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SPT-BASED LOCAL LANDMARK SCHEME FOR SHORTEST DISTANCE CALCULATION IN NETWORK ROUTING

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Abstract: *Shortest distance query is mostly used in large scale networks to achieve fastest routing speed in a network using link state protocols such as OSPF and IS-IS. The Landmark embedding approach is mostly used to get results of such kind of queries. In this approach, set of graph nodes needs to be selected as landmarks and distance from those graph nodes is calculated as an embedding. The precomputed distance from those landmark nodes is calculated as part of the answer shortest distance query using old approach. This approach doesn't give accurate and error free results. Depending on the factors related to landmark embedding new approach have been proposed to solve these problem as query dependent local landmark scheme. In this approach a local landmarks with respect to queried nodes are identified and shortest distance is calculated which is more accurate than traditional approaches. Based on this theory, better solution is provided which is Shortest Path Tree based on Local Landmark scheme to achieve fastest routing speed in large network.*

Keywords: *SPT, Least common ancestor, Local landmark scheme, Global search, OSPF.*

1. INTRODUCTION

The major problem in traditional approaches like Landmark embedding is to select accurate landmarks in huge set of nodes in network. As the size of the network grows rapidly, finding landmark nodes from huge set is cumbersome. Existing studies used various methods to achieve the same such as degree betweenness centrality, closeness centrality and coverage etc. [5],[6], [7], [8], [9], [10], [11], [12], All these methods follows triangulation based distance estimation. Triangulation based distance estimation, estimates or calculates shortest distance to landmarks. Actually in this step, [6], [12] landmark selection step is independent of the query which provides a single global view for all possible queries that can be achieved or viewed in a graph. These methods get failed when queried nodes are located nearby to each other. And also because of large size of the networks and online nature of the queries makes it hard to use these algorithms. These older approaches makes it hard to pre-compute and store the shortest calculated paths between all the nodes as it requires $O(n^3)$ space to store shortest path and $O(n^2)$ space to store the distances for the graph with n nodes. So the Query dependent local landmark system is more advantageous to find out nodes and more accurate distance.

2. RELATED WORK

2.1 What is Query-Dependent Local landmark Scheme?

This approach used to identify a local landmarks nodes dependent on queried nodes, and then shortest distance [3] between these two queried nodes is calculated as sum of their shortest distance to local landmark which is closer than globally selected query nodes. This approach is used to minimize distance estimation errors than the older methods. There were challenges to calculate a shortest distance in huge graph. First, the efficient local landmark indexing and retrieval technique is used as online computation to find a query specific local landmark. This one is used to increase query processing time. Second challenge is calculation of shortest distance from the query node to local landmark. The shortest distance should not be calculated from scratch in each cycle of query. Third, Embedding of the index should be Compaq. Estimation accuracy [4] and query processing efficiency should not be achieved at expense of increase in the offline complexity. Based on the challenges, proposed solution is shortest path tree (SPT)- based local landmark scheme.

2.2 Shortest Path tree (SPT) based local landmark scheme:

In this schema shortest path tree rooted at node r is tree composed of shortest paths from r to all the other nodes. SPTs rooted at global landmarks help to select the query-dependent local landmarks between two query nodes.

A query- dependent local landmark scheme finds local landmarks close to both query nodes to improve distance estimation. It proves a robust embedding solution that reduces dependency of query performance on global landmark selection strategy.

Given a query node pair, local landmark scheme used to find a local landmarks, which are known as least common ancestors (LCA) of given query nodes in SPT which is rooted at one of the global landmarks. It significantly improves distance estimation accuracy without increasing offline embedding or online query complexity.

The embedding is used to store into RDB (relational database), so query of local landmarks scheme is expressed in relational operation.

With both memory and relational database local landmark scheme significantly reduces average relative error (AvgErr) to scale of $0 - 10^{-3}$ which is several times better than Treesketch [13] (State of art sketch based embedding), global landmark embedding and other approaches.

2.2 SPT-Based Local Landmark function:

In this technique, shortest distance form global landmark is precomputed for embedding purpose. Shortest distance = distance of Node A to LCA + distance of Node B to LCA.

Where, Node A and B are queried nodes. LCA means Least common ancestor

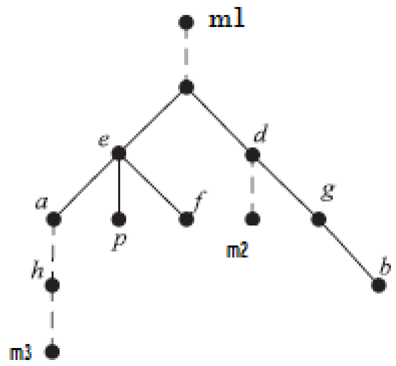

Fig. SPT rooted at m1

Fig shows a SPT rooted at node m1 . SPT contains shortest distance information from the root along with additional structure information on how nodes are connected to each other in a graph.

For example,

c is the closer node to both a and b instead of l_1. The distance is calculated using a function such as, $\partial(a,b) = \partial(c,a) + \partial(c,b)$.

3. ADVANTAGES AND DISADVANTAGES

3.1 Advantage of SPT:

1) Tree based local landmark scheme, achieves low offline complexity and online query complexity of selecting nodes (local nodes) close to the query nodes.
2) It reduces distance estimation error compared with other approaches.
3) It provides more accurate estimation of distance in Network routing.
4) It reduces a Index size of computation of shortest distance.

3.2 Disadvantages of SPT:

1) Selection of a local node from globally selected nodes is cumbersome.
2) Landmark selection heavily influences the estimation accuracy if the distance computation.

4. FUTURE WORK

The proposed SPT algorithm can be used for network routing in a wide network for packet delivery using state protocols such as OSPF, IS-IS etc. If the network topology gets changed, the existing shortest path tree (SPT) should get updated every time according to latest topology. To update latest SPT, this algorithm should change dynamically to calculate shortest distance using SPT based approach. This dynamic algorithm minimizes computation time and makes lesser changes to the SPT structure to calculate shortest distance. Depending on the weight of each edge, the SPT is updated accordingly. The nodes are deleted and added as per the weight on each edge. Whenever there is a change of edge weight, the nodes are updated in the new SPT. In this updated algorithm, In the new algorithm, we check the incoming edges for nodes and select edges representing the minimum increased (or maximum decreased) value. All these edges are put into the edge list. Actually, only a small part of the edge will contribute to the rebuilding of the new SPT. In the case of edge weight increase, those edges with the minimum increased value smaller than all its ancestors' will be in update procedure.

4.1 Mathematical Model to calculate shortest distance in Network Routing:

Input: Dataset, query node (a, b)

Where 'a' and 'b' are nodes to find distance between these 2 nodes.

System:

1. **Landmark Embedding:**

Set of nodes S = $\{l_1, l_2, \dots \dots, l_k\} \subseteq \mathrm{V}$

Where l_k nodes and V are is set of nodes.

$D(v)$=< $\delta(l_1, v), \delta(l_2, v), \ldots\ldots \delta(l_k, v)$>

Where D (v) is k-dimensional vector to represent k landmark

$\delta(a, b) = \min_{l_i \in S} \{\delta(l_i, a) + \delta(i, b)\}$

2. **Query dependent Local Landmark**

L_{ab} (S): $V^k \rightarrow V$

Where S is landmark set and queries (a, b) and L_{ab} (S) is query dependent local landmark function

Set S= { $l_1, l_2, \ldots\ldots, l_k$}

$\delta(a, b) = \delta(l_i, a) + \delta(l_i, b)$

$\delta^L(a, b) = \delta(c, a) + \delta(c, b)$

3. **Improved Shortest Path Tree :**

Let G = (V, E, w) is directed graph

Where V is the set of node and E is the set of edges and w represent the weight of each edge in graph G,

Let S (G) $\in$ V is the source node in G

W (e) to denote edge of e for each directed edge e $\in$ E

Given e: i $\rightarrow$ j,

Where i is the source node and j is the end node of e.

I: P (i) is its parent node and D (i) is the shortest distance in the SPT

Let d=D (i) +$w'(e) - D(j)$

Where d represent the increment value of node j

{N}= {e| S (e) $\in$ N, E (e) $\notin$ N}

And End part {N} = {e | E (e) $\in$ N }

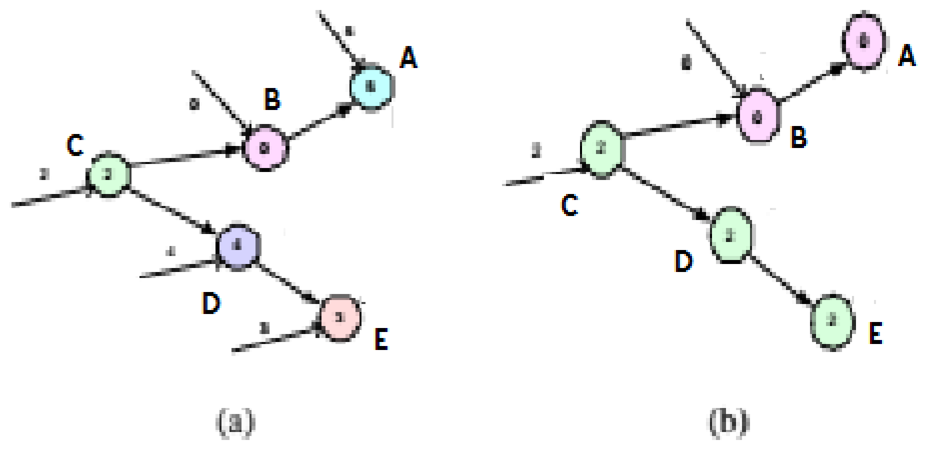

Fig. (a) Nodes with one incoming edge to denote the smallest increments; (b) The useful edges to construct the new SPT.

5. CONCLUSION

In this paper, we propose an SPT based local landmark approach, which is used to identify nodes close to queried nodes as query specific local landmarks for triangulation based system. Local landmarks are defined as Least common ancestor of query nodes in the SPT rooted at global landmarks. The proposed dynamic SPT algorithm is more advantageous over the static SPT algorithm to update SPT whenever the network topology gets changed.

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