Problem Set #7

The **due date** for this homework is **Tue 30 Apr 2013 12:59 PM EDT -0400**.

- [ ] **In accordance with the Coursera Honor Code, I (Matthew Kramer) certify that the answers here are my own work.**

Question 1

Maze Routing: Basics

Which of these are correct statements about maze routing?

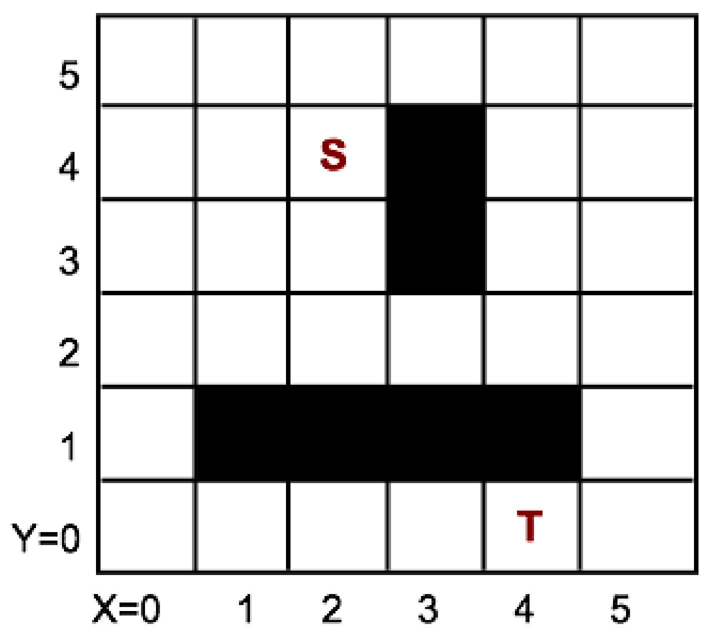
- [ ] The optimum, best path for a multi-net is called the “Steiner Tree” for this net.
- [ ] To efficiently find a minimum-cost item from the wavefront, we can use a data structure such as a heap or priority queue.
- [ ] Maze routing can only handle a maximum of two routing layers.
- [ ] To route a multi-point net, we select a point as source, label all others as targets, then use maze routing to find path from source to nearest target. Relabel all cells on the path as sources, and then rerun maze routing using all sources. Repeat the procedure until all points are connected. This method finds the best, most optimum path that connects all the points.
- [ ] If we add to the cost function a predictor that is a lower bound on the actual to-the-target extra pathcost, maze routing will still find the minimum cost path. This kind of search is called A* search.
- [ ] To represent the wavefront in maze routing, we should use a sorted linked list, since it takes linear time to search for the minimum-cost item from the wavefront ,and this achieves the best efficiency.
- [ ] After routing a net, the path of the net must be marked as obstacles to avoid other nets being routed over it.
- [ ] A large, modern ASIC has a huge routing grid. The routing is usually hierarchically divided into global routing first, followed by detailed routing.
- [ ] Maze routing routes a set of nets simultaneously.

- [ ] In maze routing, the path cost function is still consistent if a bending cost is included.

Question 2

Basic 2-point net routing in 1 layer

Consider the simple 6x6 routing grid shown below. We label a **source S** and a **target T** cells, and several obstacle cells. All white cells have unit cost. Use the simple unit-cost maze routing expansion method, and perform wavefront expansion by hand on the grid, to find a route from S to T. Which of the following are correct statements about this route?

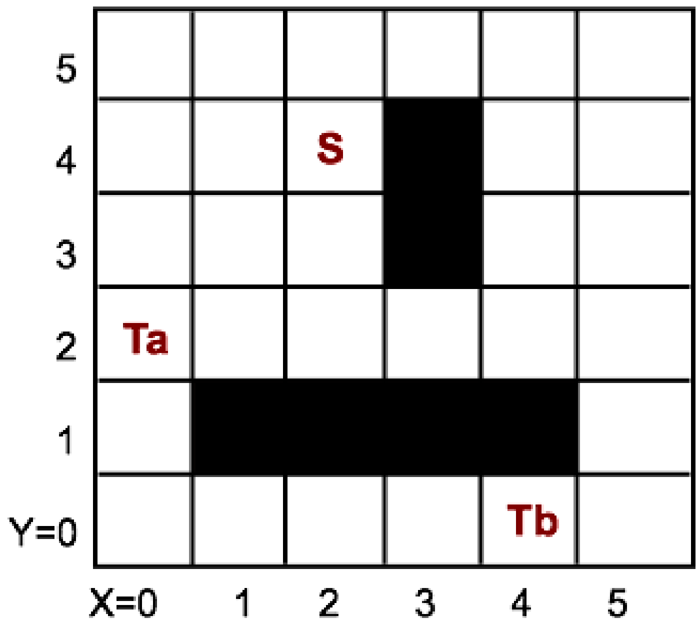


- [ ] If you expand cells strictly in pathcost order, you will expand at least 30 cells.
- [ ] The target is reached with a pathcost of 9
- [ ] There are at most 3 cells in the grid that will be reached with a pathcost of 2.
- [ ] There are at most 5 cells in the grid that will be reached with a pathcost of 3.
- [ ] The target is reached with a pathcost of 11.

Question 3

Multi-point net routing in 1 layer

Consider the simple 6x6 routing grid shown below. We label one **source S** and two **targets Ta, Tb**, and several obstacle cells. All white cells have unit cost. Use the simple unit-cost maze routing expansion method, and the technique for completing multi-point nets, and perform wavefront expansion by hand on the grid, to find a route for this 3-point net. Which of the following are correct statements about this route?



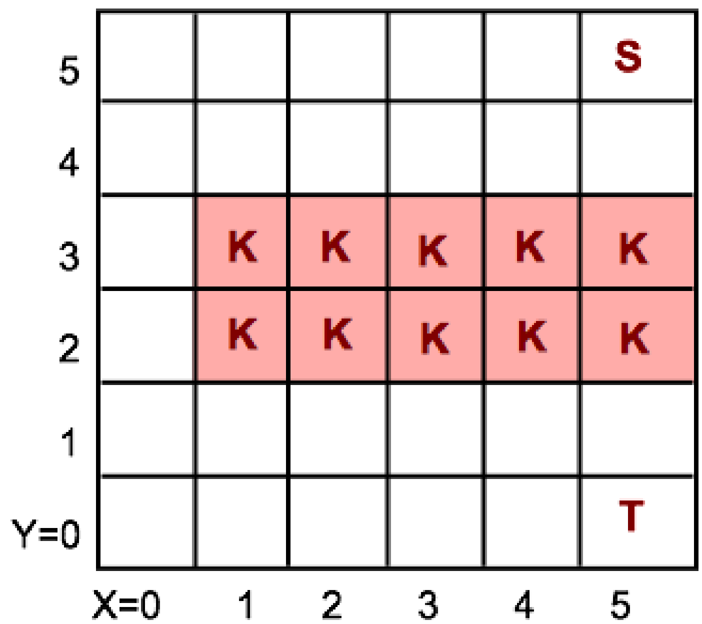
- [ ] There is an optimal 2-point path with total pathcost 9.
- [ ] There is an optimal path that routes around the right side of the obstacle in the Y=1 row of the grid.
- [ ] There is an optimal path that routes around the left side of the obstacle in the Y=1 row of the grid.
- [ ] There is an optimal 3-point path with total pathcost 11.
- [ ] Tb will be reached before Ta during the wavefront expansion from S.

Question 4

Routing with non-unit costs in 1 layer

Consider the simple 6x6 routing grid shown below. We label one **source S** and one **target T**, and several non-unit cells (in pink, with integer cost K). All white cells have unit cost. Assume your router uses the cheapest-pathcost-first maze routing expansion algorithm.

Answer this: what is the **minimum** value of K that will force the router to choose the final path to avoid all non-unit-cost cells? That is, the route will use only unit cost cells in the final answer after backtrace. K must be large enough that it is not possible to find a path through the high cost cells which has the same cost as the longer path around the left; in other words, solve for K large enough so that there are no "ties" in this cost. Type the number in the box.



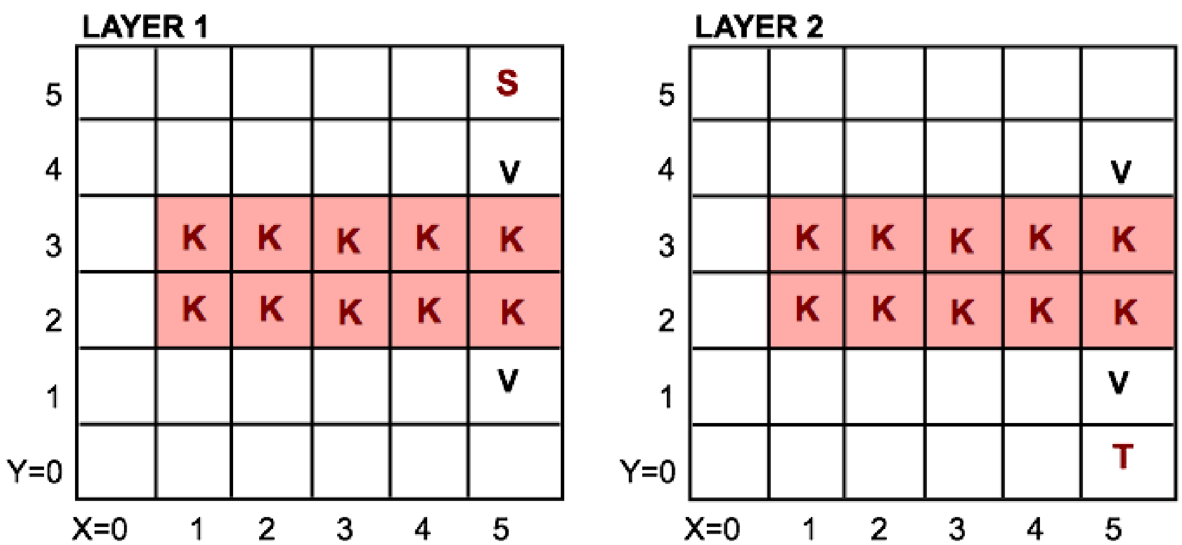
Question 5

Routing with multiple layers

Consider the simple pair of 6x6 routing grids shown below. We are routing in 2 layers:

Layer 1 (at left) and Layer 2 (at right). We label one **source S** in Layer 1 and one **target T in Layer 2**, and several non-unit cells (in pink, with integer cost **K**). All white cells have unit cost. Vias can be inserted to move from one layer to the other; however, we only allow vias where there is "V" marked in the grid. Each Via has cost=**10**. Assume your router uses the cheapest-pathcost-first maze routing expansion algorithm.

Answer this: what is the **maximum** value of **K** that will force the router to choose a final path that is a straight, vertical route using only cells in the **X=5** column on either layer? Type the number in the box.



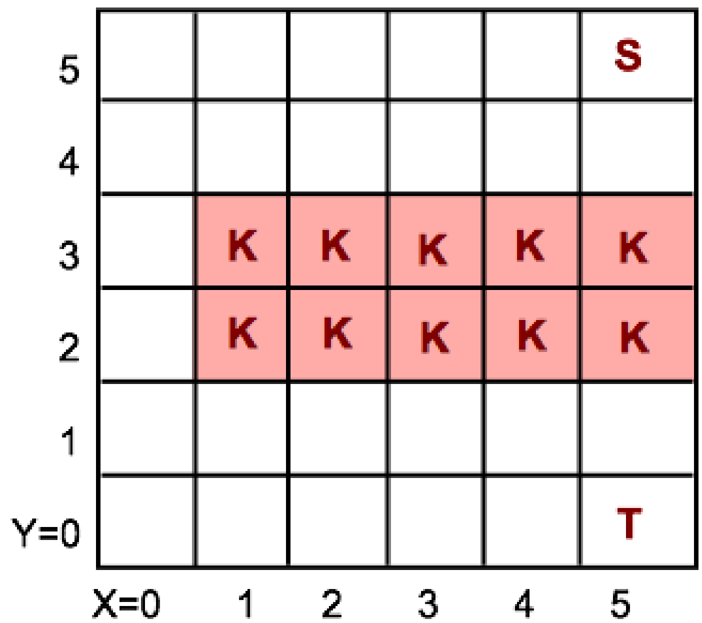
Question 6

Routing with inconsistent cost functions: Bend Penalty

Consider again the simple 6x6 routing grid from Q4, shown below. We label one **source S** and one **target T**, and several non-unit cells (in pink, with integer cost **K**). All white cells have unit cost. Assume your router uses the cheapest-pathcost-first maze routing expansion algorithm. But now, also assume that you add a **Bend Penalty of 6** to each bend. To keep this simple: assume that you are allowed to reach

each cell only once. So, your router is done when it reaches the target.

Answer this: what is the maximum value of **K** that will force the router to choose a straight vertical path using only cells in the **X=5** column of the grid? That is, the route will **not** insert any bends at all. Type the number in the box.



Question 7

Depth-first predictors for routing

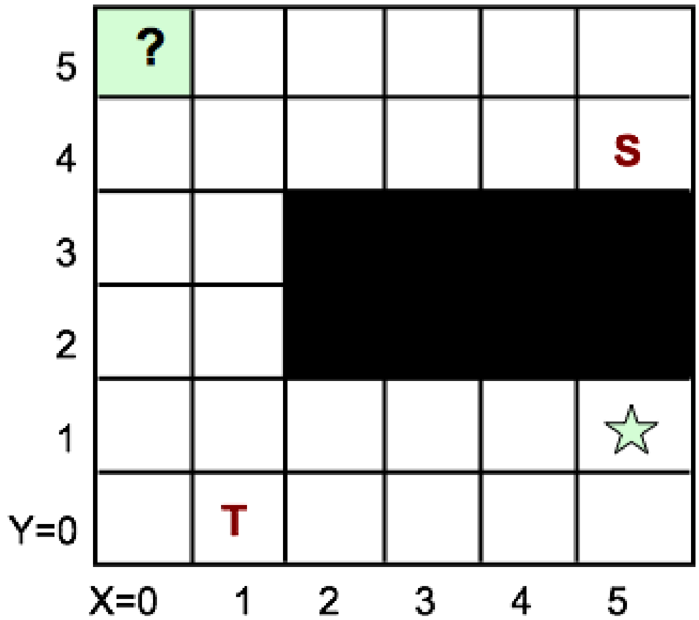
Consider the simple 6x6 routing grid from shown below. We label one **source S** and one **target T**, and several obstacles. All white cells have unit cost. Assume that your router now implements a depth-first search predictor. So, reached cells are added to the heap with a pathcost that is computed as:

```
(Pathcost of source to cell) + K*(Predictor of cost from cell to Target)
```

Your router uses the half-perimeter metric for the distance estimate. To be concrete: this distance estimate for the cell highlighted with the star in grid (5,1) is (5–1)+(1–

0)=5. Your router also “encourages” the search strongly to expand toward the target by setting K=2.

Answer this: when the cell highlighted with “?” at (0,5) is reached, and added to the heap, what is the cost used to add it to the heap? Type the number in the box.



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