CISC220H Project 2

Project due December 14.

You may not help other people debug their programs, except in the very limited way described on the class website. You may not use any code written by others, whether they are students or not. The TA and the instructor are available for office hours, and by appointment if you can't make hours because of a class conflict.

Groups

You may work with any person from any lab section in groups of 2-4 for this project. The professor reserves the right to change the group roster at any time. You may work with people who you worked with during Project 1.

Overview

The goal of this project is to help with traffic planning for a next generation Internet (this is actually underway currently – see http://www.internet2.edu/). Several assumptions will be made to simplify the domain so that we can directly apply techniques learned in class:

- All links in the network are assumed to be fiber-optic and capacity is not a concern (it is assumed that adding capacity is a much easier task than digging the route for the initial cable).
- All links can be connected through special hardware switches that can be installed anywhere that two (or more) existing links intersect.
- Each terminal position on the network provides an "on-ramp" for users. These terminal positions take traffic from external networks, place the traffic on the fiber-optic network, and then take it off the network. In this way we do not care about the interface or implementation of regional electronic networks.

Using these simplifications, we create a physical representation of the existing network as such:

- T = set of all termination points created by the links
- L = set of all existing links, where each link has endpoints in T

Assignment

1. **Part 1**

   The physical representation for the network will be read from a file format that looks like this:

```
1 0.0 5.0 First
2 1.0 2.0 Second
3 3.0 4.0 Third
#
1 2 Edge1
2 3 Edge2
```

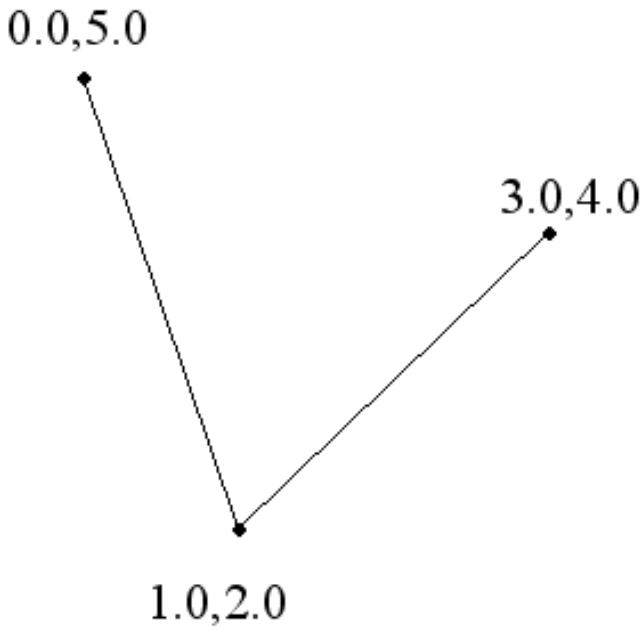

Figure 1: Example of a simple Network with 3 TerminationPoints and 2 Links

Each termination point has a line before the #. The termination point contains 4 values: identifier for the point, x position, y position, and label for the point. Each link has a line after the #. The link contains 3 values: identifiers for both termination points and a label for the link.

Create a class for a Network, TerminationPoint, and a Link. The Network should have a LinkedList of TerminationPoints and the TerminationPoints should have a LinkedList of connected Links. TerminationPoints should have a boolean flag indicating if they were part of the original file (to distinguish them from points created from intersection later).

Write a function that is able to read an input file and represent it using the Network class.

2. **Part 2**

   Use glut/OpenGL to draw the Network to the screen. Make sure to draw the TerminationPoints as small colored circles connected by the links.

3. **Part 3**

   Write a function that will take a current Network and recalculate a new Network that is exactly the same except that the new Network has no intersection points that are not TerminationPoints. This function must detect any existing Link that crosses another Link and create a new TerminationPoint at the intersection.

   We will discuss a few algorithms that can do this during class. You may do this with a naive O(E^2) algorithm that compares every Link (although other, more efficient, algorithms are available).

4. **Part 4**

   Calculate the shortest path between all TerminationPoints on the graph using Dijkstra's algorithm (http://en.wikipedia.org/wiki/Dijkstra's_algorithm). Distance between two adjacent TerminationPoints can be determined using the Cartesian/Euclidean distance formula (http://en.wikipedia.org/wiki/Euclidean_distance).

For each original TerminationPoint (as determined by the boolean flag), calculate the average shortest path. For the entire Network, calculate the average of the TerminationPoint average shortest paths.

5. **Part 5**

   Write a function on Network that calculates the minimum average path for all original TerminationPoints. This can be determined by the average Euclidean distance between each pair of original TerminationPoints. In essence, this is a measurement of what the average shortest path of a fully connected Network and represents the best that any network can do in terms of shortest paths.

   We can now output a metric on our Network that indicates how well the Network is connected. This metric will be calculated as the ratio of average shortest path divided by the minimum average path. This metric only includes paths between original TerminationPoints. The closer this ratio is to 1, the better connected the overall Network.

6. **Part 6**

   Devise a cost-effective strategy for adding new links to an existing Network. Your team will be given a file representing an existing Network. You will then be given another file representing funding events to build additional Links within your Network. The funding event file will look like:

```
500
200
100
```

   This file indicates that during the first event you may purchase and build a total of 500 distance units of new Links. You may then purchase and build 200 more distance units, and finally 100 distance units of Links.

   Each event provides for X distance worth of new fiber-optic Links which can be split however you deem appropriate. However, all funding must be used during each event to build Links and cannot be carried over for future events.

   Your goal is to improve the ratio of average shortest path on the Network to minimum average path for original TerminationPoints. For each funding event, you should output a list of new Links to be created with the funding.

7. **Part 7**

   Using the output from Part 6, create an animated display of your strategy. The animation should display the existing Network and then each funding event will be a frame in the animation showing the added Links in a different color. Also display the metric calculated in Part 5 for each step.

Submission of the final Project 2 is due December 14th at midnight.