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Another look at a algorithm

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Abstract
In the research work, the A* algorithm was modified in the steps and used to solved shortest path problem of Multiple sources-Multiple destinations network which originally cannot handle the network directly except by splitting it into either networks of single source-single destination or source-multiple destinations before superimposing them into a single network. However, the modified algorithm reduced the computational complexity rapidly by solving the problem at once without splitting it into either a networks of single source-single destination or network of source-multiple destinations like in the case of the existing algorithms.

Keywords: multiple sources-multiple destinations network, algorithm, shortest path problem

Introduction

Highways, telephone lines, electric power systems, computer chips, water delivery system and rail lines: these physical networks and many others are familiar to all of us. In each of these problem settings, we often wish to send some goods (vehicles, messages electricity, water etc) from one point to another, typically as efficiently as possible, that is, along a shortest route or via some minimum cost for pattern [1].

[2]. There are quite a number of existing Algorithms for obtaining the shortest path. These algorithms are:

- A *search Algorithms
- Dijkstra's Algorithms
- Bellman – Ford – Moore Algorithms
- Roy-Floyd – Warshall Algorithms
- Johnson's Algorithms
- Vitterbi Algorithms

The multiple sources to multiple destinations network (MSMD) is the network that has more than one source nodes and more than one destination nodes.

All these algorithms listed above cannot handle the problem of multiple sources to multiple destinations networks directly except by breaking it into single source to single destination, single source to multiple destinations or vise visa.

In [3], for 100 destinations (stops), it would take billions of years ($9.3 \text{x} 10^{157}$) to solve it (computational complexity) given the faster super-computer we have today.

For this reasons and since MSMD has a lot of application in many spheres of life like Agriculture, Energy, water resources, computer science, Engineering, transportation and others. We proposed an algorithm that can handle this problem (MSMD) at once without splitting it like the existing algorithms.

Problem of Formulation

A* search Algorithm which is an extension of Edsger Dijkstra's 1956 Algorithms. This algorithms was first described in 1968 by peter Hart, Nils, Milson, and Bertram Raphael [4]. This algorithm was developed originally, for single source to all vertices in graph (Figure 1). That is, it can solve a network problem of single to multiple destination at a time, but cannot solve MSMD in figure 3 below directly except when redesigned (by splitting it into single source to multiple destination) [5]. This algorithm is described by a recursive function:

$$f(n) = g(n) + h(n)$$

Where:
$g(n)$ = the known cost of getting from the initial node to n;

this value is tracked by the algorithm
h(n) = a heuristic estimate of the cost to get from *n* to any goal mode
f(n) = optimal path from initial node to *n* node

Algorithm
Step 1: pick and remove a location from the frontier
Step 2: mark the location as visited so that we will not process it again
Step 3: expand it by looking at it neighbours, any neighbours we haven it seen yet we add to the frontier.
Repeat these steps until the frontier is empty.

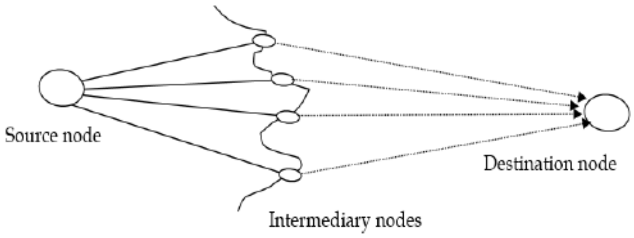

Fig 1: Single source to multiple destinations Networks

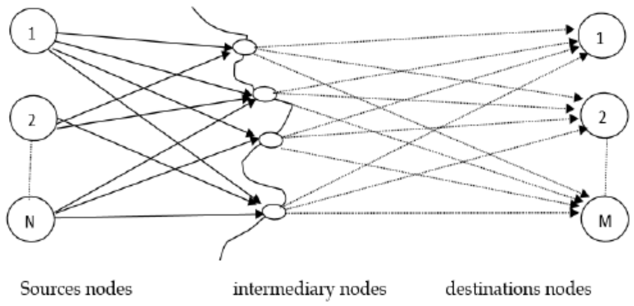

Fig 2: Multiple sources to multiple destination Networks

Propose Algorithm
To solve the kind of problem in Figure 2 above, A* and the other existing algorithms cannot handle the problem directly except by splitting it into either: Single source – single destination or single sources – multiple destinations, therefore, the A* was modified in the steps and returned the original recursive function [5].

$$d_{ij_m} = \text{optimized}\{d_{ij_{(m-1)}} + d_{kj}\}$$

where: d_{ij}^{m} = optimal distance at m

$d_{ij}^{(m-1)}$ = optimal distance at the previous stag he *(m-1)*

d_{kj} = distance (weight) at current stage

m = edges

k = vertex before *j*.

Modified Algorithm
Step 1: Add a dummy node to the sources nodes, if there are more than one source, otherwise proceed to step '2'.
Step 2: Pick and remove a location from the frontier.
Step 3: Mark the location as visited so that we will not process it again.
Step 4: Expand it by looking at it neighbours, any neighbour we haven't seen yet we add to the frontier.
Step 5: Repeat steps "2", "3" and "4" until the frontier is empty.
Step 6: Truncate dummy vertex and all its edges from the graph (network).

Data Collection
The modified algorithm was used to solve the Nigeria road network of motorable road from multiple sources (coastal towns: Lagos, Port-Harcourt, Asaba/warri and Calabar) to multiple destinations (border towns: Katsina, Sokoto and Maiduguri) model adopted from the work of Ikpotokin and Tamber [6] as represented in Figure 3 which is the Nigeria Roads Network System modeled into a logical sequence of arrows and nodes (network) for ease of analysis.

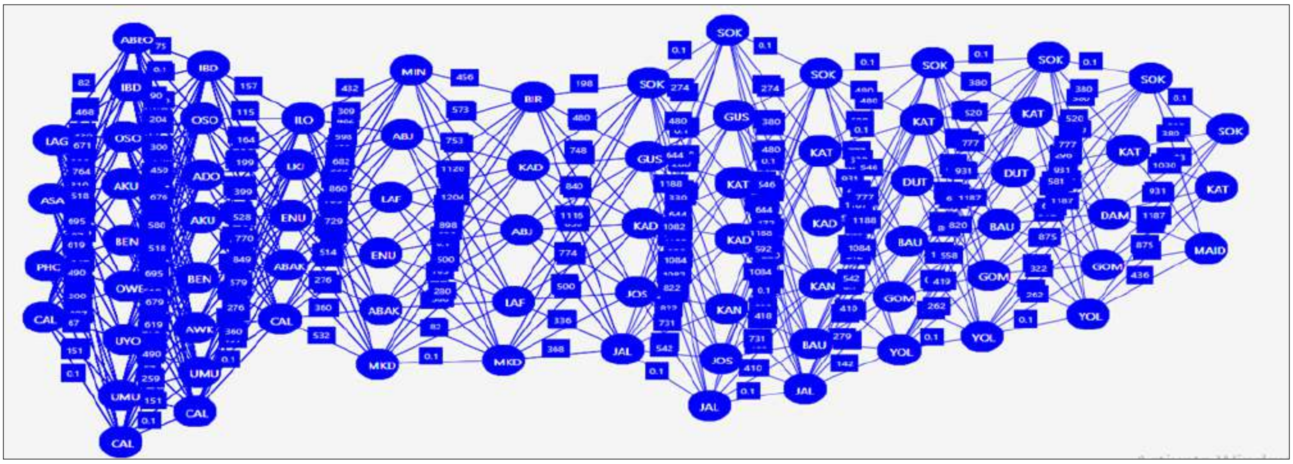

Fig 3: Nigeria road network of motorable road from multiple sources (coastal towns: Lagos, Port-Harcourt, Asaba/warri and Calabar) to multiple destinations (border towns: Katsina, Sokoto and Maiduguri) adopted from [6].

Discussion
The results obtained using the modified algorithm and the proposed algorithm in the work of Ikpotokin and Tamber [6] yielded the same results of the shortest routes of MS-MD as shown below:

1. a. Lagos to Sokoto: Lagos-Ibadan-Oshogbo-Lokoja-Abuja-Kaduna- Sokoto = 1375km
   b. Lagos to Katsina: Lagos- Ibadan-Oshogbo-Lokoja-

Abuja-Kaduna-Kano-Katsina =1298km
c. Lagos to Maiduguri: Lagos- Ibadan-Oshogbo-Lokoja-Abuja-Jos-Bauchi-Damaturu-Maiduguri =1589km

2. a. Asaba to Sokoto: Asaba-Benin-Lokoja-Abuja-Kaduna-Sokoto =1279km
   b. Asaba to Katsina: Asaba-Benin-Lokoja-Abuja-Kaduna-Kano-Katsina =1191
   c. Asaba to Maiduguri: Asaba-Umuahia-Enugu-Lafia-Jos- Bauchi-Damaturu-Maiduguri =1404km
3. a. Port Harcourt to Sokoto: PHC-Umuahia-Enugu-Abuja-Kaduna- Sokoto =1291km
   b. Port Harcourt to Katsina: PHC-Umuahia-Enugu-Abuja-Kaduna-Kano-Katsina =1203km
   c. Port Harcourt to Maiduguri: PHC-Umuahia-Enugu-Lafia-Jos- Bauchi-Damaturu-Maiduguri =1352km
4. a. Calabar to Sokoto: Calabar-Lafia-Jos-Gusau-Sokoto = 1314km
   b. Calabar to Katsina: Calabar-Enugu- Abuja-Kaduna-Kano-Katsina =1240km
   c. Calabar to Maiduguri: Calabar-Lafia-Jos- Bauchi-Damaturu-Maiduguri =1282km.

Findings

In this research paper, it was discovered that, the proposed algorithm:

1. Solve the MS-MD directed graphs of shortest route problem without splitting it which reduce the stress, time and energy taken to solve same problem with the existing algorithms.
2. The computational complexity has reduced drastically from 4680 computations by Single source-single destination to 1251 computations by multiple sources to multiple destinations.
3. This algorithm can also be used to find the longest path (critical path) as well as the alternate (next) longest path.
4. This algorithm can also be used to find the shortest path (stagecoach) as well as the alternate (next) shortest path if the other one fails.

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