Items-mapping and Route Optimization in a Grocery Store using Dijkstra's, Bellman-Ford and Floyd-Warshall Algorithms

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***Abstract*— The study applies three shortest-path-finding algorithms namely Dijkstra's, Bellman-Ford and Floyd-Warshall Algorithms into a grocery store to provide users the shortest path to be traversed by the user while getting the items on their grocery list. The application created is a server-client-based system with the client being an application installed in an android tablet while the server application is a C# program based on Microsoft Visual Studio Environment. The path lengths provided by the three algorithms are equal for most instances but they differ on computational time based on different number of items in the list. Actual tests were conducted in a grocery store and the time spent to buy, distance travelled by the user and steps taken have all been reduced after using the application.**

Keywords: Dijkstra's, Bellman-Ford, Floyd Warshall, server-client based, item mapping, grocery store

I. INTRODUCTION

Nowadays, groceries allow customers to use two types of shopping lug: a basket and a cart. The shopping cart is more preferred by the customers because it is easy to navigate by just simply pushing or pulling. New items are frequently introduced and the customers are having hard time finding the exact location of their desired items and they spend more time roaming inside the store.

The study will focus on the use of three techniques: Dijktra's, Bellman-Ford, and Floyd-Warshall. With the use of the WiFi technology and Android SDK (Self-Development Kit), the computed shortest-path processed by each algorithm will be mapped and displayed on an Android Tablet.

The proposed study intends to help the shoppers locate the items provided in their clear list of items to purchase. When the android application is installed in their smart phone, shopping will be much easier and more efficient.

II. RELATED WORKS

In Dijkstra's algorithm, the cost is assigned with respect to the characteristics of the edge to be traversed in the algorithm's application. It is one of the most effective graph algorithms that can be modified in solving various problems. Its common applications include network routing protocols such as Open Shortest Path First (OSPF), BGP, and RIP, traffic information systems, and logistics distribution lines [1].

In solving a shortest path problem, the Bellman Ford algorithm can be used to compute the cost of the cheapest paths from a single source vertex or node to all other nodes in a weighted directed graph. Unlike the Dijkstra's algorithm, Bellman Ford algorithm can deal with negative edge weight and cycles in a graph, hence it is more versatile to practice, and it has a simple analysis and best theoretical running time [2].

Floyd-Warshall is a technique that takes advantage of overlapping subproblems, optimal substructure, and trades space for time to improve the runtime complexity of algorithms. A single execution of the algorithm will find the shortest paths between all pairs of vertices [3]. Other applications for Floyd-Warshall Algorithm are Bipartiteness, Minimax, Maximin and Safest path.

III. METHODOLOGY

1. Database

The proponents modelled the map based on a typical grocery layout. The database of items under their respective categories is made through ocular inspection. By subdividing the grocery store, the floor plan is simplified into 20 shelves with 4 vertical and 3 horizontal isles.

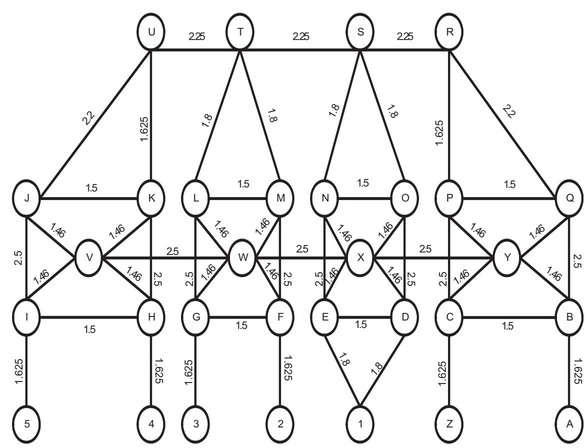

Fig.1. Weighted Graph

The assigned weight on each edge of the graph is the normalized actual distances between the neighboring shelves. (See Fig.1) The researchers used a pedometer and walked through the grocery store while taking note of the shelves' location and its neighbors within the store.

The database is embedded on the android application created. The application identifies under which categories do the chosen items of the user falls under and the category is flagged and its representation is added to the data string which will then be sent to the server for processing.

2. Optimization Techniques

Dijkstra's Algorithm finds the shortest path from a single node to another node which may include all other nodes in the

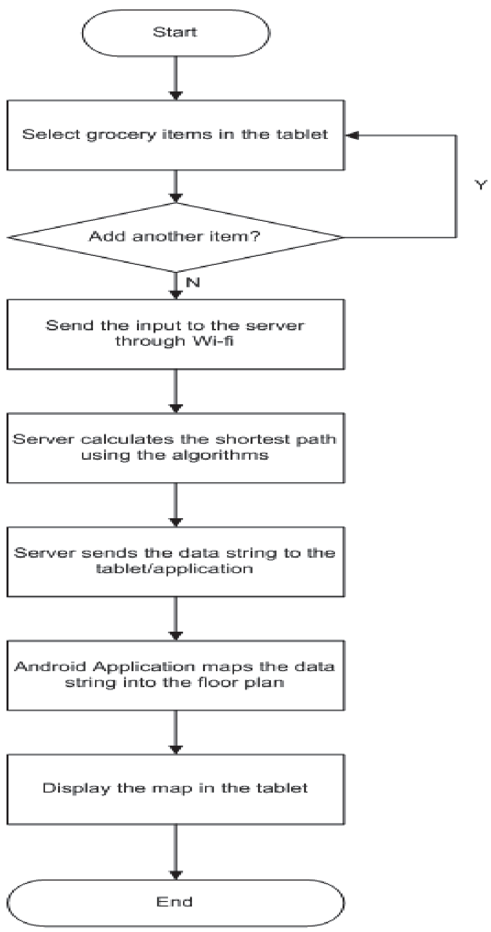

Fig.2. System Flowchart

weighted graph. Its steps include assigning of the current node, labelling its weight, finding the current node's neighbors and its edges' weights (distance or cost), comparison of costs, labelling the lowest cost node as a permanent node and as the new current node [1].

Bellman ford algorithm's structure is similar to Dijkstra's algorithm but only differ that Bellman-Ford algorithm can solve the single source shortest path problem in general case in which edge weights can be negative. If a negative cycle exists or not, it returns the value and the shortest path[4].

Floyd-Warshall algorithm is a dynamic programming formulation, to solve the all-pairs shortest path problem on directed graphs. It finds the shortest path between every pair of vertices in a graph and it also finds only the lengths not the path[5].

3. Evaluation

The three algorithms, Dijkstra, Bellman-Ford and Floyd-Warshall will be used to generate the shortest path to traverse the store with respect to the selected items of the user. The three techniques will be programmed in the simulator and the results will be compared.

Criteria for choosing the applicable optimization technique:

1. Length/Cost. It is the total distance computed by the algorithm. The shortest distance needed to cover the items selected in the shopping list.

2. Computational Time. It is the total time to process the computation of the shortest path's data string.

The optimal result to the grocery cart will be applied. In determining the optimal and efficiency of the result, the shortest length and fastest computational time is the basis.

There are simulations of the three optimization techniques for items less than 5, greater than or equal to 5 but less than 10, greater than or equal to 10 but less than 15, and greater than or equal to 15 up to 20. The length or cost is computed with the total time to compute the three algorithms.

Fig. 3. Shortest Path of Dijkstra for one item

Figure 3 is a sample route for the tests for less than 5 items for Dijkstra, exactly the same route resulted for Bellman-Ford and Floyd-Warshall. In a given trial, three algorithms has the same cost which is 14.49, however, Floyd-Warshall has a different route compared to the two algorithms. Also, Dijkstra and Floyd-Warshall has the same computational time.

Tests conducted for items greater than or equal to 15 up to 20 items resulted to Figure 4 for Floyd Warshall. Similar routes were noted for all three algorithms for other tests conducted. In a given trial of eighteen items, the three algorithms have the same cost which is 54.91 and with exactly the same route. This is due to the simplicity of the map and routes. However, based on results, Floyd-Warshall has the fastest computational time.

The rest of the tests using the three algorithms simulated the shortest path. As expected, the total length computed for each simulation is optimal. However, the computational time for each vary. The Bellman-Ford algorithm has the highest computational time and Floyd-Warshall proves to have the lowest computational time.

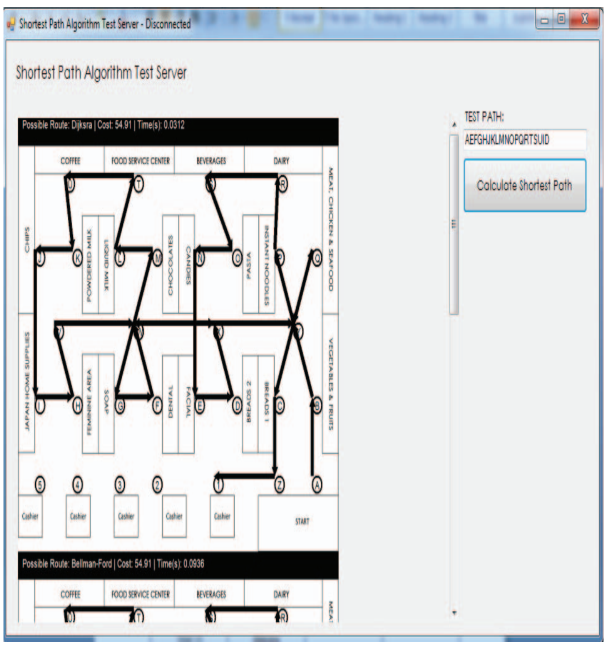

Fig. 4. Shortest Path of Floyd-Warshall for eighteen items

4. Testing

The actual testing was held in a grocery store. Figure 5 is the GUI of the Android application developed and sample list of items that can be selected or bought.

Figure 6 is a sample output map for the items selected. The user is provided a map/direction to the items selected. Twenty users tried the application to determine the amount of time it will take to get all the items in the shopping list with and without the device. Based on the results shopping time was reduced including the distance travelled by the user.

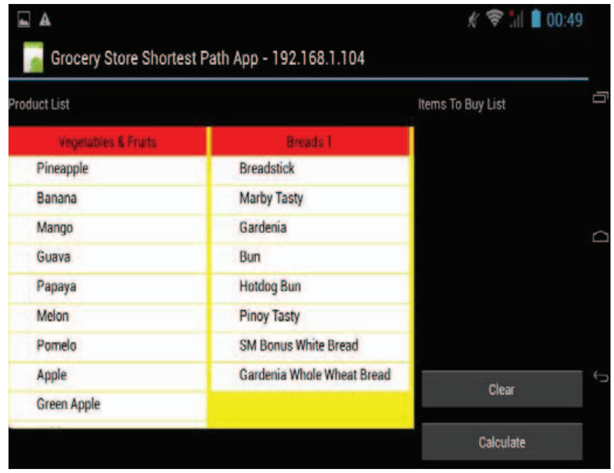

Fig. 5. Home Page of the Android Application

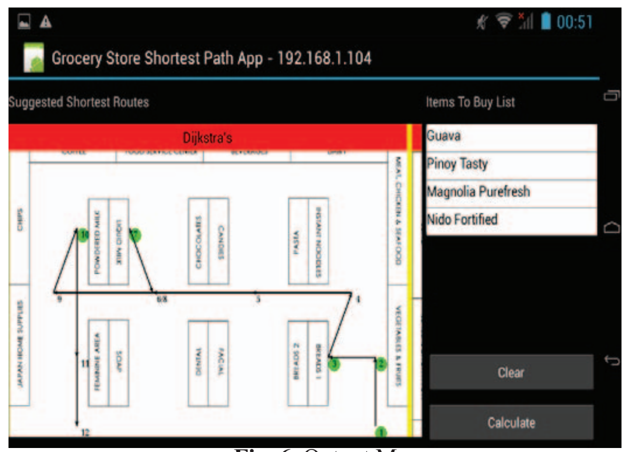

Fig. 6. Output Map

IV. RESULTS AND CONCLUSION

The evaluation of the three optimization techniques is conducted based on their path length and computational time. The path lengths of the three optimization techniques are equal on every trial conducted due to the simplicity of the simulated grocery set up. These algorithms are optimized and are created to be able to handle complex computational problems and the simplicity of the grocery store's floor plan did not possess such quality. However, the computational time of the three algorithms is the basis for choosing the most applicable algorithm for the problem.

For items less than 5, Dijkstra's Algorithm has the least computational time but for items greater than 5 but less than 10, Bellman-Ford and Floyd-Warshall are equal. For items greater than 10 but less than 20, Floyd-Warshall has the least computational time and thus, making it the most applicable algorithm to be implemented.

The testing of the system's functionality is conducted in a grocery store. The users' time, distance traveled and numbers of steps are recorded through a digital pedometer. The results show a reduction in time, distance traveled and number of steps from roaming around the grocery store and getting the items on their grocery list.

The implementation cost covering the server application is on the grocery owner's side. The shopper will install the android client application in their tablet or smart phone.

V. **RECOMMENDATIONS**

The researchers recommend to the people who want to innovate this project to (1) expand database grocery items, (2) incorporate price list with respect to the list of items given to our research, (3) allow the server to track the user's current location, and (4) use other path-finding algorithms like Heuristic.

VI. REFERENCES

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