Conditional Shortest Path Routing in Delay Tolerant Networks

[1]G. Rajitha devi (Lecturer), [2]B. Sujatha (Assistant professor)

Abstract:

Routing in delay tolerant networks (DTN) is a challenging problem because at any given time instance, the probability that there is an end-to-end path from a source to a destination is low. Since the routing algorithms for conventional networks assume that the links between nodes are stable most of the time and do not fail frequently, they do not generally work in DTN's. Therefore, the routing problem is still an active research area in DTN's To realize the DTN vision, routes must be found over multiple unreliable, intermittently-connected hops. Many researchers have investigated this fundamental challenge, to overcome these challenges, this paper propose Conditional Shortest Path Routing (CSPR) protocol that routes the messages over conditional shortest paths in which the cost of links between nodes is defined by conditional intermeeting times rather than the conventional intermeeting times. Through trace-driven simulations, we demonstrate that CSPR achieves higher delivery rate and lower end-to-end delay compared to the shortest path based routing protocols that use the conventional intermeeting time as the link metric.

Index Terms: DTN, CSPR, ROUTER, MANET.

I. Introduction

Delay-tolerant networks (DTNs) have the potential to connect devices and areas of the world that are not well-served by current networking technology. Instead of relying on end-to-end network connectivity, DTNs take advantage of temporary connections to relay data in a fashion similar to the postal network [1]. These networks could be useful in scenarios ranging from interconnecting sensors to connecting remote regions of the world.Routing algorithms in DTN's utilize a paradigm called *store-carry-and-forward*. When a node receives a message from one of its contacts, it stores the message in its buffer and carries the message until it encounters another node which is at least as useful (in terms of the delivery) as itself. Then the message is forwarded to it. Based on this paradigm, several routing algorithms with different objectives (high delivery rate etc.) and different routing techniques (single-copy [2] [3], multi-copy [4] [5], erasure coding based [6] etc.) have been proposed recently. However, some of these algorithms [7] used unrealistic assumptions, such as the existence of oracles which provide future contact times of nodes.

Yet, there are also many algorithms (such as [8-10]) based on realistic assumption of using only the contact history of nodes to route messages opportunistically. One obstacle that currently limits deployment of these networks is that it is difficult to determine how to get data from the source to the destination. Current DTN-like networks have been built using static routing [11,12]. This is an effective approach for small networks with simple topologies. However, the benefit of these networks will increase if they can be scaled to service larger areas. To achieve this goal, routing protocols are needed to automate network configuration.This paper presents a routing protocol designed to be easy to deploy in order to accelerate the use of DTNs. This philosophy led to three design goals. First, the routing must be self-configuring. This is critical for equipment that may be deployed far from network experts, and to maintain connectivity in the face of failure. Second, the protocol must provide acceptable performance over a wide variety of connectivity patterns. Finally, it must make efficient use of buffer and network resources, being scalable with the number of messages delivered.

II. Literature survey

Work on DTN networks shows that it is possible to automatically route in networks, even when nodes are mobile and the link quality varies. There is a huge body of work on routing protocols [13-15] and metrics [16, 17] for this environment. However, these protocols and metrics find end-to-end paths, and do not support communication between nodes in different network partitions.Recent studies on routing problem in DTN's have focused on the analysis of real mobility traces (human [11], vehicular [18] etc.). Different traces from various DTN environments are analyzed and the extracted characteristics of the mobile objects are utilized on the design of routing algorithms for DTN's. An approach that uses a single copy of each message is presented by Jain *et al.* [7].

They assume that the contact schedule is completely known in advance, and use this knowledge to create a number of routing metrics. Their results show that the efficiency and performance increases with the amount of information used for the metric. The weakness of this approach is that each node must have access to accurate schedule data. To provide this information, the routing must be manually configured with the contact schedules, which must be repeated each time the schedule changes. Handorean *et al.* explore alternatives for distributing connectivity information, but they still assume that each node knows its own connectivity perfectly [19]. From the analysis of these traces performed in previous work, we have made two key observations.

First, rather than being memoryless, the pairwise intermeeting times between the nodes usually follow a log-normal distribution [20] [21]. Therefore, future contacts of nodes become dependent on the previous contacts. Second, the mobility of many real objects are non-deterministic but cyclic. Hence, in a cyclic MobiSpace [22], if two nodes were often in contact at a particular time in previous cycles, then they will most likely be in contact at around the same time in the next cycle.

III.   Conditional shortest path routing mechanism

A.   Existing system : Message delivery in sparse DTN is difficult due to the fact that the network graph is rarely (if ever) connected. A key challenge is to find a route that can provide good delivery performance and low end-to-end delay in a disconnected network graph where nodes may move freely. Some bridge nodes are identified based on their centrality characteristics, i.e., on their capability to broker information exchange among otherwise disconnected nodes. Due to the complexity of the centrality metrics in populated networks the concept of ego networks is exploited where nodes are not required to exchange information about the entire network topology, but only locally available information is considered. Then times rather than the conventional intermeeting times. Through trace-driven simulations, we demonstrate that CSPR achieves higher delivery rate and lower end-to-end delay compared to the shortest path based routing protocols that use the conventional intermeeting time as the link metric. We proposed a new metric called conditional intermeeting time inspired by the results of the recent studies showing that nodes' intermeeting times are not memory less and that motion patterns of mobile nodes are frequently repetitive. Then, we looked at the effects of this metric on shortest path based routing in DTN's. For this purpose, we updated the shortest path based routing algorithms using conditional intermeeting times and proposed to route the messages over conditional shortest paths. Finally, we ran simulations to evaluate the proposed algorithm and demonstrated the superiority of CSPR protocol.

C. Algorithm Description: Our algorithm basically finds conditional shortest paths (CSP) for each source-destination pair and routes the messages over these paths. We define the CSP from a node n_0 to a node n_d as follows:

$$CSP(n_0, n_d) = \{n_0, n_1, \ldots, n_{d-1}, n_d \mid R_{n_0}(n_1|t) + \sum_{i=1}^{d-1} T_{n_i}(n_{i+1}|n_{i-1}) \text{ is minimized.}\}$$

Here, t represents the time that has passed since the last meeting of node n_0 with n_1 and $R_{n_0}(n_1|t)$ is the expected residual time for node n_0 to meet with node n_1 given that they have not met in the last t time units. $R_{n_0}(n_1|t)$ can be computed as in with parameters of distribution representing the intermeeting time between n_0 and n_1. It can also be computed in a discrete manner from the contact history of n_0 and n_1. Assume that node i observed d intermeeting times with node j in its past. Let $\tau_i^1(j), \tau_i^2(j), \ldots \tau_i^d(j)$ denote these values. Then:

$$R_i(j|t) = (\sum_{k=1}^{d} f_i^k(j)/|\{T_i^k(j \ge t\}|) \text{ where,}$$

SimBet Routing is proposed which exploits the exchange of pre-estimated "between's' centrality metrics and locally determined social "similarity' to the destination node. We present simulations using real trace data to demonstrate that SimBet Routing results in delivery performance close to Epidemic Routing but with significantly reduced overhead. Additionally, we show that SimBet Routing outperforms PRoPHET Routing, particularly when the sending and receiving nodes have low connectivity.

B.   PROPOSED SYSTEM: We propose Conditional Shortest Path Routing (CSPR) protocol that routes the messages over conditional shortest paths in which the cost of links between nodes is defined by conditional intermeeting

$$f_i^k(j) = \{ T_i^k(j)-t \quad \text{if } T_i^k(j) \ge t$$

0   otherwise
Here, if none of the d observed intermeeting times is bigger than t (this case occurs less likely as the contact history grows), a good approximation can be to assume $R_i(j|t) = 0$.   We will next provide an example to show the benefit of CSP over SP. Consider the DTN illustrated in Figure 1. The weights of edges (A, C) and (A, B) show the expected residual time of node A with nodes C and B respectively in both graphs. But the weights of edges (C, D) and (B, D) are different in both graphs.

While in the left graph, they show the average intermeeting times of nodes C and B with D respectively, in the right graph, they show the average conditional intermeeting times of the same nodes with D relative to their meeting with node A. From the left graph, we conclude that SP(A,D) follows (A,B,D). Hence, it is expected that on average a message from node A will be delivered to node D in 40 time units. However this may not be the actual shortest delay path. As the weight of edge (C, D) states in the right graph, node C can have a smaller conditional intermeeting time (than the standard intermeeting time) with node D assuming that it has met node A. This provides node C with a faster transfer of the message to node D after meeting node A. Hence, in the right graph,

CSP(A, D) is (A,C,D) with the path cost of 30 time units. Each node forms the aforementioned network model and collects the standard and conditional intermeeting times of other nodes between each other through epidemic link state protocol. However, once the weights are known, it is not as easy to find CSP's as it is to find SP's. where the CSP(*A*, *E*) follows path 2 and CSP(*A,D*) follows (*A*, *B*, *D*). This situation is likely to happen in a DTN, if
$\tau D(E|B) \geq \tau D(E|C)$ is satisfied. Running Dijkstra's or Bellman-ford algorithm on the current graph structure cannot detect such cases and concludes that   CSP(*A,*   *E*)   is   (*A,*   *B,D,*   *E*).
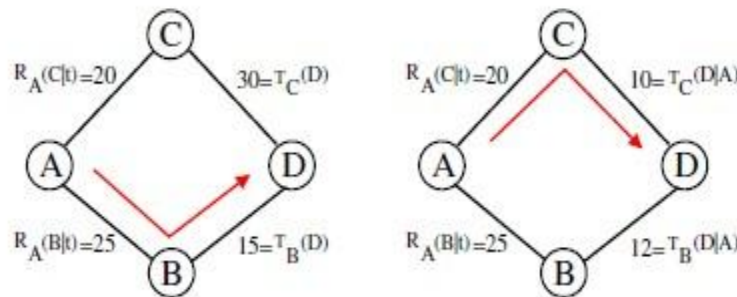

Fig. 1. The shortest path from a source to destination node

IV.   Implementation in this paper our approach consists of the following modules

A.   Networking module : Client-server computing or networking is a distributed application architecture that partitions tasks or workloads between service providers (servers) and service requesters, called clients. Often clients and servers operate over a computer network on separate hardware. A server machine is a high-performance host that is running one or more server programs which share its resources with clients. A client also shares any of its resources; Clients therefore initiate communication sessions with servers which await (listen to) incoming requests. This information is shown in Fig 2 & 3
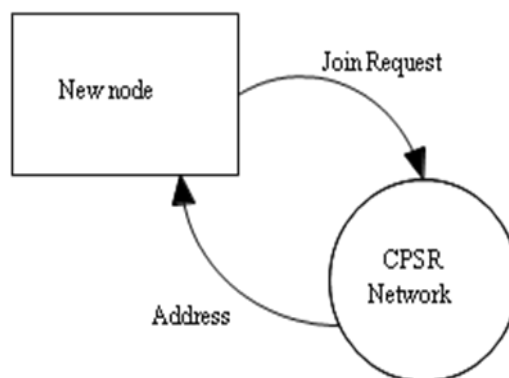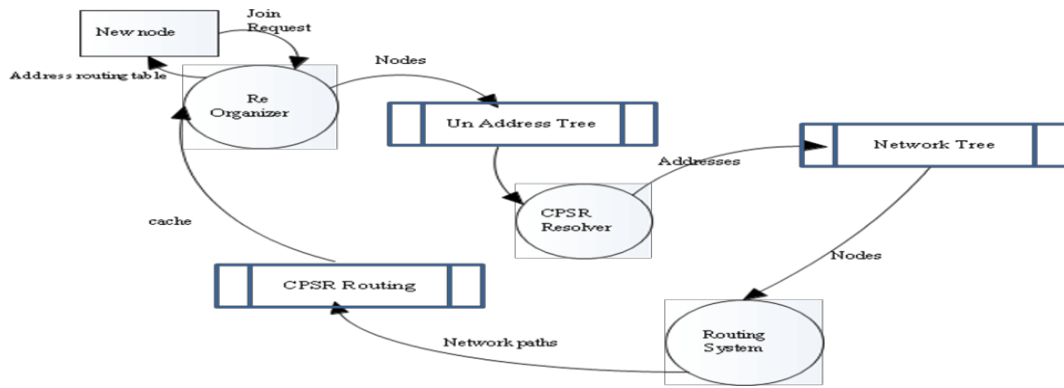

Fig 2 Node info

Fig 3 Network Procedure

B. Multi Hop Module : Analyze the load for a homogeneous multi-hop wireless network for the case of straight line routing in shortest path routing is frequently approximated to straight line routing in large multi-hop wireless networks. Since geographical and geometric attributes of nodes and routes affect the nodal load, we employ results from geometric probabilities to solve the problem. Based on our analytical results, we are able to show the precise relationship between the number of nodes and the load at each node, and the geographical distribution of the relaying load over the network for different scenarios. Interestingly, straight line routing itself can balance the relay load over the disk in certain cases. This info shown in Fig 4 and 5.
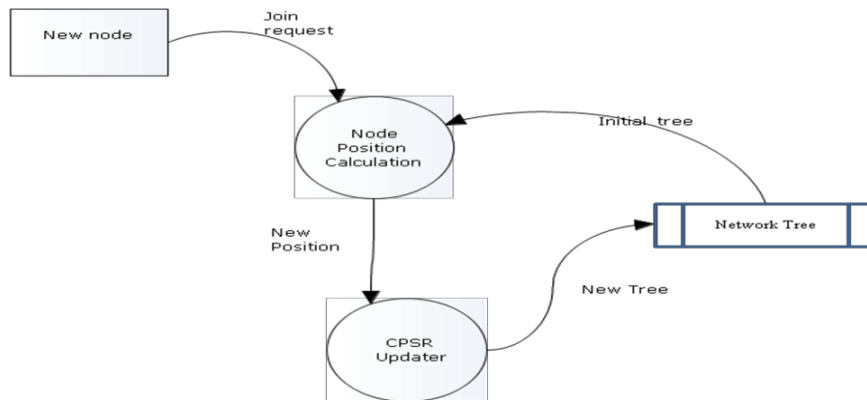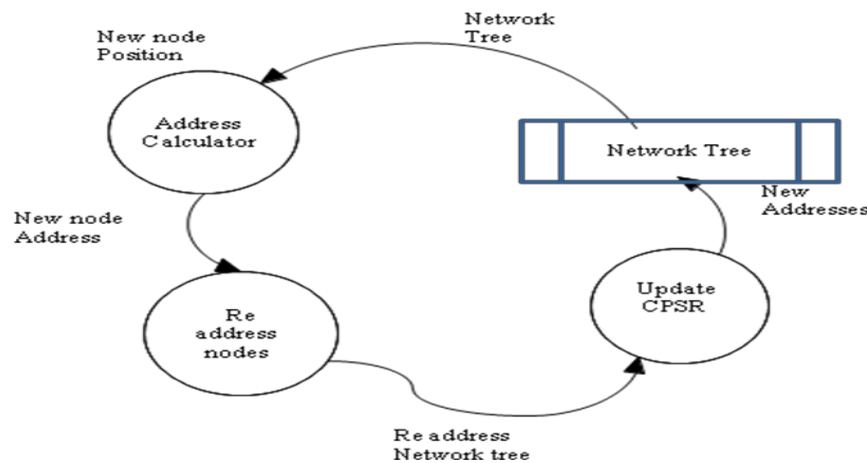

Fig 4 Multi hop info

Fig 5 Multi hop procedure

C. Simulations result : To evaluate the performance of our algorithm, we have built a discrete event simulator in Java. In this section, we describe the details of our simulations through which we compare the proposed

Conditional Shortest Path Routing (CSPR) algorithm with standard *Shortest Path Routing* (SPR). To collect several routing statistics, we have generated traffic on the traces of these two data sets. For a simulation run, we generated 5000 messages from a random source node to a random destination node at each seconds. We assume that the nodes have enough buffer space to store every message they receive, the bandwidth is high and the contact durations of nodes are long enough to allow the exchange of all messages between nodes.

V.   Conclusions and future work

Delay-Tolerant network (DTN) is a network in which no simultaneous end-to-end path exists. And the messages delivered in the DTN usually have large delivery latency due to network partition. These special characteristics make DTN routing a challenging problem. For this purpose, we updated the shortest path based routing algorithms using conditional intermeeting times and proposed to route the messages over conditional shortest paths. Finally, we ran simulations to evaluate the proposed algorithm and demonstrated the superiority of CSPR protocol over the existing shortest path routing algorithms.

Future Work : In future work, we will look at the performance of the proposed algorithm in different data sets to see the effect of conditional intermeeting time in different environments.

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