Modified Bubble Rap Routing for Intermittently Connected Networks

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ABSTRACT

Intermittently connected mobile network (ICMN) is a delay-tolerant ad hoc network that is made up of mobile nodes. Here most of the time there does not exist a complete path from source to destination, or such a path is highly unstable and may break soon after it has been discovered. Extreme mobility may render a complete path discovery highly inefficient. In these networks, there is usually no supporting infrastructure for routing. Due to frequent network disruption and intermittent connections in ICMN, it is difficult to establish reliable end-to-end paths between mobile peers. Conventional routing schemes fail, as they try to establish complete end-to-end paths, before any data is sent. In a social network, nodes show group behaviors so that some nodes meet each other more frequently than others. Bubble Rap routing protocol is used to forward the message to the destination based on the two metrics such as Community and Centrality nodes. Global ranking and local ranking systems are calculated to forward the message thus providing higher delivery rates and shorter delivery delays in the ICMN.

General Terms
Mobile Ad hoc Networks [MANET], Bubble Rap.

Keywords
Social network, Forwarding, Intermittently Connected Network.

1. INTRODUCTION
An intermittently connected mobile network (ICMN) is a delay-tolerant ad hoc network that is made up of mobile nodes. Typical examples include Zebra Net [1], the vehicular adhoc network (VANET) [2], and the pocket switched network (PSN). In these networks, there is usually no supporting infrastructure (such as mesh nodes or base stations) for routing. Due to frequent network disruption and intermittent connections in ICMN, it is difficult to establish reliable end-to-end paths between mobile peers. There is an existence of a contemporaneous path to the destination nor assume accurate knowledge of the destination's location or even address, beforehand. Under such intermittent connectivity many traditional protocols fail e.g., TCP, DNS, etc. So for this reason that novel networking architectures are being pursued that could provide mobile nodes with better service under such intermittent character. The biggest challenge to enable networking in intermittently connected environments is that of routing. Conventional Internet routing protocols e.g., RIP and OSPF, as well as routing schemes for mobile ad hoc networks such as DSR, AODV, etc., assume that a complete path exists between a source and a destination, and try to discover these paths before any useful data is sent. Thus, if no end-to-end paths exist most of the time and these protocols fail to deliver any data to all but the few connected nodes. However, this does not mean that packets can never be delivered in these networks. Over time, different links come up and down due to node mobility.

2. SOCIAL NETWORK ANALYSIS
Social network analysis (SNA) has attracted a significant attention in many research areas such as anthropology, biology, communication studies, economics, information science, computer science and engineering. SNA mainly focuses on studying relationships among social entities and the patterns and implications of these relationships. With the increasing popularity of online social networks and new information technologies (such as mobile computing, E-commerce, distributed systems, and smart sensing), SNA becomes a more powerful tool to study the relationships and ties among users, and thus may guide the design of new policies, protocols, or applications for different information systems.

To identify the social relations among people and to extract their social properties is by building a social graph (also called social network). A social graph is a global mapping of everybody and how they are related. Such a graph is an abstract graph where vertices represent individual people and edges describe social ties between individual people. Social ties can be expressed in many forms. People with close relationships such as friends, family members, etc. tend to meet more often, more regular and with longer duration, nodes can extract, relationships from the recorded contact graph, estimate their social metrics, and use such information to choose relays with higher probabilities of successful forwarding.

3. RELATED WORK
Numerous DTN routing and forwarding schemes have been proposed over the last few years. The primary difference between various DTN routing protocols is whether the future topology is deterministic. Because we mainly focus on routing in a stochastic mobile network without supporting infrastructure, whose topology is time evolving and, thus, difficult to predict, our problem is different from a deterministic network or the category of controlling node movements.

Epidemic routing is a simple and fast way to perform routing throughout the network [3]. However, it is extremely wasteful of resources, such as wireless bandwidth and storage space. One approach for reducing the overhead of epidemic routing is to distribute a bounded number of copies [9]. Because this approach does not make use of gaining knowledge about network conditions, its performance is not satisfactory under more realistic mobility conditions.

Spray and Wait, presented by Thrasyvoulos Spyropoulos et al [9] distributes only a small number of copies each to a different relay. Each copy is then "carried" all the way to the destination by the designated relay and it consists of the following two phases:

- **Spray phase***:* For every message originating at a source node, L message copies are initially spread – forwarded by the source and possibly other nodes receiving a copy – to L distinct "relays".
- **Wait phase***:* If the destination is not found in the spraying phase, each of the L nodes carrying a message copy performs direct transmission (i.e. will forward the message only to its destination)

It leads to the limitations because a relay with a copy will naively wait until it moves within range of the destination itself. This does not tell us how the L copies of a message are to be spread initially.

Spray and Focus suggested by Thrasyvoulos Spyropoulos et al [10] where, a fixed number of copies are spread initially exactly as in Spray and Wait, but then each copy is routed independently according to the single copy utility-based scheme with transitivity and it consists of two phases

- **Spray phase**: for every message originating at a source node, message copies are initially spread—forwarded by the source and possibly other nodes receiving a copy—to L distinct "relays".

- **Focus phase**: let $U_X(Y)$ denote the utility of node X for destination Y; a node A, carrying a copy for destination D, forwards its copy to a new node B it encounters, if and only if $U_B(d)>U_A(D)+ U_{th}$ where U_{th} is the utility threshold.

Recently, several social-based routing protocols have been proposed. In essence, temporal or spatial information is a kind of representation of the social context. Probabilistic ROuting Protocol using History of Encounters and Transitivity(PROPHET)[5], in which a probabilistic metric called delivery predictability is established, P(a;b) ε [0; 1], at every node a for each known destination b. This indicates how likely it is that this node will be able to deliver a message to that destination. When two nodes meet, they exchange summary vectors, and also a delivery predictability vector containing the delivery predictability information for destinations known by the nodes. This additional information is used to update the internal delivery predictability vector as described below. After that, the information in the summary vector is used to decide which messages to request from the other node based on the forwarding strategy used.

4. BUBBLE RAP ROUTING

Bubble Rap routing [4] is a social based routing. It combines the knowledge of community structure and node centrality to make forwarding decisions. The message is forwarded to the next node when the rank is higher than the current node. When the source and destination nodes are in the same community local ranking is enough to deliver the message to the destination but source and if destination nodes are in different community it first detects the community in which destination is found based on community ID and deliver the message using global ranking.

4.1 Community Detection

Community is an important concept in ecology and sociology [5]. In ecology, a community is an assemblage of two or more populations of different species occupying the same geographical area. In sociology, community is usually defined as a group of interacting people living in a common location. Community ecologists and sociologists study the interactions between species/people in communities at many spatial and temporal scales. It has been shown that a member of a given community is more likely to interact with another member of the same community than with a randomly chosen member of the population. Therefore, communities naturally reflect social relationship among people. Since wireless devices are usually carried by people, it is natural to extend the concept of social community to explore interactions among wireless devices. It is believed that devices within the same community have higher chances to encounter each other.

4.2 Finding Global and Local ranking

Each node in the community is assumed to have two rankings: global and local. While the global ranking denotes the popularity (i.e. connectivity) of the node in the entire society and local ranking denotes its popularity within its own community. Messages are forwarded to nodes having higher global rankings until a node in the destination's community is found. Then, the messages are forwarded to nodes having higher local ranking. Thus, the probability of finding the destination's community is increased, so that the shortest delivery delay is attempted. Ranking is used to find the centrality of nodes in the community.

4.3 Implementation of Bubble Rap routing

Bubble Rap routing is a social based routing protocol that relied on two social characteristics (community and centrality). They assumed that each node belongs to at least one community and its node centrality in the community describes the popularity of the node within this community. Each node has a global centrality across the whole network (or called global community), and a local centrality within its local community. A node may also belong to multiple communities and hence have multiple local centralities. Taking advantages of these social characteristics, Bubble Rap Forwarding basically includes two phases: a bubble-up phase based on global centrality and a bubble-up phase based on local centrality. In both phases, the bubble-up forwarding strategy is utilized to forward messages to nodes which are more popular than the current node (i.e., with higher centrality).

In Fig.1 shows that the source node *s* has a message with destination of *d*, it first bubbles the message up based on the global centrality, until the message reaches a node which is in the same local community C_d as the destination *d*. After the message reaches *d*'s community at node *u*, Bubble Rap Forwarding switches to the second phase which uses members of C_d as relays.

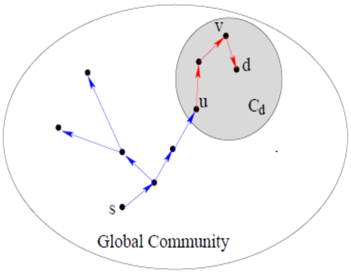

Fig 1: Bubble Rap Routing

This forwarding strategy continues to bubble up the message through the local community based on local centrality until the destination is reached.

5. SIMULATION SETUP

To aid in the evaluation of the protocol, we have developed a QualNet simulator [12]. The simulator focuses on the operation of the routing protocols, and does not simulate the details of the underlying layers. When doing an evaluation of a protocol or system, it is very important that the models used in the evaluation are realistic. The performances are analysed based on a two metrics such as Average end-to-end delay and Delivery ratio. The parameters for the simulation analysis are given in Table 1.

The performance metrics of this protocol is carried out using QUALNET simulator [12]. The protocols compared are Spray and Wait and Bubble Rap routing protocol. Through extensive simulation, the analysis of the protocols is carried out in various metrics.

5.1 Average End-to-End Delay

The end to end delay is defined as the average time interval time between the generation of a packet at a source node and the successful delivery of a packet at the destination node. Low end to end delay gives better performance of the network.

Table 1. Simulation Parameters

PARAMETER	DEFAULT VALUE
Routing Protocol	Spray and Wait, Bubble Rap
Dimension	1500x1500m
Mobility model	Random waypoint
Simulation time	500 sec
Packet size	512 kb
Number of Packet transmitted	100
Traffic type	CBR
Path loss model	Two ray model

Average end-to-end delay = (Total transmission of packets) / (Number of Packets received)

Where,

Transmission delay of packet=Time packet received at server-Time packet transmitted at client

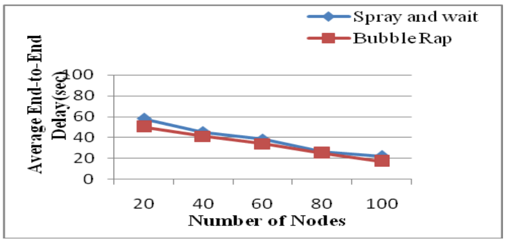

Fig 2: Number of Nodes Vs Average End-to-End Delay

Bubble Rap is compared with Spray and Wait routing protocol, the delay in the proposed system is decreased from 7% to 3%. In spray and wait, fixed number of copies are sprayed to the relaying node and it waits until the destination is reached. So it takes time for the message to reach the destination when compared to bubble rap where message is forwarded based upon the ranking. So delay is decreased in bubble rap.

5.2 Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of total number of data packets received successfully at destination to number of data packets generated at the source. It is calculated by using the formula,

Delivery Ratio=Total number of packets received /Total number of packets sent.

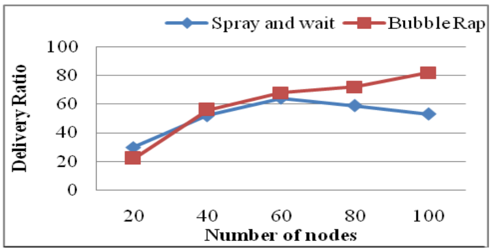

Fig.4 Number of Nodes Vs Delivery Ratio

Bubble Rap is compared with Spray and Wait, the delivery ratio in the proposed system is increased from 6% to 18%.In spray and wait, fixed number of copies are sprayed to the relaying node and it waits until the destination is reached. So it is difficult for the message to reach the destination when compared to bubble rap where message is forwarded based upon the ranking. So delivery ratio is increased in bubble rap.

6. CONCLUSION

Considering the constraint brought by mobility and limited resources in ICMN, particularly for resource-constrained devices it is important for routing protocols to efficiently deliver data. Social based routing protocol bubble rap is based on two social metrics such as community and centrality. Global and local ranking are used in the community for forwarding message to the destination. The proposed system shows that the bubble rap increases the delivery ratio and decreases the delay comparatively with the existing spray and wait routing.

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