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Landmark Centric Routing Protocol for Wireless Sensor Networks in Mobile Delay Tolerance Environments

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Abstract—Delay tolerant networks (DTN) are those networks where instantaneous end-to-end paths among nodes may not be possibly established or are absent for a longer period of time. Continuous end-to-end connections are not possible due to mobility of nodes, low power resources and limited data storage space. To overcome the frequent disconnections, DTMSN routing protocols focuses on the relationships and interests of nodes from a social-aware aspect thus, messages can be delivered to its destination through a series of relay nodes which have some social interactions among them. In this paper a social-aware landmark metric was exploited which indicates the geographical location corresponding to a node interest or a node community. If we take the geographical aspect into concern, some additional relay nodes that don't have direct relation with the destination community but will pass by that location can provide significant aid in making routing decision.

Keywords— Delay Tolerant Network, routing protocols, social grouping, geographical utility

I. INTRODUCTION

Delay tolerant networks are sparse mobile wireless networks which lack continuous end-to-end connectivity from source to destination.Traditional routing protocols for wired and wireless networks fail to work in the DTN environment because they expect a well-established connection between source and destination. Routing protocols developed for DTN should be adapted to this challenging environment by sending multiple copies of data packets to increase delivery probability assuming atleast one of the copies reaches the destination[1]. A store and forward approach [3] is used in DTN networks where Nodes receiving the packet copies store them until they meet other nodes or meet the destination node. Hence routing is a challenging job in delay tolerant environments.

In order to ensure packet delivery in DTNs special routing protocols has been developed which uses the social behavioral patterns of the mobile nodes. This social network routing is a technique based on the social interests and relationships of the nodes in a network. Several popular routing protocols in DTNs are based on this social routing aspect[3][5][10] which route the message based on the nodes interest and relationship of the node but there is still a deficiency in message transfer though we consider this social behavior in our routing decisions. In order to overcome this problem a landmark protocol is proposed which performs routing decisions based on the geographical utility of the nodes. A community structure is formed among the nodes based on the node interests which helps in identifying a node easily and efficient message transfer in a less period of time. As there are several constraints like limited power and limited resourcesand fast delivery in DTNs, this landmark based protocol accomplishes its task in prescribed time.

II. PREVIOUS WORK

Several routing protocols have been proposed earlier for delay tolerant environments by taking the social relations of the nodes into consideration.In the real life, people may belong to multiple communities (or groups), and people from the same community tend to interact more often than the people from different communities and interests. Different community based routing protocols has been proposed which utilizes communities to implement efficient message transmission[1][8]. By taking the contact frequency and duration into account social relations between nodes are detected. Based on the obtained social ties between nodes, each node builds its friendship community where a set of nodes has close friendship amongthemselves. Messages are simply forwarded to the node which is the destination or includes the final node in its friendship community. Thus, hops of message transmission have been greatly reduced. In addition, the friendship community varies over time.

Tamer Abdelkader,et al proposed SGBR routing protocol. SGBR is a heuristic multiple-copy routing protocol. This protocol exploits social grouping among network nodes to increase the possibility of packet delivery, without flooding the network with many redundant copies. A mathematical model of single-copy optimal routing, OPT, is formulated, assuming the availability of present and future node contacts and buffer information. The results are used as a performance benchmark to compare with the heuristic protocols [1].

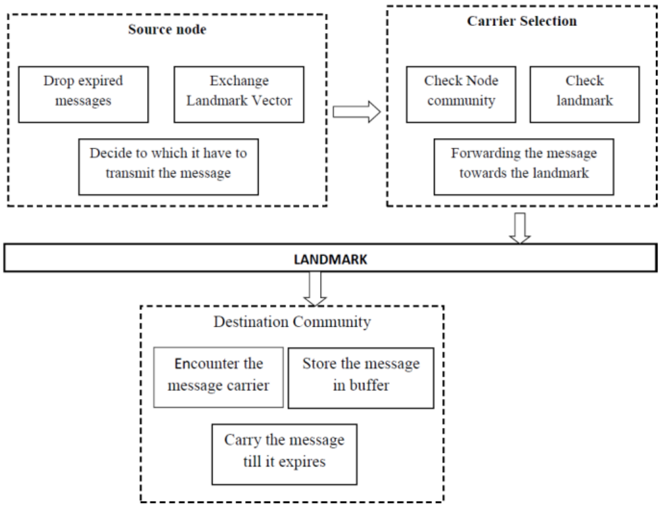
E. Bulutet al proposed Friendship based routing protocol. Three behavioral features are proposed to Identify the friendship between the nodes they are frequency, regularity, longevity. Few nodes contact frequently means their contacts must be long-lasting and are in strong friendship, whereas few nodes meet infrequently but regularly are still considered as friends and this is called weaker friendship. A new metric social pressure metric (SPM) was introduced which is interpreted as a measure of a social pressure that motivates friends to meet frequently to share their messages [2].

P. Costaet al proposed Social cast routing protocol which relies on the notion of utility for the selection of message carriers in order to enable store and forward communication. The utility in social cast is linked to movement patterns and co-location of the nodes as nodes with similar interest are likely to be co-located. Routing in social cast takes place in three phases they are interest dissemination, carrier selection and message dissemination. Each node broadcasts a control message describing its interests to its 1-hopneighbours along with its utility values which helps in identifying the next best carrier of the message or the interested nodes. when the nodes having similar interest encounters then a copy of the message is sent to those nodes [3].

Apart from these several other routing protocols also have been proposed [6][7][9] for routing in DTNS.
Based on these routing protocols a landmark centric routing protocol has been proposed for much more efficient data delivery, which performs the routing decisions based on the geographical utility of the nodes , node interest and node community.

III. LANDMARK-CENTRIC ROUTING PROTOCOL

DTMSN routing protocols follow Social network routing technique for determining the path for data transfer based on social behavior patterns of the nodes ie, social interest and relationships[4]. They concentrate on the relationships between nodes to deliver messages to its destination by a series of relay nodes which have some social interactions [1]. LCRPis a social aware landmark based routing protocol which not only concentrates on relationship between nodes but also takes geographical aspect into consideration which helps in finding the additional relay nodes which though does not belong to destination community but pass through the destination location provides significant help in transferring the message to the destination node or community. This helps in ensuring high packet delivery in lesser time.



LCRP is an extension of SGBR, Social Cast and other popular routing protocols[1][3][6][9] which uses one-to-community multicast scheme. When a message is generated it is labeled with a destination community based on a particular node interest. Label (m) specifies the destination community of message m which helps in identifying whether the member nodes of a community should receive the message or not. Com (n) specifies the label of community that node n belongs to and this information is stored in the nodes n buffer. With the help of these two functions a node decides whether it should receive particular message m or not. If a node does not belong to destination community it chooses the next best carrier of the message through carrier selection method, which determines the relay of the message for each hop. The carrier selection in community structure or landmark has higher priority to determine the next carrier of the message as nodes of same community are more likely to meet each other than an ordinary node. When neither of the two meeting nodes belongs to the destination community then the carrier is chosen based on the landmark utility. This helps in bringing the message nearer to the destination node or destination community and after encountering the destination node at some point of time the message is transferred. This destination node carries the message till it expires.

3.1 Message Delivery

When two nodes meet each other they first drop the expired messages and then exchange their Landmark Vector. Then, for each message, the protocol makes two decisions. If the node is the destination of the message, the message should be delivered to it, if not a new carrier of the message should be determined by using carrier selection method.

Algorithm for Message Delivery( )

1. lmVector(sn) →Landmark vector of node sn
2. msgBuffer(sn)→ Message buffer maintained by node sn
3. dc→Destination community
4. m→message

5. label1(m)=dc
6. The node sn encounters node dn
7. Drop packets with their lifetime expired in node sn and dn 's buffer
8. The node sn exchange landmark vector lmVector(sn) to dn
9. #Sink
10. if ([**lsearch**msgBuffer(sn) m]>=0)
11. if ([lsearch community(dc) dn]>=0)
12. #Deliver message m
13. The node sn deliver the message m to the node dn
14. **lappend**msgBuffer(dn) m
15. End if
16. End if
17. if ([**lsearch**msgBuffer(dn) m]>=0)
18. if ([**lsearch** community(dc) sn]>=0)
19. #Deliver message m
20. The node dn delivers the message m to the node sn
21. **lappend**msgBuffer(sn) m
22. End if
23. End if
24. **CarrierSelection**sndn m dc label1(m)
25. **Proc**copy (msg j dc)
26. global array names n ns array names community tim null msg1 array names lmVector array names Com array names msgBuffer
27. #Forward the data to node dn
28. The node j deliver the message m to the node $n Sn= dn
29. **CarrierSelection**sndn m dc label1(m)
30. End Proc

3.2 Carrier Selection

The carrier selection in community structure or landmark has higher priority to determine the next carrier of the message as nodes of same community are more likely to meet each other than an ordinary node. When neither of the two meeting nodes belongs to the destination community then the carrier is chosen based on the landmark utility. This helps in bringing the message nearer to the destination node or destination community and after encountering the destination node at some point of time the message is transferred. This destination node carries the message till it expires.

Algorithm for carrier selection( )

1. **Proc**CarrierSelection (sndn msg1 dc labelv)
2. global array names Com array names lm array names nd
3. if ((Com(sn)==labelv) and (Com(dn)==labelv))
4. **copy** msg1 dn dc
5. elseif ((Com(sn)==labelv) and (Com(dn)!=labelv))
6. setnew_carrier(msg1) sn
7. copy msg1 new_carrier(msg1) dc
8. elseif ((Com(sn)!=labelv) and ($Com(dn)==labelv))
9. setnew_carrier(msg1) dn
10. copy msg1 new_carrier(msg1) dc
11. elseif (($Com(sn)!=labelv) and ($Com(dn)!=labelv))
12. if ($nd(sn,$lm(dc))<$nd(dn,$lm(dc)))
13. setnew_carrier(msg1) sn
14. copy msg1 new_carrier(msg1) dc
15. End if
16. if (nd(sn,lm(dc))>nd(dn,lm(dc)))
17. setnew_carrier(msg1) dn
18. copy msg1 new_carrier(msg1) dc
19. End if
20. End if
21. End Proc

3.3 Performance Metrics

Packet Delivery Ratio:It is the number of packets delivered to the destination. This illustrates the level of data packets delivered to the destination.

∑ Number of packet receive / ∑ Number of packet send

Delay: the average time taken by a data packet to arrive at the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that are successfully delivered to destination are considered.

∑ (arrive time – send time) / ∑ Number of connections

Routing Overhead:Resource consumed or lost in completing a process to discover the route is called as routing overhead. In our scenario, the number of packets which carries the routing information is the routing overhead.
RO=Number of RREQ+ No. of RREP+ No. of RERR packets.

IV. SIMULATION ENVIRONMENT

NS2 is one of the most popular open source network simulators. The original NS is a discrete event simulator targeted at networking research.It is used for thesimulation of network protocols with differentnetwork topologies and is capable of simulatingwired as well as wireless networks. Landmark routing protocol has been implemented using ns2.
The simulation parameters used in the protocol was given in table below.

Simulation Environment Parameters	Default value
Simulation area	5000m x 5000m
Number of hosts	100
Hosts speed	[1-6] m/s
Transmission range	250m
Number of interests	4
Number of communities	4
Simulation time	20s

parameter	Value
Channel type	Wireless
Radio-propagation model	Two ray ground
MAC type	IEEE 802.11
Interface queue type	PriQueue
Antenna model	OmniAntenna
Communication Protocol	UDP(User Datagram Protocol)
Traffic Model	CBR(constant Bit Rate)
Max Packet in interface Queue	50
Number of Mobilenodes	55

We have taken HCMM as the human mobility model to represent the default network environment of LCRP. The network area is 5000 meters × 5000 meters with 100 nodes in the network,each node has a transmission range of 250 meters. These settings are able to provide a sufficiently sparse and disconnected network. We assume that half of the nodes are publishers and all nodes are subscribers, and messages are published during the interval [3000 s, 4000 s] over a total period of 28800 s, with a publishing interval of 60 s. The amount of node interests in the network is 4. When a node is moving, the speed is uniformly chosen at random over the range of 1 to 6 meters per second, and the pause time is set to be 10 seconds. Each node has a large enough buffer to store messages, unless the message gets expires it won't be discarded.

V. RESULTS AND ANALYSIS

Performance of LCRP is compared with SGBR and Social-Cast [1][3]. Simulation results show that LCRP achieves high packet delivery ratio, less delivery cost and low average delay when compared to SGBR and Social-Cast routing protocols.

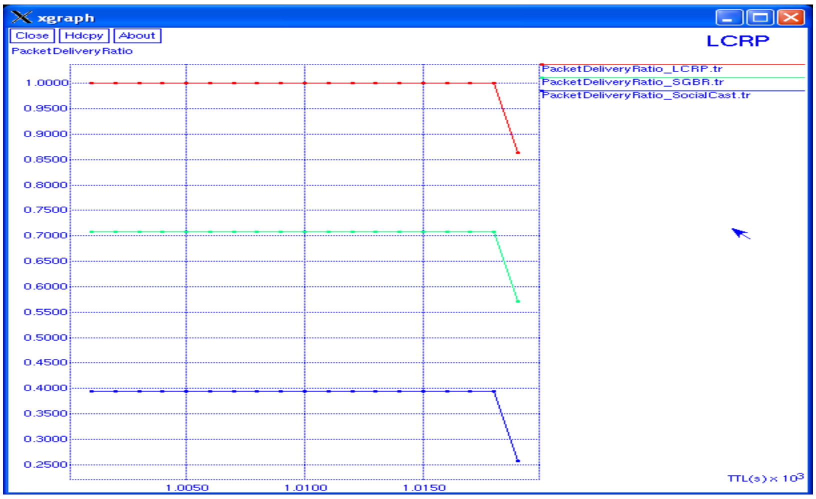


Figure 5.1Comparison of Packet Delivery Ratio of Three Protocols

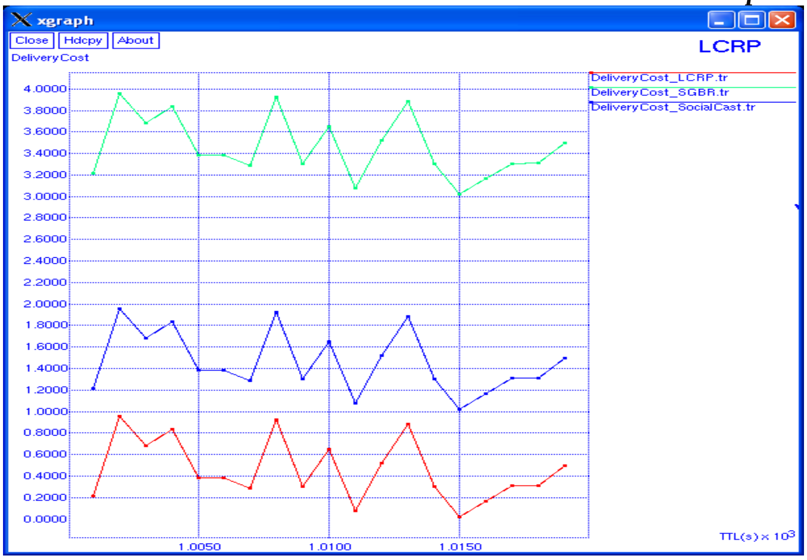


Figure 5.2 Comparing the Delivery Cost of Three Protocols

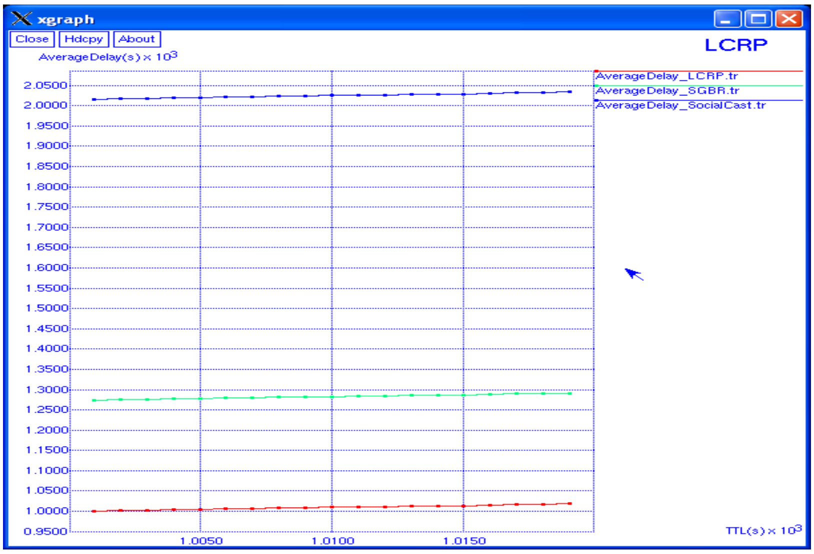


Figure 5.3 Comparison of Average Delay of Three Protocols

VI. CONCLUSION AND FUTURE SCOPE

In this project an analysis is made on the effect of social network theory to forwarding scheme and node mobility in DTMSNs. Landmark a mobility-associated social-aware metric is considered which is used to accurately predict node mobility geographically on the basis of social network analysis. Using this metric a Landmark centric routing protocol is implemented which is an extension to the existing routing protocols in DTMSNs. Performance of this protocol is evaluated by comparing it with existing DTMSN routing protocols SGBR and Social-Cast. Simulation results show that this protocol achieves highest packet delivery ratio, low delivery cost and less average delay when compared to the other two protocols.In future, we can estimate the geographical landmark information to implement LCRP more accurately. Evidently, a more accurate estimation will lead to a better performance of LCRP.

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