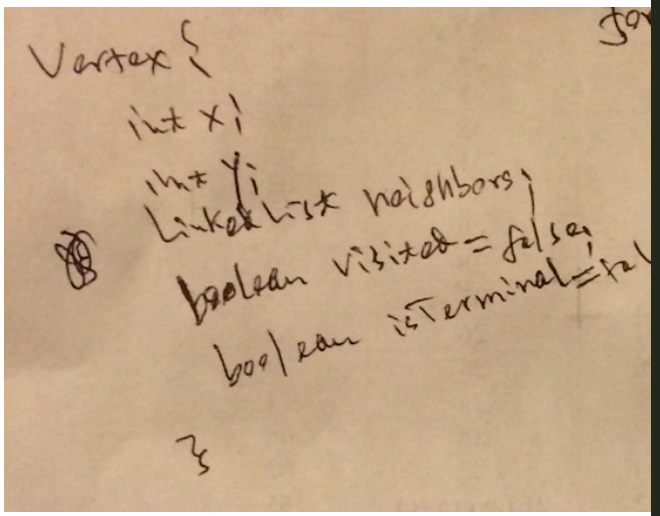
My DFS method

- Recursive
- Use a stack so I can record my path

```
Traveler_Ray traveler = new Traveler_Ray();
Grid grid = new Grid(n);
traveler.grid = grid;
Stack<Vertex> stack = new Stack<Vertex>();
traveler.DFS(stack, grid.getStartingVertex());
```

```
private void DFS(Stack<Vertex> stack, Vertex v) {
    stack.push(v);
    List<Vertex> unvisitedNeighbors = v.getUnvisitedNeighbors(stack);
    if (unvisitedNeighbors.isEmpty())
        grid.processSolution(stack);
    else    {
        for (Vertex n : unvisitedNeighbors){
            DFS(stack, n);
        }
    }
    stack.pop();    // shouldn't have to do this
}
```

Vertex class




```java
public class Vertex {
    private int x;
    private int y;
    private LinkedList<Vertex> neighbors;

    public Vertex() {
        this.neighbors = new LinkedList<Vertex>();
    }

    public String toString()    {
        return "" + getX() + getY() + " ";
    }

    public void setNeighbors(LinkedList<Vertex> neighbors){
        this.neighbors = neighbors;
    }

    public LinkedList<Vertex> getUnvisitedNeighbors(Stack<Vertex> s){
        LinkedList<Vertex> list = new LinkedList<Vertex>();
        for(Vertex v : neighbors)   {
            if(s.search(v) < 0) {
                list.add(v);
            }
        }
        return list;
    }
}
```

Grid class

- 2-D array of Vertex
- Hole Vertex
- Starting Vertex
- buildGraph()
- processSolution(stack)
- allVisited(stack)
- The main() method for testing the class

```
Grid 4 created: starting: 00 , hole: 10
+ X + +

+ + + +

+ + + +

+ + + +
```

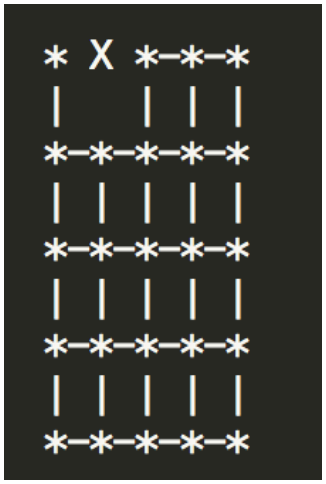
```
public class Grid {
    private Vertex[][] vertices;
    private int size;
    private int hole_x = 1;
    private int hole_y = 0;
    private int starting_x = 0;
    private int starting_y = 0;
    private SolutionSet solutions;
    private int numAttempts = 0;

    public Grid(int n)  {
        size = n;
        vertices = new Vertex[n][n];
        for(int i=0; i<n; i++)  {
            for(int j=0; j<n; j++)  {
                Vertex v = new Vertex();
                v.setX(i);
                v.setY(j);
                vertices[i][j] = v;
            }
        }
        buildGraph();
        solutions = new SolutionSet(this);
    }
```

```
public static void main(String[] args) {
    Grid grid = new Grid(4);
    System.out.println("Grid " + grid.size() + " created: starting: "
        + grid.getStartingVertex() + ", hole: " + grid.getHole());
    System.out.println(grid);
}
```

Grid class – continued

- buildGraph() method



```
* X *-*-*
|   | | |
*-*-*-*-*
| | | | |
*-*-*-*-*
| | | | |
*-*-*-*-*
| | | | |
*-*-*-*-*
```

```
private void buildGraph()   {
    for(int i=0; i<size; i++)   {
        for(int j=0; j<size; j++)   {
            Vertex v = vertices[i][j];
            int x = v.getX();
            int y = v.getY();
            if(x == hole_x && y == hole_y)
                continue;
            LinkedList<Vertex> neighbors = new LinkedList<Vertex>();
            // down: x, y+1
            if(!(x==hole_x && y+1==hole_y) && y+1<size)
                neighbors.add(vertices[x][y+1]);
            // right: x+1, y
            if(!(x+1==hole_x && y==hole_y) && x+1<size)
                neighbors.add(vertices[x+1][y]);
            // up: x, y-1
            if(!(x==hole_x && y-1==hole_y) && y-1>=0)
                neighbors.add(vertices[x][y-1]);
            // left: x-1, y
            if(!(x-1==hole_x && y==hole_y) && x-1>=0)
                neighbors.add(vertices[x-1][y]);
            v.setNeighbors(neighbors);
        }
    }
}
```

Drawing a solution

- Start with grid.toString()
- Replace certain ‘ ‘ with ‘-’ or ‘|’
- Math!

```
public String toString()    {
    StringBuilder buf = new StringBuilder();

    for(int row=0; row<size; row++) {
        // first line: "+ X + +\n"
        for(int col=0; col<size; col++) {
            // + or X
            if(row == hole_y && col == hole_x)
                buf.append('X');
            else
                buf.append('+');
            // ' ' or '\n'
            if(col<size-1)
                buf.append(' ');
            else // last one
                buf.append('\n');
        }
        // 2nd   line: "       \n"
        for(int col=0; col<size; col++) {
            buf.append(' ');
            // ' ' or '\n'
            if(col<size-1)
                buf.append(' ');
            else // last one
                buf.append('\n');
        }
    }

    return buf.toString();
}
```

```
// draw the solution represented by stack given the grid
public String toStringShow(Grid grid)   {
    StringBuilder g = new StringBuilder(grid.toString());
    int size = grid.size();

    for(int i=1; i<stack.size(); i++){
        Vertex v1 = stack.get(i-1);
        Vertex v2 = stack.get(i);
        int x1 = v1.getX(), y1 = v1.getY();
        int x2 = v2.getX(), y2 = v2.getY();
        // either x1==x2 or y1==y2
        if(x1 == x2)    { // x1==x2: 1 step down or up from (x1,y1)
            // locate (x1,y1)
            int index = 4 * size * y1 + 2 * x1;
            // locate where to set '|'
            if(y1 < y2) index += 2*size;
            else index -= 2*size;
            g.setCharAt(index, '|');
        }
        else {  // y1==y2: 1 step right or left from (x1,y1)
            // locate (x1,y1)
            int index = 4 * size * y1 + 2 * x1;
            // locate where to set '-'
            if(x1 < x2) index++;
            else index--;
            g.setCharAt(index, '-');
        }
    }

    return g.toString();
}
```

Issues I ran into

- Traveler:DFS(): why stack.pop()?
- Grid:Grid(): v = new Vertex() after vertices = new Vertex[n][n].

```
public class Traveler_Ray {

    private Grid grid;

    private void DFS(Stack<Vertex> stack, Vertex v) {
        stack.push(v);
        List<Vertex> unvisitedNeighbors = v.getUnvisitedNeighbors(stack);
        if (unvisitedNeighbors.isEmpty())
            grid.processSolution(stack);
        else    {
            for (Vertex n : unvisitedNeighbors){
                DFS(stack, n);
            }
        }
        stack.pop();    // shouldn't have to do this
    }
```

```
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    public Grid(int n)  {
        size = n;
        vertices = new Vertex[n][n];
        for(int i=0; i<n; i++)  {
            for(int j=0; j<n; j++)  {
                Vertex v = new Vertex();
                v.setX(i);
                v.setY(j);
                vertices[i][j] = v;
            }
        }
        buildGraph();
        solutions = new SolutionSet(this);
    }
```