A Routing Algorithm of Data in Networks of Metro and Mega Cities

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Abstract – Data transmission in networks is carried out by either the distance-vector or the link-state routing protocols, using the Bellman-Ford and the Dijkstra's algorithms respectively for the least-cost path from a source to a destination. Inter-network is carried out by the path-vector routing protocol that also uses the Bellman-Ford algorithm. These protocols require dynamically shared maintenance of large charts by the nodal routers of the network. For a large network over the global earth, the author [7] has recently presented algorithms that adopts a near geodesic path connecting the source node to the destination node. However, when the nodes lie in the same city spread over a large area, the algorithm degenerates in to a simpler form. This paper presents an algorithm appropriate for such cases.

Index Terms – Router network, link cost, near straight line path, algorithm.

I. INTRODUCTION

Data transmission networks have increasingly become large with ever changing topology due to increase of stationary and mobile devices. The proliferation is particularly noticeable in large metro and mega cities. A data network architecture essentially consists of router ground stations that are connected by radio/ microwave transmitters or by fiber-optic cables, forming different links of the network. A device intending to transmit data through the network to some destination remains continuously logged on to one of the nodal ground stations of the network. For transmission of the data to the destination certain algorithms are employed. The commonly used routing protocols are of three types: distance-vector routing, link-state routing, and path-vector routing developed by CISCO. For selecting the optimal path, the distance-vector routing algorithm employs the Bellman-Ford algorithm (Coreman Et. la. [1]), while the link-state routing algorithm employs the Dijkstra's algorithm (Bose[2]). The path-vector algorithm is of the distance-vector type, differing from the latter in significant detail. These routing protocols are RIP (Routing Information Protocol) and IGRP (Interior Gateway Routing Protocol) of the distance-vector type (CISCO systems [3] and [4]), Open Shortest Path First (OSPF) of the link-state type (CISCO Systems [5]) and BGP (Border Gateway Protocol) of the path-vector type (CISCO Systems [6]).

In order to take in to account the spherical architecture of networks on a global scale, the present author (Bose [7]) has proposed algorithms for near geodesic path on the spherical earth from a source to a destination station. The algorithms are based on formulas of spherical trigonometry. If however, the source and destination stations fall in a smaller area, as in metro and megacities, the geodesic path method degenerates in to a simpler algorithm. This paper presents such an algorithm with the objective of minimising data transmission in the networks of such cities. The algorithm employs shortest rectilinear geometrical path between and the destination stations.

II. SHORTEST LINKED GEOMETRICAL PATH

A large network of a metro or megacity can be assumed to be laid on a horizontal plane. All the nodal stations of the network are assumed to possess their latitude and longitude from GPS data. Let A_1 and A_n be the source and the destination stations with latitude and longitude $(\phi_1\, \lambda_1)$ and $(\phi_n,\, \lambda_n)$ respectively. Let θ_n be the deviation of the node A_n from the north pole N, that is $\theta_n = \angle NA_1A_n$. Then as in Bose [7] the angle θ_n is given by the expression

$$\theta_n = \arcsin\Big[\frac{\cos\phi_n \sin(\lambda_n - \lambda_1)}{\sin a}\Big] \tag{1}$$

where a is the great circular arc joining A_1 and A_n on the spherical globe. It is given by the expression

$$\cos a = \sin\phi_1 \sin\phi_n + \cos\phi_1 \cos\phi_n \cos(\lambda_n - \lambda_1) \tag{2}$$

so that,

$$\sin a = \sqrt{1 - \cos^2 a} \tag{3}$$

Next, let every node A_i possess a record of the deviation from the northern direction θ_k of all of its nearest neighboring nodes A_k. If A_i is on or close to the straight geometrical path joining A_1 and A_n, then for the next hop to A_k, the magnitude of the angular deviation of A_k and the destination A_n is

$$\chi_k = |\theta_k - \theta_n| \tag{4}$$

For the shortest link between A_i and A_k, the angle χ_k should be minimum provided the costC_k of the link is favorable, that is the cost does not exceed a certain maximum C_{mac}. In other words, if p is a fractional priority assigned to χ_k, the relative priority of C_k/C_{max} is $1 - p$ and the optimal path is obtained by minimising the objective function

$$z_k = p\,\chi_k + (1-p)\,C_k/C_{max} \tag{5}$$

III. THE ALGORITHM

The method outlined in the preceding section leads to the followinf algorith.

Algorithm. Shortest Geometrical Path Transmission.

1. Input: $\phi 1,\, \lambda 1,\, \phi n,\, \lambda n;$ \\Latitude, Longitude of Source and Destination.

$p,\, C_{max}$ \\ Fractional priority of deviation from shortest geometrical path , and maximum permitted cost of a link.

$\theta[\,]$ \\ Angular deviation from North of nearest neighboring stations around node i, $(i = 1,\, 2,\, 3, \cdots, n-1)$.

2. Output: $\phi[\,],\ \lambda[\,]$ \\ Latitude, Longitude of intermediate nodes, $(i = 2,\, 3, \cdots, n-1)$.

3. if $(\phi n = \phi 1$ and $\lambda n = \lambda 1)$ stop.

4. $\cos a \leftarrow \sin\phi 1 \sin\phi n + \cos\phi 1 \cos\phi n \times \cos(\lambda n - \lambda 1);$

$\sin a \leftarrow \sqrt{1 - \cos^2 a};$

$\theta n \leftarrow \arcsin(\cos\phi n \sin(\lambda n - \lambda 1)/\sin a)$

5. $i \leftarrow 1;$

$\phi[1] \leftarrow \phi 1;\ \lambda[1] \leftarrow \lambda 1$

6. for $k \leftarrow 1$ to i_{max} \\ $i_{max} \leftarrow$ Nearest neighbor stations around node i.

$\chi[k] \leftarrow |\theta[k] - \theta n|$

$C[k] \leftarrow$ Cost of link joining node i

with node k \\ To be fetched from a chart or a precedure

if ($C[k] > C_{max}$) exit \\ Bocked link

$z[k] \leftarrow p\chi[k] + (1-p)\, C[k]/C_{max}$
\\ Objective function to be minimised

end for

7. for $k \leftarrow 1$ to $i_{max} - 1$ \\ Sort angles

$\chi[k]$ to avoid ties

for $l \leftarrow k+1$ to i_{max}

if($\chi[k] > \chi[l]$) then

temp$\leftarrow \chi[k]$; $\chi[l] \leftarrow \chi[k]$; $\chi[l] \leftarrow$ temp

end if

end for; end for

8. $k_{min} \leftarrow 1$

for $k \leftarrow 2$ to i_{max}

if($z[k_{min}] > z[k]$) $k_{min} \leftarrow k$

end for

9. $i \leftarrow k_{min}$ \\ Next hop to node

$\phi[i] \leftarrow \phi[k_{min}]$; $\lambda[i] \leftarrow \lambda[k_{min}]$

10. if($i = n-1$) Stop

11. Go To Step **6**

12. end

IV. CONCLUSION

Data transmission networks having large topology require lengthy tables of information at nodal router stations for lossless steady transmission of user data. Currently, the stations continuously share their information of status continuously with other stations of the network. The combined effect of these two types of traffic in the network, tends to increase the work load of the routers by significant amounts. At present the Bellman-Ford or the Dijkstra's shortest path algorithms ([1], [2]) are used for the transmission of user's data for reducing the workload. In recent years Bose [7] has presented algorithms for transmission in a global scale network, in which the earth's sphericity comes in to play. The algorithm adopts a geometric linked path as close as possible to the geodesic joining the source and the destination stations of the network. Large metro and mega cities having high tele densities require similar such geometric solution on a plane for reducing congestion in the city's data network. This paper presents such an algorithm where the transmission path is as close as possible to the geometrical straight line joining the source and the destination nodes. The direction of the links is assessed by their deviation from the local northern direction. Also, the position of every node is assumed to be known from the GPS locator. For a mobile destination, its search could be carried out by flooding in sectors around the source.

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