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Shortest Path Performance Within Real Road Network: Case Study in Malaysia

Rohaizan Ramlan, Alina Shamsuddin and Faiz Shamsuddin

Universiti Tun Hussein Onn Malaysia, Malaysia

Abstract: The performance of shortest path algorithm has been tested in many researches. However, in most of the testing on shortest path algorithms have been based on randomly generated networks, which may not have the characteristics of real road networks. The purpose of this exploratory study is to identify the performance of shortest path on Malaysia's road network. In this paper, set of shortest path algorithms has been evaluated using a variety of real road networks. Visual basic platform via various types of computers has been adopted to evaluate the algorithm. The run time is collected to obtain the result. Based on the result, Floyd-Warshall has produced the best running time for real road network.

Key words: Graph, Network and Shortest Path.

INTRODUCTION

Shortest path has frequently been used on daily basis activity such as a journey between two locations, whether walking from room to room, from one route to another or from city to city. The performance of shortest path algorithm has been tested in many researches, to name a few (Cherkassky et al. 1993) and (Zhan And Noon, 1998). Through shortest path method the path which could save time and cost can be identified. Even though shortest path calculation is the main objective in most transportation system and network analysis, it is hard to find one shortest path network algorithm for real road network. This is due to the fact that most of the research utilized randomly generated data. Most importantly, none of the algorithm being produced by the researchers can be utilized to prepare the best algorithm and can overcome the arising problem occurred during the calculation on the real network (Yen, 1975).

Zhan end Noon (1998), has conducted a research on the related matter regarding the most suitable shortest path network method with the road structure in the United State of America. They found that the modified Djikstra is the most suitable method with this network. This exploratory research has been conducted in order to calculate the shortest path running time utilizing real road data of the State of Johor and Malacca. There are a few considerate matters in this research as assumption; which is the tested data did not take into account the negative path in the network structure. Other than that, the network has a directed path from a node to all nodes in the network range. Thus the network has two ways directed path. Lastly, obstructions in the network such as traffic light, traffic jam and damaged road factor has not been considered.

This paper is organized as follows. Literature review provides some definition and background of real road network, shortest path, node and arc also the running time. Data analysis details the running time and result. While the conclusion section, concludes the paper with some recommendations.

MATERIAL AND METHOD

Road Network of Johor and Malacca State:

The road in Johor and Malacca generally can be divided into three which is highway, federal road and state road. Highway is the road being constructed by the government or being privatized to other party. The user of this road will be charged with a payment being known as toll. Federal road is the road which has been declared in the Federal Road Ordinance (1959). State road is the main road which connects every district's administration centre in each state. The highway marking system is the combination of E alphabet and number such as (E5). For the federal road, single numbering system has been used such as 1, 3, 50 and 76. While for the state road, the marking system is the combination between the alphabetical recognition of the state with numbers such as (J11). The marking of the roads begin from the state of Johor.

Table 1 presented the relation between the number of arc and node together with the arc ratio per node for each state. The ratio of the arc per node indicated the difference of ratio value between the artificial road networks with the real network of roads (Zhan end Noon, 1998). The real road network has the arc per nod ratio value in the range of 3.45 until 9.16. Different value took place in the artificial road network where the arc per nod ratio value was higher with the value of higher than 10.00 (Zhan end Noon, 1998).

Corresponding Author: Rohaizan Ramlan, Universiti Tun Hussein Onn Malaysia, Malaysia
E-mail: rohaizan@uthm.edu.my

Table 1: Summary of path data of Johor and Malacca.

State	No. of Node	No. of Arc	Arc/Node ratio
Johor	146	339	2.32
Malacca	50	143	2.86
TOTAL	196	482	2.45

Shortest Path:

There are two types of shortest path which is Single-source shortest path and All-pair shortest path. Djikstra is an example the Single-source shortest path algorithm. In the meanwhile, Floyd-Warshall algorithm is an example of All-pair shortest path with a matrix concept.

Network:

Generally a network usually being visualize in the form of graph (http://www.ncgia.ucsb.edu). Graph is a set of dots and the relation between these dots. The graph can be divided into two which is digraph and non directed graph. The direction of the arc for the non directed graph can be considered in both directions, while the arc of the digraph has direction (Mustafa, 2003).

It also can be categorized into weighted and non weighted graph. For the weighted graph, every node has its own related weight. The weight can be positive or negative or only negative weight. Weight also can be referred as distance, cost or duration of journey (Mustafa, 2003).

Graph can also be categorized into a few group of graph such as planar graph, acyclic graph, strongly connected graph and two sectioned graph (Mustafa, 2003).

Nodes and Arcs:

Node represents the circle in the graph (Douglas, 2001). Node is usually being marked with alphabet or number to differentiate each of it. In the calculation of distance, node refers to the source or destination in the particular graph.

Arc represents the path which connects two nodes. Arc has an arrow to show the direction of the path. Weight mark for the arrow of the arc can be positive or negative. There is also arc with no arrow. This can be translated into a path that can be passed with two different directions.

Running Time:

Running time will be produced utilizing a few types of computers to compare the result. Among the used computer is laptop, personal computer and lab computer. The computer specification for the test is different based on the brand, central processing unit, processor, RAM and hard disk. Based on this, there will be variations in the running time result which contributes towards a solid proving towards the analysis of the computers' appliance which produces the best running time.

Selected Method:

There are a few algorithms which can be adopted in order to solve the shortest path problem. The selected algorithms are Djikstra and Floyd-Warshall (http://www.ncgia.ucsb.edu). This selection has been made due to the fact that this method is well-known, widely used and easy to use.

Djikstra Algorithm:

Djikstra algorithm is a type of algorithm which manipulates Prim and Breadth-First Search (BFS) algorithm. It is better known as first shortest path (SPF). Djikstra calculate the shortest distance of a pair of node (James, 1990). Djikstra applied the greedy method which uses a simple solving method which looks for the shortest distance from one node to another by choosing the nearest vertices. In order to calculate the distance of different node, the same calculation principle will be repeated. It is the simplest algorithm in solving the shortest path problem. This algorithm cannot solve the negatively valued weight (no path) and if such weight exists, the given solution will be infinity.

All nodes being marked with distance from the source of node as a temporary value. Then the node with the smallest distance value will be expended and it will be grouped permanently. Updating of the distance value will be made after new node has been found and this process will continue until there are no more nodes left in the particular graph (http://www.ece.nwu.edu).

Floyd-Warshall Algorithm:

Floyd Warshall algorithm has been designed to solve the problem of all-pair shortest path for a graph with a negative value (http://www.ece.nwu.edu). It is a type of algorithm which gives the cost matrix and special path matrix in order to reduce the calculation on the arcs and large data storage (Mustafa, 2003).

This algorithm connects any node on the graph and it then can be chosen as the source node and the present source node will be made as the destination node. In this method, two matrix in the form of n X n will be de-

fined which is the weight matrix (d_{ij}) and shortest path matrix (sp_{ij}).There will n iteration which have to be done on both of the D matrix and the SP matrix.

The programming software which has been used to count the running time is *Microsoft Visual Basic 6.0*. On the other hand, *Microsoft Access 2003* has been used as the data base which stores the node, path between two nodes and distance value for the path.

Results:

Running time is the calculation which involves the generated shortest path algorithm process. The starting and the finishing time for the algorithm to solve the calculation have been collected. Then, the total calculation will be calculated until millisecond.

The running time verification took place on different set of computers with different specifications in order to see the variety in the generated running time.

For the laptop, the used brand is *Compaq Presario 2200*. This computer has a central processing unit of *Intel Celeron M*, 1.40 Ghz processor, 224 Mb *RAM*, and 15 Gb hard disk. The balance of the free space in the hard disk is 11.2 Gb.

While for the personal computer, *HP Pavilion mx704* was used. This computer uses *Intel Pentium 4* processor, computer processing unit of 2.60 GHz, 248 MB *RAM* together with 30 Gb hard disk left with 22.5 Gb of free space.

For the lab computer, *Fujitsu* brand was used. This computer was connected with LAN (*Local Area Network*). This computer also has a *RAM* value as much as 124,520 Kb, and 14.6 Gb hard disk with 4.79 Gb of free space.

The tables and diagrams for the generated resulting process have been arranged starting with the Floyd-Warshall method, followed by the Djikstra method.

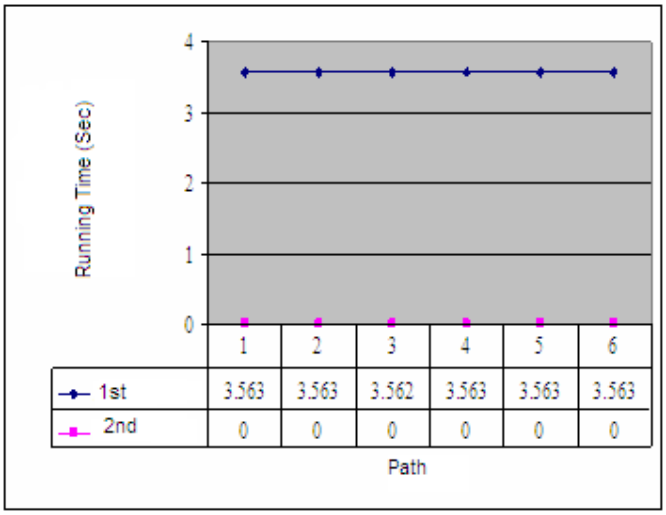

Fig. 1: Relation of running time for *Floyd-Warshall* method.

Figure 1 indicates the graph of the running time relation with path. The running time for Floyd-Warshall decrease after the first generation for each path in the first run. The second run and the subsequent run has resulted in a zero value. This is because, for the Floyd-Washall method, the quest for the algorithm incorporates all nodes in the network of the first run. As a result, for the following run, the distance and the shortest path between any nodes automatically achieved.

Figure 2 shows the graph of the running time relation for the *Bellman-Ford* method. The graph indicates a constant running time for the first and subsequent run. This is due to the fact that the Djikstra method look for the shortest path based on node per node.

The running time between the different shortest path methods for the overall data (196 nodes) has been generated. For the *Djikstra* method, the running time is 6.076 second. On the other hand, the *Floyd-Warshall* method has produced the shortest running time of 3.546 second. It is clear that the Floyd-Warshall method is the method which produced the best running time for the data set of the Johor and Malacca State.

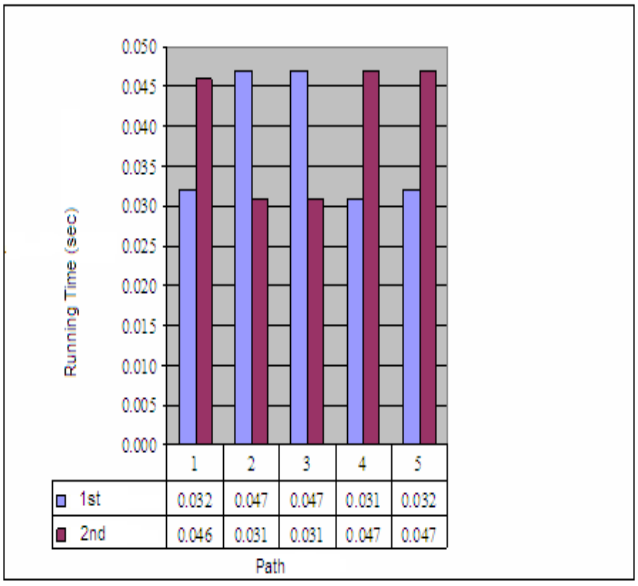

Fig. 2: Running time relation for Djikstra method.

Table 2: Comparison of the shortest path methods.

Method	*Djikstra*	*Floyd_Warshall*
Path		
Johor Bahru – Skudai	0.031	3.546
Johor Bahru – Muar	0.031	0
Johor Bahru – Mersing	0.031	0
Merlimau – Batang Malacca	0.015	0
Johor Bahru – Bemban	0.047	0
Johor Bahru –Batang Malacca	0.047	0

Conclusion:

The analysis indicated that, the utilization of the Djikstra method in the road network of Johor and Malacca is not encouraged. Based on the conducted analysis, the Djikstra method gave the longest running time for the 196 nodes which is the total node for Johor and Malacca. With the increasing number of nodes in the road structure in the future, the Djikstra method is no longer relevant.

Floyd-Warshall method has been shown to produce the best running time. With this, it has proven that the Floyd-Warshall method is the best shortest path method based on the running time parameter. Hence, a more in depth research is needed in proving that the Floyd-Warshall is the best in term of the road network in Malaysia.

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