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Centrality Measures to Identify Traffic Congestion on Road Networks: A Case Study of Sri Lanka

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Abstract: *This study presents a graph theoretical approach to identify the traffic congestion on a road network. Problem address on a city called Kiribathgoda situated in the western province of Sri Lanka. In the analysis of social networks, centrality measures played a vital role to identify the central nodes in a given network. We look at the applicability of centrality and betweenness measures in order to identify the most important locations which directly affect to the traffic congestion in road networks in Sri Lanka. Using the graph theoretical approach a traffic network for a selected area was constructed and several centrality measures were calculated. According to our simulation results, it was noted that the practically identified locations could be identified from the simulations carried out using the centrality measures.*
Keywords- *Centrality Measures, Betweenness Measures, Road Network, Graph, Traffic*

I. INTRODUCTION

Traffic congestion has become a major problem that affects many human activities on a daily basis, resulting in both serious of transportation delays and also environmental damages. Therefore identifying the junctions of roads which directly involve in traffic congestion would be helpful to design the road networks. Since massive financial and man-hour loss due to traffic congestion, it becomes a major issue for all of us to analyze the traffic networks. In order to control traffic congestion, it is essential to understand the development of traffic flows. Many relations in real world problems can be represented by graph networks, in which the data are represented by nodes and the relationship between nodes are represented by links. Web graphs, internet graphs, communication networks, biological networks such as food web are some of the examples of the existing networks [1]. One of the main goal of network analysis is to determine the most important nodes in a given network. Several measures of importance have been studied in the literature to quantify how much a node is important. The objective of this problem is to identify the most important locations in the network and design the routes in order to control the traffic congestion. Most authors have been analyzed road networks from the viewpoints of shortest path, cost minimization etc. In 1995, Yang. H. et.al, introduced a model for determining traffic assignment and optimizing signal timings in road networks [2]. In [3], the relationship between centrality measures and the density of traffic for some simple particle hopping models on networks was identified with emerging scale-free degree distributions. Network representation was used to analyze the patterns in a street [4]. An efficient algorithm to find the shortest route between two nodes of a large scale, time-dependent graph were developed on road network [5]. Cut-set of a graph were used to find the optimal control of the traffic system [6]. However, centrality measures were considered by very few authors to analyze the traffic flows. We used centrality measures to analyze one way road network constructed for small area in Sri Lanka [7]. In this study, we use the centrality measures to analyze the congestion on the two way road networks in Sri Lanka based on directed graphs. Advantages of centrality measures are that it can provide a useful measurement to identify the importance of nodes, intersections and also relation between road segments. In order to test the validity, we construct a road network using most possible number of routes which covered an area between Thorana junction and Kiribathgoda junction. Constructing two networks as undirected graphs based on one way routes from Thorana junction to Kiribathgoda junction and Kiribathgoda junction to Thorana junction, we construct a large directed network which represent the actual road network near Kiribathgoda city. This study is based on four centrality measures named Degree, Closeness, Betweenness and Eigenvector, which are mainly used to analyze the social networks such as food web, internet graphs, and biological networks etc. These measures are used to compute the centrality of road networks. By considering centrality measures, we could identify the most important nodes and the road segments in our road network. It could also be verified that our computed centrality measures are useful to identify the traffic congestion in our road network. Correlation analysis to compare the shortest path betweenness and random walk betweenness were also carried out. Clustering analysis of the networks are useful to identify the distribution of the road networks and measure the density of the traffic.
The rest of the paper is organized as follows. Definitions and notations of the centrality measures are given in Section 2. The methodology is outlined in Section 3 and the implementation results are discussed in Section 4. Finally, the conclusion is stated in Section 5.