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An Experimental Result of Conditional Shortest Path Routing In Delay Tolerant Networks

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Abstract: *Delay tolerant networks are characterized by the sporadic connectivity between their nodes and therefore the lack of stable end-to-end paths from source to destination. Since the future node connections are mostly unknown in these networks, opportunistic forwarding is used to deliver messages. However, making effective forwarding decisions using only the network characteristics (i.e. average intermeeting time between nodes) extracted from contact history is a challenging problem. Based on the observations about human mobility traces and the findings of previous work, we introduce a new metric called conditional intermeeting time, which computes the average intermeeting time between two nodes relative to a meeting with a third node using only the local knowledge of the past contacts. We then look at the effects of the proposed metric on the shortest path based routing designed for delay tolerant networks. 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 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.*
Keywords*:* *Delay Tolerant Network, MobiSpace, Network Model, Routing protocols, Short test Path.*

I. Introduction

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 [1]. The basic idea of using erasure coding is simple and has been explored in many applications [7]. However, it is not clear if and when it will perform better than simpler alternatives based on pure replications in DTNs.

DTNs are useful when the information being routed retains its value longer than the disrupted connectivity delays delivery. The routing problem in a DTN may a first appear as the standard problem of dynamic routing but with extended link failure times. This is not the case. For the standard dynamic routing problem, the topology is assumed to be connected and the objective of the routing algorithm is to and the best currently-available path move traced-to-end. In a DTN, however, an end-to- end path may be unavailable at all times; routing is performed over time to achieve eventual delivery by employing long-term storage at the intermediate nodes.

In Existing Work adopted it for the shortest path based routing algorithms designed for DTN's. We propose *conditional shortest path routing* (CSPR) protocol in which average conditional intermeeting times are used as link costs rather than standard2 intermeeting times and the messages are routed over conditional shortest paths (CSP). We compare CSPR protocol with the existing shortest path (SP) based routing protocol through real trace- driven simulations. The results demonstrate that CSPR achieves higher delivery rate and lower end-to-end delay compared to the shortest path based routing protocols. This shows how well the conditional intermeeting time represents inter node link costs (in the context of routing) and helps making effective forwarding decisions while routing a message. We redefine the intermeeting time concept between nodes and introduce a new link metric called conditional intermeeting time. It is the intermeeting time between two nodes given that one of the nodes has previously met a certain other node.

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II. Proposed Methodology

To show the benefits of the proposed metric, we adopted it for the shortest path based routing algorithms designed for DTN's. We propose *conditional shortest path routing* (CSPR) protocol in which average conditional intermeeting times are used as link costs rather than standard2 intermeeting times and the messages are routed over conditional shortest paths (CSP). We compare CSPR protocol with the existing shortest path (SP) based routing protocol through real trace driven simulations. The results demonstrate that CSPR achieves higher delivery rate and lower end-to-end delay compared to the shortest path based routing protocols. This shows how well the conditional intermeeting time represents inter-node link costs (in the context of routing) and helps making effective forwarding decisions while routing a message.

New metric called conditional intermeeting time that measures the intermeeting time between two nodes relative to a meeting with a third node using only the local knowledge of the past contacts. Such measure is particularly beneficial if the nodes move in a cyclic so-called Mobi-Space in which if two nodes contact frequently at particular time in previous cycles.

III. Conditional Intermeeting Time

An analysis of real mobility traces has been done in different environments and with variable number of attendants and led to significant results about the aggregate and pair wise mobility characteristics of real objects. Recent analysis on real mobility traces have demonstrated that models assuming the exponential distribution of intermeeting times between pairs of nodes do not match real data well. Instead up to 99% of intermeeting times in many datasets is log-normal distribution. To take advantage of such knowledge, we propose a new metric called conditional intermeeting *time* that measures the intermeeting time between two nodes relative to a meeting with a third node using only the local knowledge of the past contacts.

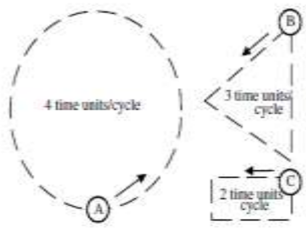

Fig. 1. A physical cyclic MobiSpace with a common motion cycle of 12 time units.

IV. Conditional Shortest Path Routing

Shortest path routing protocols for DTN's are based on the designs of routing protocols for traditional networks. Messages are forwarded through the shortest paths between source and destination pairs according to the costs assigned to links between nodes. Furthermore, the dynamic nature of DTN's is also considered in these designs. Two common metrics used to define the link costs are minimum expected delay and minimum estimated expected delay .They compute the expected waiting time plus the transmission delay between each pair of nodes. However, while the former uses the future contact schedule, the latter uses only observed contact history.

Routing decisions can be made at three different points in an SP based routing: *i*) at source, *ii*) at each hop, and *iii*) at each contact. In the first one (source routing), SP of the message is decided at the source node and the message follows that path. In the second one (per-hop routing), when a message arrives at an intermediate node, the node determines the next hop for the message towards the destination and the message waits for that node. Finally, in the third one (per contact routing), the routing table is recomputed at each contact with other nodes and the forwarding decision is made accordingly. In these algorithms, utilization of recent information increases from the first to the last one so that better forwarding decisions are made; however, more processing resources are used as the routing decision is computed more frequently.

NETWORK MODEL CONSTRUCTION

We prepare the model a DTN as a graph G = (V , E) where the vertices (V) are mobile nodes and the edges (E) represent the connections between these nodes. However, different from previous DTN network models, we assume that there may be multiple unidirectional (Eu) and bidirectional (Eb) edges between the nodes.

V. Neighbour Node Connection

These edges differ from each other in terms of their weights and the corresponding third node. This third node indicates the previous meeting and is used as a reference point while defining the conditional intermeeting time (weight of the edge). In, we illustrate a sample DTN graph with four nodes and nine edges. Of these nine edges, three are bidirectional with weights of standard intermeeting times between nodes, and six are unidirectional edges with weights of conditional intermeeting times.

INTERMEETING CALCULATION TIME (DELAY TOLERANT TIME SPECIFICATION)

Each node first adds up times expired between repeating meetings of one neighbor and the meeting of another neighbor. Then it divides this total by the number of times it has met the first neighbor prior to meeting the second one. For example, if node *A* has two neighbors (*B* and *C*), to find the conditional intermeeting time of $\tau A(B|C)$,each time node *A* meets node *C*, it starts a different timer. When it meets node *B*, it sums up the values of these timers and divides the results by the number of active timers before deleting them.

VI. Conditional Shortest Path Routing Identification

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 as in. However, once the weights are known, it is not as easy to find CSP's as it is to find SP's. Consider where the CSP(*A*, *E*) follows path 2 and CSP(*A*, *D*) follows (*A*, *B*, *D*).

Algorithm 1 update (node m, time t)

```
if m is seen first time then
    firstTimeAt[m] ← t
else
    increment β_m by 1
    lastTimeAt[m] ← t
end if
for each neighbor j ∈ N and j ≠ m do
    start a timer t_mj
end for
for each neighbor j ∈ N and j ≠ m do
    for each timer t_jm running do
        S[j][m] += time on t_jm
        increment C[j][m] by 1
    end for
    delete all timers t_jm
end for
for each neighbor i ∈ N do
    for each neighbor j ∈ N and j ≠ i do
        if S[j][i] ≠ 0 then
            τ_s(i|j) ← S[j][i] / C[j][i]
        end if
    end for
    τ_s(i) ← (lastTimeAt[i] − firstTimeAt[i] ) / β_i
end for
```

VII. Experiment Results

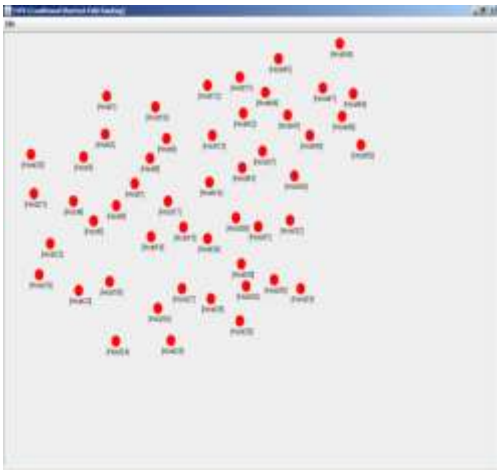

Fig 1: Select the number of nodes

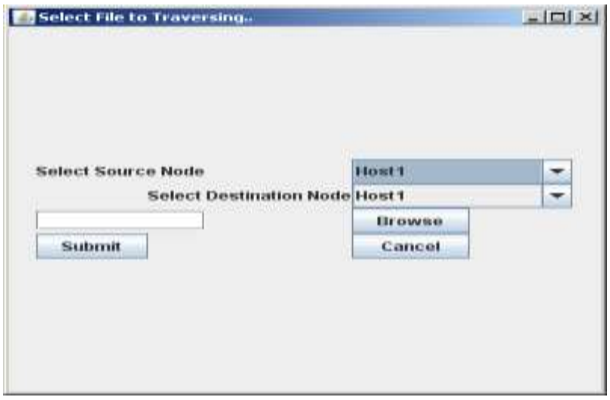

Fig 2: Select file to traversing

Fig 3: Select source node and destination node

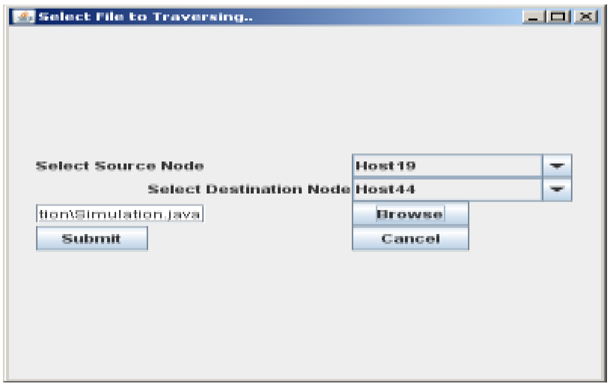

Fig 4: Select the file to traverse by clicking on browse

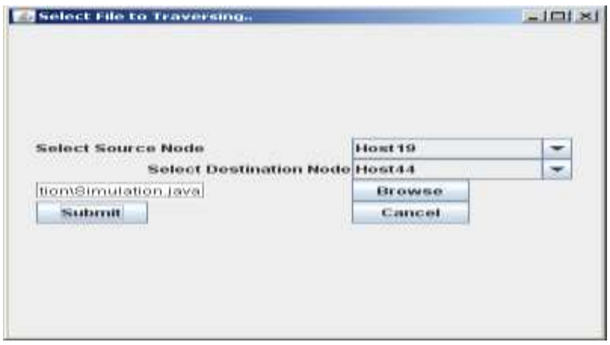

Fig 5: Send the file by clicking on submit

Fig 6:File was successfully sent

VIII. Conclusion & Future Enhancement

We introduced 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 over the existing shortest path routing algorithms. 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. Moreover, we will consider extending our CSPR algorithm by using more information (more than one known meetings) from the contact history while deciding conditional intermeeting times. For this, we plan to use probabilistic context free grammars (PCFG) and utilize the construction algorithm presented in. Such a model will be able to hold history information concisely, and provide further generalizations for unseen data.

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