CONFERENCE PROCEEDING

A Graph Theory Approach to USIM Road Network

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ABSTRACT

Graph theory is a field in discrete mathematics that studies the mathematics behind a mathematical structure, called graph. A graph is defined as connection of vertices (nodes) by edges (lines). This research has transformed Universiti Sains Islam Malaysia (USIM)'s road network into a graph and nodes, which are more important in terms of distance and accessibility, using various centrality measures. The shortest and the longest routes that connect all nodes without forming a cycle, specifically looking at the shortest paths from Kolej GENIUS Insan to other nodes, are also computed. This research concludes that places such as a university campus, or a business park, or any communal area can be viewed from the perspective of graph theory in which the information gathered can be further utilized in university future infrastructure plan.

Keywords: *Graph Theory, centrality, USIM*

INTRODUCTION

Graph theory is a field in discrete mathematics that studies the mathematics behind a mathematical structure, called graph. Most research in graph theory involves the calculation of shortest path that connects two vertices, variation of paths in a graph, and measurement of nodes' centralities. These calculations often use existing algorithms such as Prim's and Kruskal's greedy algorithm and Dijkstra algorithm. Graph theory are often applied in planning road networks and public transportation pathway in advanced countries, designing an electronic circuit, and in the Global Positioning System (GPS). Besides that, graph theory can also be used to analyze road networks in places that have lots of buildings, including universities. This study aims to analyze Universiti Sains Islam Malaysia (USIM)'s road network using graph theory approaches and algorithms. This will enable the university's management to know which faculty is the most important under different types of measurements, so they know which faculty is the most accessible for staffs and students for future events planning. This study will also help USIM students to go to other faculties and points in the university by taking the shortest path to save their time. Various algorithms and centrality measurements were assigned on the main faculties and points in USIM, including Prim and Kruskal algorithm, betweenness centrality and closeness centrality to find out the minimum and maximum spanning tree of USIM's road networks, and the most important point in USIM under different centrality measurements.

MATERIALS AND METHODS/ METHODOLOGY

Finding the Minimum Spanning Tree (MST)

To find the MST for this graph, there are two main and similar algorithms, which are Prim's and Kruskal's algorithms. However, a slight difference between these two is

that Prim uses the weight of the vertices, while Kruskal makes use of the weight of the edges. For this graph, Kruskal's algorithm was used to make use the weight of the edges.

Finding the Maximum Spanning Tree (MaxST)

To find the MaxST, the same method was used in finding the MST of the graph. However, instead of picking from the lightest node, the heaviest node was picked so that the tree formed consists of nodes of maximum weight with no cycle.

Degree Centrality

Degree centrality has several meanings depending on one's network. In this study, degree centrality considers the node's strength and total number of connections. The formula used is simply: node's total connections x node's strength. A node's strength is given by the sum of the reciprocal of the weight of the edges connecting the node to another node. The reciprocal of the weight of the edges is taken because, the lower the weight of the edge, the shorter the distance between two nodes, the higher the degree centrality score.

Closeness Centrality

The formula used to calculate closeness centrality is = . Firstly, the number of potential paths that exist in a network was calculated. To calculate that, we can use the combination, nCr, which gives us 136 possible paths in this graph. Then, the geodesic path between each 136 possible paths was listed. Geodesic path means the shortest path between each node. Then, a table was set with all nodes. The table was filled with the geodesic distance between nodes, by referring to the geodesic path from a node to another. The sum of the geodesic distance between a node to another was calculated.

RESULTS AND DISCUSSION

Minimum Spanning Tree

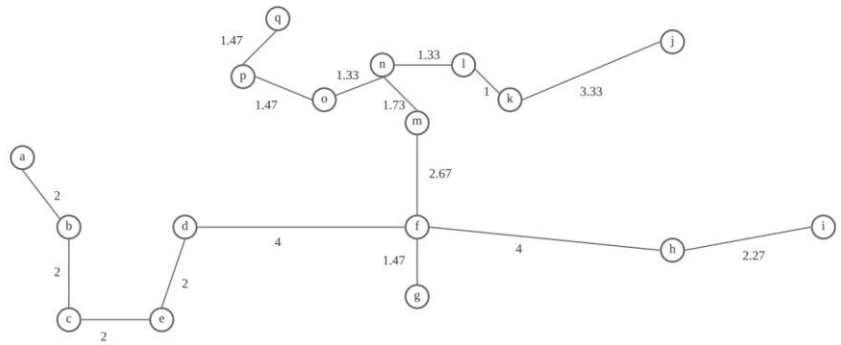

Figure 1. Aerial view of MST formed.

Maximum Spanning Tree

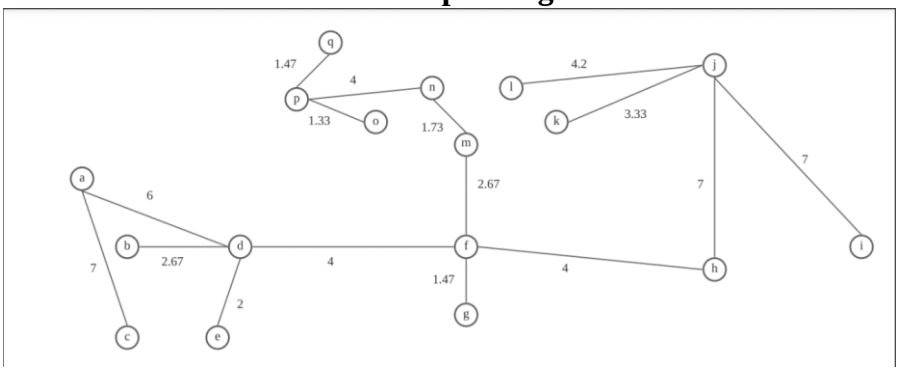

Figure 2. Aerial view of MaxST formed

Degree Centrality

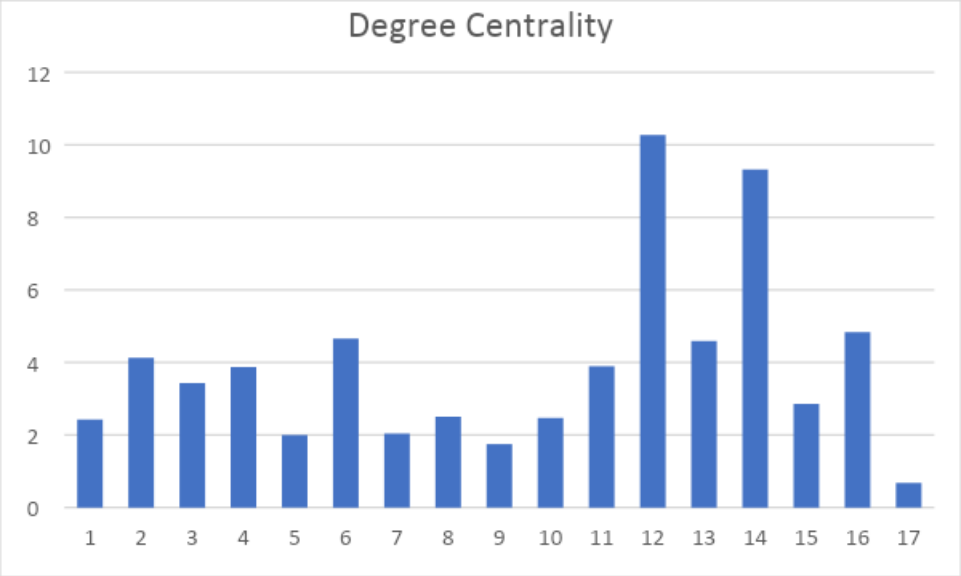

Figure 3. Distribution of degree centrality score among the 17 nodes.

Closeness Centrality

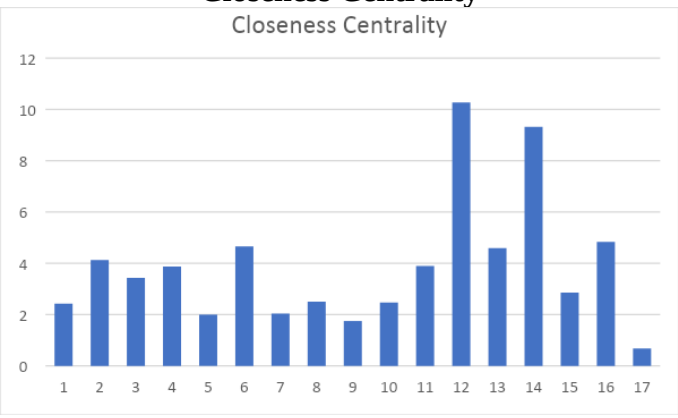

Figure 4. Distribution of the closeness centrality score among the 17 nodes.

Discussion

The accessibility of a certain node or building is crucial for future events, to attract more audience. From this study, it is found that the most accessible point or node in

USIM is the Bulatan Iqra'. This is logical as this point is the most passed point in USIM. Visitors will need to pass this iconic landmark after entering the main gate to go to other points in the university. However, this point is not ideal to do large scale events as it cannot hold a lot of people at a time. For future event planning, that requires a lot of audience, the university management can try to conduct events in between the second, third and fourth most closeness-centralized nodes, namely the Chancellery, Library and Islamic Centre. Plus, there is a lot of space between those 3 points, enabling it to hold a lot of audience. This makes the area between those 3 points as the most ideal place to conduct large-scale events that need a lot of audience. In terms of a node's total number of connections and strength, Islamic Centre is the most central node. As a node's strength is defined by the sum of the reciprocal of the weight of the edges, this also means, nodes with lighter connecting edges has higher degree centrality score as compared to nodes that has heavier connecting edges. So, the node with the highest total of connection and strength is node l, Islamic Centre.

CONCLUSION

The study concludes:

1. The shortest path that connects all nodes in USIM is the Minimum Spanning Tree (MST), obtained by using the Kruskal's greedy algorithm.
2. The longest path that connects all nodes in USIM is the Maximum Spanning Tree (MaxST), obtained by using the Kruskal's greedy algorithm.
3. The most important node in terms of node's strength and total of connections is node l (Islamic Centre).
4. The most important node in terms of accessibility is node f (Bulatan Iqra').

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