# Telecommunication Networks Design Algorithm


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## Abstraction


Team TXSU has worked on four programming projects relating to network planning over the course of two semesters, with each project focusing on different aspects of routing and maximizing efficiency while minimizing cost.


## Introduction

In the Fall 2019 Semester, Team TXSU worked on:

- Project 1 – The Terminal Concentrator Assignment Project
- Project 2 – The Unconstrained Minimum Spanning Tree Algorithm

In the Spring 2020 Semester, Team TXSU worked on:

- Project 3 – The Constrained Minimum Spanning Tree Algorithm
- Project 4 – The Ford Fulkerson Algorithm
- Project 2 GUI – Graphical User Interface for the Unconstrained Minimum Spanning Tree Algorithm

## Terminal Concentrator

The Terminal Concentrator Project, Project 1, determines the minimum total cost of interconnections between the terminal(s) and concentrator given terminals (row concentrators (columns) and interconnection costs (element) This program will ask the user to input the size of the matrix and a constraint number. After these initial inputs the program will output the matrix values with selected entries in parentheses.

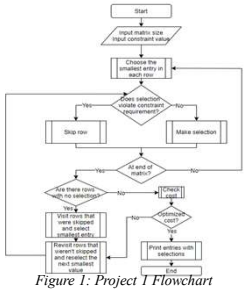

Figure 1: Project 1 Flowchart

Given the following matrix with a constraint of 2:

| | | | | |
|---|---|---|---|---|
| 3 | 4 | 4 | 4 | 4 |
| 8 | 15 | 15 | 14 | 11 |
| 13 | 3 | 10 | 13 | 8 |
| 8 | 12 | 5 | 10 | 8 |
| 13 | 15 | 1 | 12 | 6 |

The following selections will be made

| | | | | |
|---|---|---|---|---|
| (3) | 4 | 4 | 4 | 4 |
| (8) | 15 | 15 | 14 | 11 |
| 13 | (3) | 10 | 13 | 8 |
| 8 | 12 | (5) | 10 | 8 |
| 13 | 15 | (1) | 12 | 6 |

These selections will provide a cost of 20

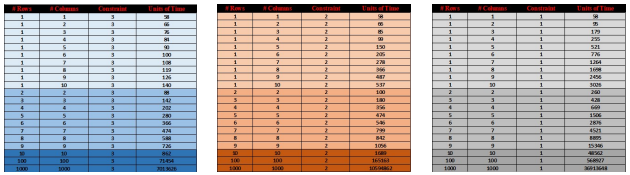

Figure 2: Three chart showing performance based on the terminator, concentrator, and constraint

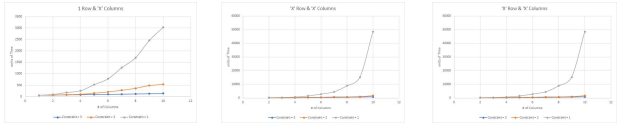

Figure 3: Three graphs showing Constraint Vs Performance based on the ratio of terminators to concentrators

## Unconstrained Minimum Spanning Tree UMST

The purpose of this program is to connect nodes in a way such that the cost of the connections formed is as small as possible and does not form any loops. This program will take in the size of the vertices followed by node positions to fulfill the size of the vertices. The output will be the edges that are formed to make the optimal connections.

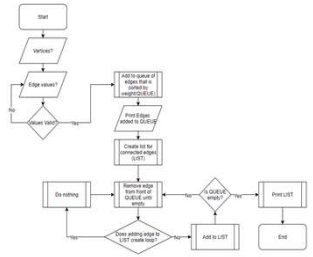

Figure 4: Project 2 Flowchart

```
Welcome to Kruskal's Algorithm!
Please enter the number of vertices: 6
Please press 'a' for user-input matrix or 'b' for generate a matrix: b
Nodes added:
(0,3,0)
(1,3,5)
(1,2,6)
(3,4,9)
(3,5,2)
Minimum Spanning Tree:
Edge-0 source: 0 destination: 3 weight: 0
Edge-1 source: 3 destination: 5 weight: 2
Edge-2 source: 1 destination: 3 weight: 5
Edge-3 source: 1 destination: 2 weight: 6
Edge-4 source: 3 destination: 4 weight: 9
Minimum cost was: 22
Total time: 40
```

Figure 5: Project 2 Sample Output

| Vertices | Average |
|---|---|
| 2 | 8 |
| 5 | 40 |
| 8 | 68.2 |
| 10 | 117.2 |
| 50 | 791.8 |
| 100 | 3025.4 |
| 500 | 62591.2 |
| 1000 | 181916.4 |
| 5000 | 3822689.4 |
| 10000 | 22624360.4 |

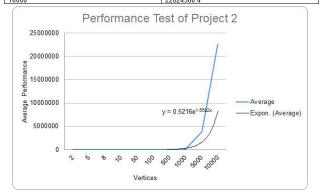


Figure 6: Project 2 Performance Chart and Graph

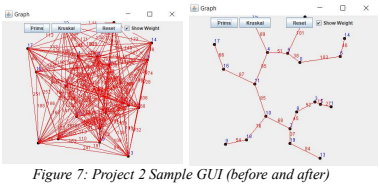

Figure 7: Project 2 Sample GUI (before and after)

## Constrained Minimum Spanning Tree CMST

The goal of this project is to connect nodes optimally by selecting the smallest cost connections while keeping in mind of the maximum possible number connections that a node can make. This works by taking in the size of the vertices, constraint value, and node positions in order to output optimal connections of edges.

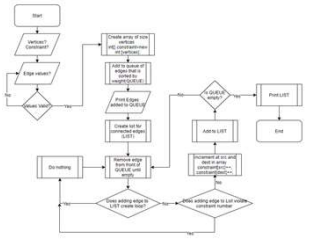

Figure 8: Project 3 Flowchart

```
Welcome to Modified Kruskal's Algorithm!
Please enter the number of vertices: 5
Please enter the value for the constraint: 2
Please press 'a' for user-input matrix or 'b' for generate a matrix: b
Nodes added:
(0,2,5)
(0,1,0)
(2,4,4)
(0,3,0)
(1,3,0)
(1,4,9)
Minimum Spanning Tree:
Edge-0 source: 0 destination: 1 weight: 0
Edge-1 source: 0 destination: 3 weight: 0
Edge-2 source: 2 destination: 4 weight: 4
Edge-3 source: 1 destination: 4 weight: 9
Minimum cost was: 13
Total time: 39
```

Figure 9: Project 3 Sample Output

| Vertices | Average |
|---|---|
| 5 | 8 |
| 6 | 32.4 |
| 8 | 71.4 |
| 10 | 138.2 |
| 50 | 1139.8 |
| 100 | 4495.2 |
| 500 | 79998.8 |

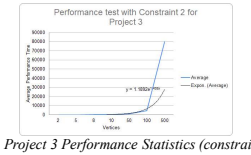


Figure 10: Project 3 Performance Statistics (constraint = 2)

| Vertices | Average |
|---|---|
| 5 | 8 |
| 6 | 39.2 |
| 8 | 65.4 |
| 10 | 87 |
| 50 | 747 |
| 100 | 2723 |
| 500 | 33173 |

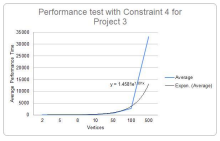


Figure 10: Project 3 Performance Statistics (constraint = 3)

## Ford Fulkerson Algorithm

The purpose of this project is to calculate the maximum flow rate from arbitration sink and source nodes of a given graph. This program works by taking in node positions and edge values to output the maximum flow into the sink node.

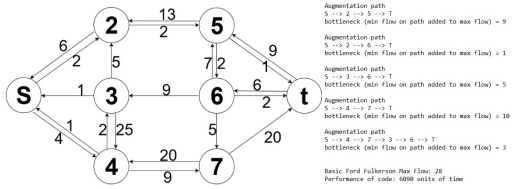


Figure 12: Project 2 Sample output from given graph

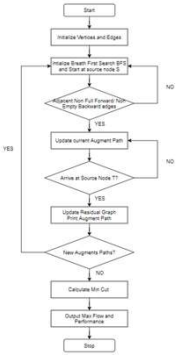

Figure 11: Project 4 flowchart

| Vertices | Average |
|---|---|
| 5 | 5645.5 |
| 6 | 6896.2 |
| 10 | 9853.4 |
| 50 | 25688.4 |
| 100 | 45254.6 |
| 500 | 240513.8 |
| 1000 | 637589.6 |
| 5000 | 63327222.4 |
| 10000 | 170113602.5 |

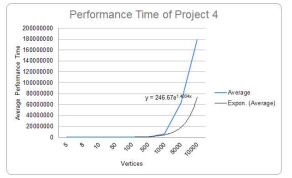


Figure 13: Project 4 performance chart and graph

## Glossary

- Terminal- A user end device connected to a network
- Concentrator – Devices used to connect user to the network
- Edge – Line/Connection formed by a pair of nodes/vertices
- Minimum Spanning Tree – Subset of a graph where all vertices are connected with the least amount of edges possible
- Node – A point at which lines intersect
- Telecommunication – Communication through electric signals or electromagnetic waves

## Acknowledgements


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