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DECISION SUPPORT SYSTEM FOR FINDING THE SHORTEST PATH FROM ABUBAKAR TAFAWA BALEWA UNIVERSITY TEACHING HOSPITAL BAUCHI TO ANY DESTINATION WITHIN BAUCHI STATE METROPOLITAN USING DIJKSTRA ALGORITHM

***ABDULLAHI MIKAIL; *ZAKKA BENISEMENI ESTHER; *MBIMI NASU WORMI; **OKORE SOPHIA KINGSLEY; & *SANUSI ABDULHAMID DANTATA**
**Computer Science Department, Federal Polytechnic Bauchi, Bauchi State. **Computer Science (General Studies) Department, Maritime Academy of Nigeria, Oron, Akwa Ibom State*

Abstract

Finding the shortest path on uncertain transportation networks is a great challenge in theory and practice. There are several resources of uncertainty in the transportation networks such as traffic congestion, weather conditions, vehicle accidents, repairing roads, etc. The shortest path is an issue that involves the route from one point (nodes) to another. It is to find a path with a minimum travelling time. Nowadays, traffic problems have affected many transport users, especially in the Bauchi State Metropolitan area. The time wasted on the road causes a lot of problems for the users. Furthermore, the costs between the two destinations are rather expensive. Therefore, the inability of users to use the shortest path has attracted the researcher to propose several travel alternatives to overcome this problem. Consider Abubakar Tafawa Balewa Teaching Hospital Bauchi (ATBUTH) which is specialized in general medicine. To provide fast and efficient patient care services at minimal time and costs, medical ambulances need to be dispatched promptly to emergent calls from the public. The objectives of this research are to find the shortest path from Abubakar Tafawa Balewa University Teaching University Bauchi to any destination within Bauchi State Metropolitan and to cut down the cost between these two destinations. The time of the shortest path problem and the *cost problem are drawn together. Moreover, the Dijkstra algorithm is applied to find the shortest path. The shortest path is calculated by using Djikstra Algorithm, JavaScript and Google API. Nevertheless, both the time and cost of the shortest path are constructed in the same paths. The time and cost of the journey are described by driving a car from Abubakar Tafawa Balewa University Teaching University Bauchi to any destination within Bauchi State Metropolitan*

Keywords: *shortest path, Decision support system, Dijkstra algorithm, cost, time.*

Introduction

Traffic problem has affected transport users. This is because of the time wasted on the road. Although the number of road and expressway is increasing, traffic problems in Bauchi State Metropolitan area are growing. The shortest path is a problem that involves the route from one point (nodes) to another (Kumari & Geethanjali, 2010).

It is to find a path with a minimum travelling time. It is important for every passenger especially workers who need to arrive at their workplace on time. For instance, to improve the effectiveness of travelling time, there is a need to provide some rational alternatives that can cut down the time of one's journey. Furthermore, the shortest path is also used to minimize the cost (Gupta et al., 2016).

Travelling is part of daily life. The Shortest path (SP) to the given destination, therefore, becomes inevitable to minimize costs, losses in productivity, pollutions, risks etc. The shortest path problem history is difficult to trace back. One can imagine that even in very primitive (even animal societies), finding the shortest paths (for instance, to food, colony) is essential. In the past, when drivers encountered traffic congestions/delays on the road network, they had to queue up and wait until the congestions clear off before continuing in their journeys, but not so today. In recent times, technological advances in operational research and information technology have engineered a new thought to traffic management and control systems using several shortest path/path-finding algorithms e.g. Dijkstra, Bellman-Ford, A*, Floyd-Washall, Backwardrecursive etc. to evaluating the shortest/fastest path en route embarkation. Patel et. al., (2014)

However, to tackle real-life transportation problems today, the problems are reduced to simplified mathematical routing models (i.e. operations research models) embedded in various decision support systems such as Tora, Lingo etc., which can be solved iteratively oftentimes. These decision support systems use dynamic programming principles (that breaks complex tasks into simpler tasks easily solvable). This study illustrates the development of a simple application that runs on a dynamic programming principle to show the relevance to the decision support system of finding the shortest path to a destination in a road network. Arjun et al. (2015).

Bad roads are critical problems experienced daily on our road networks most especially in the urban areas, and thus influences the travel time of vehicles/productivities in cases like ambulance calls, fire service calls, armed robbery attack calls, quick calls for stock supplies at business supermarkets/warehouses etc. The shortest/fastest path to the destination hitherto being inevitable to minimize these costs, losses, risks etc. The shortest path problems use dynamic programming technology/methodology (i.e. breaking down complex tasks into simpler easy tasks to solve) to finding the shortest path to the destination (Kumari et. al., 2010).

There are different types of shortest path problems namely: The shortest path from a node to a node, the shortest path from a node to many nodes, the shortest path from many nodes to a node and the shortest path from many nodes to many nodes in some other few instances. In some applications, the shortest paths between two nodes are not necessarily a direct edge but a detour through other traversals. Again, one might require not only the shortest path to a destination but a second and third shortest path depending on the given occasion/problem (Chandak et. al., 2016).

Dijkstra algorithm has been used in general. It is a variant to find the shortest path between two nodes but is a more common variant which fixes a single node as it is the source of the node and finds the shortest path from the sources to all the nodes. Dijkstra algorithm builds the optimal path based on the node that it reaches. However, it cannot handle the negative edges (Kai et al., 2014).

The main objective of this study is to find the shortest path from Abubakar Tafawa Balewa University Teaching Hospital Bauchi (ATBUTH) to any destination within Bauchi metropolis by using Dijkstra's algorithm and to cut down the cost between the two destinations. It will concentrate on all roads that start from Abubakar Tafawa Balewa University Teaching Hospital Bauchi to any destination within Bauchi metropolis that will give the shortest distance and the lowest cost of the journey. It will consider several roads that will be chosen as the best road to meet the objective. Data is collected from Google API.

RELATED WORK

Arjun et al. (2015) stated that the shortest path problem is a problem to find the vertices between the sources on the graph. Engineers usually use Dijkstra's algorithm in their calculations. This survey has stated an optimization method that mostly enhanced the nodes selection of the shortest path and data structure and organization. In brief, the optimized Dijkstra's algorithm which has advanced space complication, time complication and storage combination, decreases the storage space, data redundancy and hugely increases the running rate.

Tirastittam and Waiyawuththanapoom (2014) did a case study on a Bangkok metropolitan public transport planning system using Dijkstra's algorithm. The research was about the public transport planning system, using Dijkstra's algorithm, focusing on buses, Bangkok Mass Transit System (BTS) and Metropolitan Rapid Transit (MRT) schedules because the citizens lack information and they are scared to use the subway system mainly because of the time and safety factors. The researchers' objective was to design a public transportation planning system by using Dijkstra's algorithm in the Bangkok area to judge the public transportation users' satisfaction. One of the research by Patel and Chitra Baggar (2014) was a survey of the Bellman-Ford algorithm and Dijkstra's algorithm to search for the shortest path in Geographic Information System (GIS) application. The researchers wanted to make a comparison between the Bellman-Ford method and Dijkstra's method and choose the best one. The main problem in transportation management is finding the shortest path and using the act of Geographic Information System (GIS). The conclusion made by the researchers is that Dijkstra's algorithm is very quick to use compared to the Bellman-Ford algorithm and it also works widely in real-time applications.

According to Ahuja et al (1993), shortest path problems lie at the heart of network flows and its study is a natural starting point for introducing many key ideas from network flows. Researchers have studied several different types of (directed) shortest path problems:

i. Finding shortest paths from one node to all other nodes
ii. Finding shortest paths from every node to every other node
iii. Various generalizations of the shortest path problems etc.

Pathfinding Algorithms

A path-finding algorithm at its core is an algorithm that searches a graph by starting at one node, exploring adjacent nodes until the terminal node is reached, generally with the intent of finding the shortest path. Pathfinding algorithms are associated basically with two problems namely:

i. Finding an optimal path between two nodes in a graph and
ii. Finding the optimal shortest distance apart.

Although graph searching methods such as breadth-first search would find a route if given enough time, other search methods such as depth-first, binary search etc which explores the graph, would tend to reach the destination node sooner. Recently, some major work was done by Cherkassky (1996) where about seventeen algorithms were thoroughly evaluated using several simulated networks with various degrees of complexities/constraints. The results suggested that there is no single algorithm that performed consistently well in all the simulated networks (Zhan, 1993). Since the early 1980's every pathfinding/vehicle routing system were seen as a decision support system (DSS) due to its links to the database management system to organize large amounts of data (e.g. customer-specific orders, size of vehicle fleet etc) and the use of a visual interface needed to support problem-specific decisions (Tarantilis, 2002).

Shortest Path Algorithms

The shortest path algorithm generally is an algorithm that searches for the optimal minimum path/distance from the start location to the destination. At the broadest level, shortest path algorithms can be classified into three taxonomic categories:

i. The type of shortest path problem being solved e.g. single source to all nodes and the all-pairs SP problem
ii. The input to the network e.g. whether the network is sparse/dense, planar/non-planar, positive/general edge weights, grid/general structure etc
iii. The solution methodology e.g. labelling and label-correcting.

Since 1957, considerable progress has been made after Minty published his paper Minty et al (1957) on "A comment on the shortest route problems"; this progress includes major papers published by Bellman (1958), Dijkstra's (1959), Moore (1959), Dreyfus (1969) amongst others. Minty succinctly described the basic shortest path problem for symmetrical networks as a network that for every pair of nodes the cost of a link between the two nodes is independent of the starting node. To state the shortest path problem beyond doubt, Minty graphically showed/suggested constructing a model of the network, made of strings, each string of the length being proportional to the costs of the modelled link. To find the links of the shortest path, one has to pull the source and terminal nodes of the journey as far away as possible. The tight strings are the links of the shortest path (Ireneusz, 2000). Recently, Zhan and Noon (1996) investigated three algorithms:

i. The graph growth algorithm implemented with two queues,
ii. Dijkstra's algorithm was implemented with approximate buckets, and
iii. Dijkstra's algorithm was implemented with double buckets.

Their studies showed that in real road networks that these algorithms have advantages over each other depending on which input e.g. 1-to-1 or 1-to-many etc shortest path problems are being considered.

DESIGN

The shortest path cannot cross all the vertices. It needs to search for the shortest path from vertex sources to all vertices and then calculate the path between the vertices that are attracted to. Due to its simplicity, it only deals with graphs with non-negative edges. It is often advantageous to route all communication on a sparse spanning sub-network, typically a spanning tree. Unvisited vertices are consistently on the list. It selects a vertex and allocates the maximum possible cost for each of the other vertexes. In each of the following steps of the Dijkstra algorithm (**Error! Reference source not found.** shows a flowchart of the algorithm), it attempts to reduce the cost for every vertex. The cost will be the length of the journey, time taken to achieve that vertex from the source vertex or money. The minimization of cost is a multi-step procedure shown in the steps below:

Step 1: assign to every node a tentative distance cost: set it to zero for our initial node and to infinity for all other nodes.

Step 2: mark all nodes "temporary". Set the initial node as "permanent". Create a set of the "temporary" consisting of all the nodes of the network except the initial node (i.e. permanent).

Step 3: for the current (i.e. permanent) node, consider all of its "temporary" nodes and compute their tentative distance costs. Even though a node has been examined, it's not marked as "permanent" at this time, and it remains in the "temporary" set until all nodes have been examined and the least costs determined.

Step 4: when all the nodes of the current node are checked, mark the current node as "permanent" and remove it from the "temporary" set. The "Permanent" node will never be checked again.

Step 5: if the destination node has been marked "permanent" (when planning a route between two specific nodes) or if the smallest tentative distance cost among the nodes in the "temporary" set is infinity (when planning a complete traversal), then stop/terminate. The algorithm has finished, otherwise, continue.

Step 6: Select the "temporary" node, marked with the least tentative distance cost, and set it as the new "permanent node" and go back to step 3.

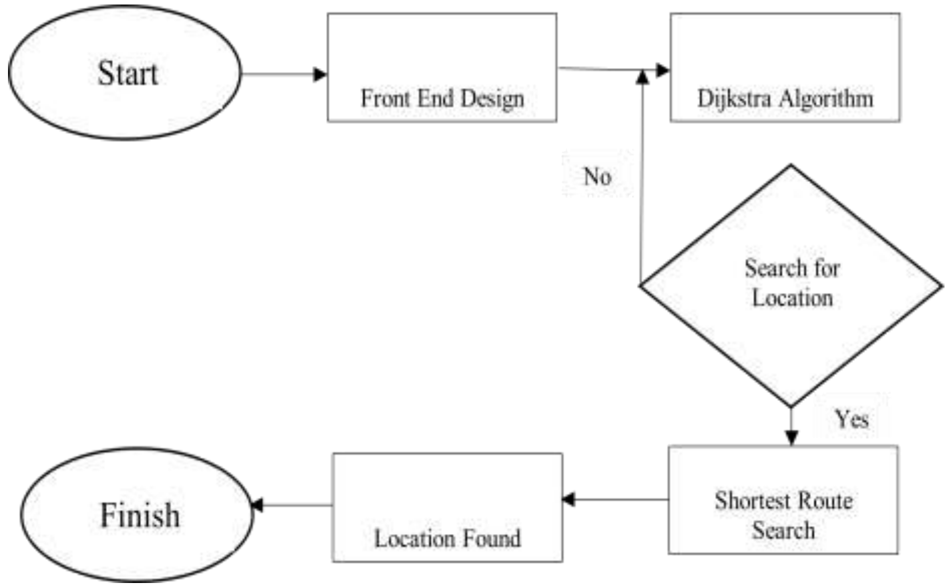

Figure 2 Shortest Route Search Methodology

The Decision Support System was built to find the nearest route from the user. Improved Dijkstra's algorithm has been used as a part of the proposed system to provide the shortest path. The architecture of the proposed system is in **Error! Reference source not found.**. Dijkstra's algorithm is used to find the shortest path between source and destination.

The developed system is a web-based and mobile application design to help users in making fast decisions when embarking on a trip by road. The application users Google API to track the possible road/route that can lead to the destination of the users and gives the best and shortest path that the users can track to be able to arrive at his/her destination within the shortest period. The API request will take the user request and return feedback showing details of all possible routes. To find the shortest path from Abubakar Tafawa Balewa University Teaching Hospital Bauchi (ATBUTH) to any destination within Bauchi metropolitan by using Dijkstra's algorithm and to cut down the cost between the two destinations. It will concentrate on all roads that start from Abubakar Tafawa Balewa University Teaching Hospital Bauchi to any destination within the Bauchi metropolitan that will give the shortest distance and the lowest cost of the journey. It will consider several roads that will be chosen as the best road to meet the objective. Data is collected from Google API.

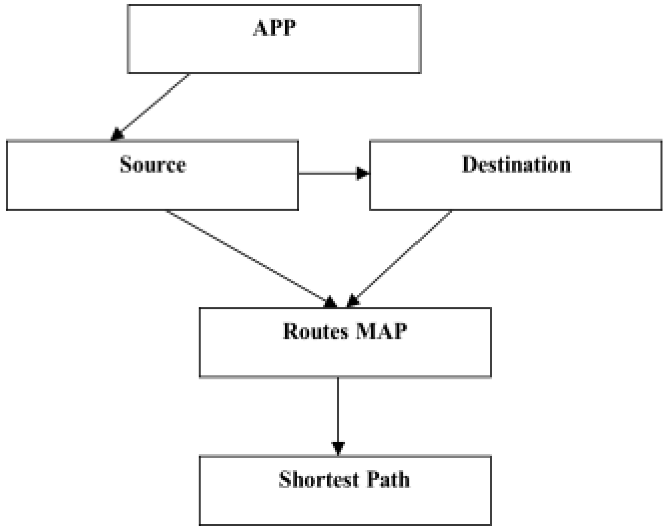

FIGURE 3: SYSTEM BLOCK DIAGRAM

Interface System Design

At this stage, the system interface is designed to interact between the user and the system. This stage is very important because a good interface design will make users feel comfortable in using a computer application. Figure 4 illustrates the pathfinder that can enable us to capture between source and destination

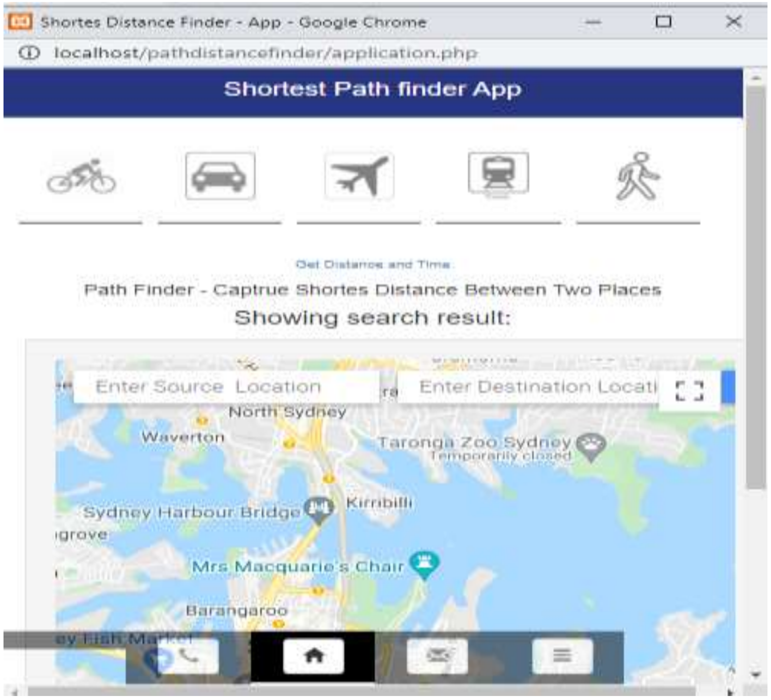

FIGURE 4: PATHFINDER

EXPERIMENTAL RESULT

In comparison to the input, the process and the output of this research work. The recruitment is done based on the multiple criteria decision making. Figure 5 illustrates the resulting output of the developed system, with a different route from Abubakar Tafawa Balewa University Teaching Hospital Bauchi to Reemee Medicare Hospital Bauchi.

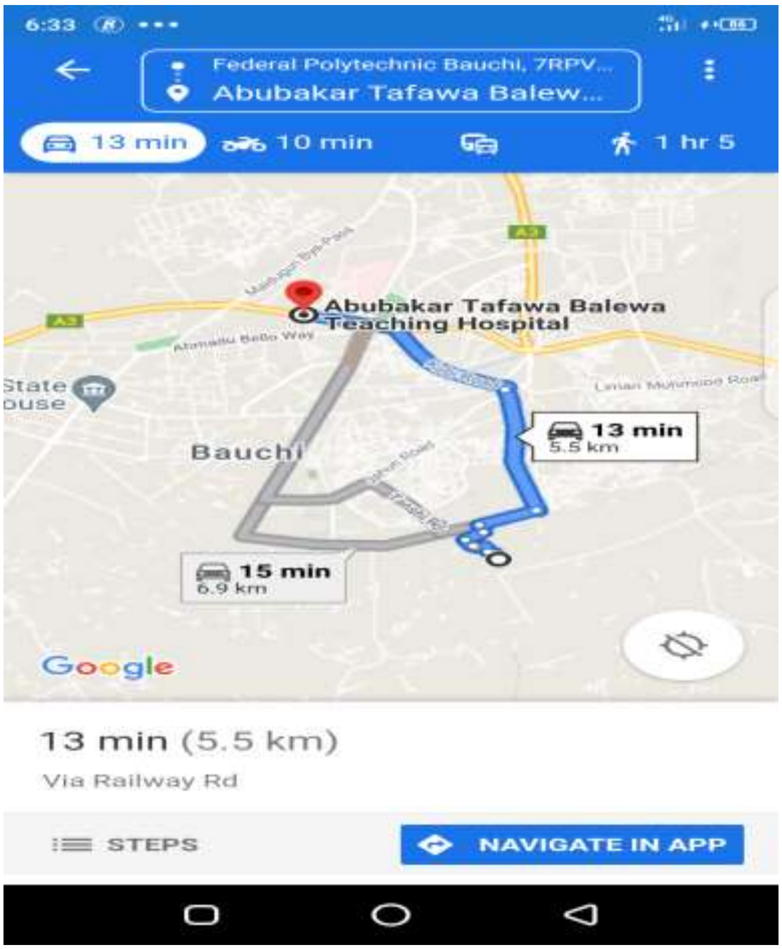

FIGURE 5: THE RESULTING OUTPUT OF THE DEVELOPED SYSTEM

Discussion

The test was successful: using the developed system we were able to find the shortest path from Abubakar Tafawa Balewa University Teaching Hospital Bauchi to Reemee Medicare Hospital Bauchi, in table 1 below, we were able to find two routes that will lead us to Reemee Medicare Hospital Bauchi with the following distance and time.

Table 1: Result of the shortest path from Abubakar Tafawa Balewa University Teaching Hospital Bauchi to Reemee Medicare Hospital Bauchi

Route	**Distance**	**Time**
1	5.5km	13min
2	6.9km	15min

CONCLUSION

Based on the results, it shows that the main objective of this research has been met. The goal of this research is to optimize the path by limiting the maximum detour and cost from Abubakar Tafawa Balewa University Teaching Hospital Bauchi (ATBUTH) to any destination within Bauchi metropolitan. The method that has been used is the Dijkstra algorithm. Therefore, the path can be chosen either for the shortest time and the cheapest cost.

Thus, the usefulness of this decision support system for finding the shortest path to a Destination within a road network cannot be over-emphasized. In this research, Dijkstra's algorithm was applied to evaluating the late arrival of the medical ambulances and as such providing necessary decision makings required at the moment. The software deployment was simple and easy to use by even a novice due to the user-friendly interface.

This research needs to be continued as it can get a better path. Moreover, other researchers can continue this study by using a different method other than the Dijkstra algorithm since it may produce a different result. In addition, other researchers can also continue this study by using a different path or a different destination. Furthermore, new researchers can also add a lot of vertexes as it can be more efficient to find the shortest way

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