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RESEARCH ARTICLE

Social Based Routing in Delay Tolerant Network

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Abstract: Delay tolerant network (DTN) is a kind of network where there is no end to end connection. Hence, route establishment between source and destination is difficult and also message delivery in such network is difficult. Probabilistic delay tolerant network uses past encounter records to forward the data or to select the forwarder. Probabilistic routing has limited local view of the network. So, most of the time, it cannot select better forwarder to route the message. Epidemic routing floods the message into the network. It requires more network resources. In social based routing, each node possesses a social map of its surrounding social network to select the forwarder. Here we have focused on different routing techniques based on social behavior of the network to establish the route from source to destination.

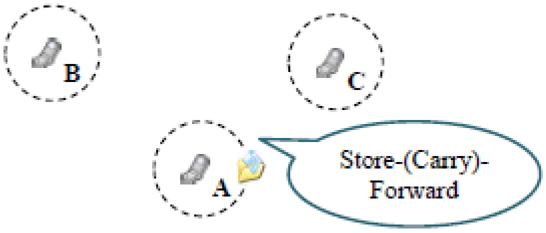
Index Terms: network, DTN, Routing, Epidemic routing, probabilistic routing, floods

1. Introduction

Communication network that may be wired or wireless has always been assumed that there is connection present at all the time. That is there is end to end path present between source and destination. But in DTN that is in delay tolerant network, there is no end to end path.

Delay tolerant network is network where nodes are mobile in nature. So, there is no fix location of any node in network. Hence finding route in this type of network is difficult and challenging

DTN is an ad hoc wireless network and has characteristics such as intermittent connectivity, long or variable delay and low delivery ratio. Hence routing in such type of network is difficult. In sparse mobile ad-hoc network, mobile density is low and also the contacts between the nodes in network doesn't occur frequently hence network graph is rarely connected. Message delivery in delay tolerant network must be delay tolerant. DTN architecture required to the store messages in non-volatile memory when reliable delivery of message is required.



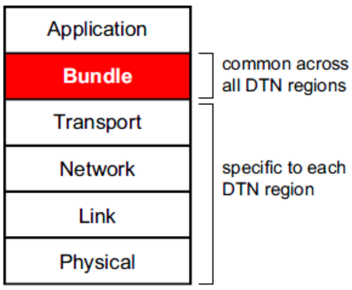
DTN data delivery

In DTN, data delivery occurs through the physical movement of the node. If node A wants to send message to node B it may be possible that shortest path may be from node C, which moves towards the range of node B. Here in DTN, there is no end to end connection hence store and forward carry paradigm comes in picture.

A. DTN Architecture

In this delay tolerant network architecture, source generates bundle that is no. of messages combined to form bundle and stores it until it doesn't find any relay node or destination node. If source doesn't find any relay node it stores that message and moves hence this DTN architecture is also call as store-carry-forward architecture. Relay node may store the bundle if it doesn't find any relay or destination node. DTN architecture defines different types of contacts as:

- Opportunistic.
- Scheduled.
- Predicated.



DTN overlay network architecture

B. Applications of Delay tolerant network

- Vehicular Communication.
- Battlefield.
- Mobile military deployments across seas and desserts.
- Wildlife Tracking.
- Deep sea communication.
- Interplanetary Internet.

Delay tolerant network or disruption tolerant network is also called as episodically connected network. Existing routing algorithm such as AODV and DSDV cannot delivery adequate performance in delay tolerant network. There are number of routing strategies have been proposed. If the future topology of network is known then this type of network is deterministic. If nodes know nothing about the network then nodes forwards the messages to its neighbor node. Protocol used in this type of network is called as epidemic.

C. Types of routing algorithms

C.1 Deterministic routing

Here, in deterministic routing, future movement of the node is completely known by the network. Here path is selected based on available knowledge about the motion of the hosts in the network. This type of routing is also called as forwarding based routing. In forwarding based routing algorithm there are less resource wastage because when message reaches to the destination there is no other copy of that message present on the other node than the destination. One of the examples of deterministic routing is probabilistic routing. In Probabilistic routing algorithm, nodes probability has been calculated to find the nodes probability of delivering messages to the destination. Nodes probability has been calculated by nodes past encountered records. Messages are forwarded to the node which has higher delivery ability to meet the destination than the other. Probabilistic routing algorithm does not flood the message into the network.[3]

In Utility base routing, utility function is used for data forwarding and decision making which chooses the nodes with higher utility. Utility matrix can be frequency of node encounters.

In community based routing, nodes are grouped into communities. Nodes which are within the communities have strong connections.

C.2 Stochastic routing

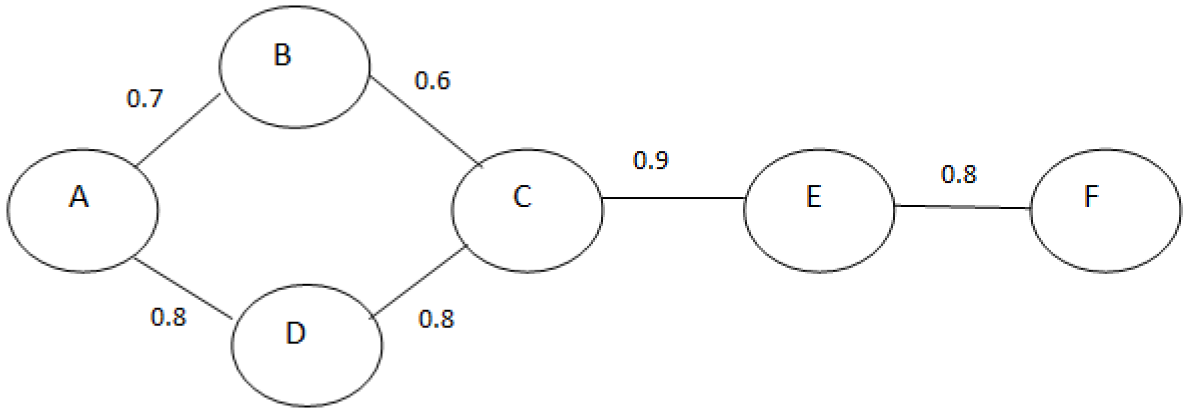
Here, in this network behavior or nodes movement is not known. This type of routing is also called as opportunistic routing where no information is known about connectivity and mobility of the nodes. There are number of routing strategies proposed in such type of network such as Epidemic routing. This type of routing is replication based routing. In replication based routing there are number copies of message or message is present in the network and it has high delivery ratio. Replication based routing algorithm are Epidemic routing, prophet routing, Maxpro, bubble rap protocol etc. Epidemic routing is flooding type of routing protocol. Here when two nodes meet, they exchange their messages with each other and replicates message from the other node which is not on its memory. It requires high storage and transmission resources. As there is less no. storage space and resources in delay tolerant network hence. This epidemic routing algorithm is not efficient and not practical.[3].

There is one more type of routing algorithm present in delay tolerant network such as social based routing.

2. LITERATURE SURVEY

A. SMART: Utilizing Distributed Social Map for Lightweight Routing in Delay-Tolerant Networks [1]

In this paper [1], each node maintains social map to records it surrounding social network. Each node in network contains a map of it surrounding network. When two nodes in the network meet, they exchange their social map



Social map of E[1]

Figure contains social map of node E. When node E meets C they both exchange their friends map. Then, after exchanging friend map E will get to know that messages for node B could be forwarded to node C. Each node maintains its top L friend list. Top L friend list contains the nodes whose meeting frequency is greater than the other. The stability of these top L friend is calculated by MIT reality project and Huggler project.[1] Benefits of this social map are it provides much Browder view of the network and it finds the route of any length. Due to the stability of these top L friends it requires less frequent update of this social map. Social map can be constructed by assigning friendship rank to each top L friends of the node.

- Algorithm steps:

When any two nodes say node A and node B meets with each other. They exchange their friends map with each other, which updates their social map. Node A and node B process the messages sequentially. By using this social map, if destination node is absent, then node check whether the other node has higher degree. If other node has higher active degree, then send the message to that node. Active degree means it has more contacts with other node. If destination is present then node checks if the other node has shortest path to the destination than itself if it present then it will send that message. Shortest path can be calculated by using Dijkstra algorithm. If incoming message has no space that is storage is full on node then that message is dropped which lived for longest period of time. Then the process of current message stops [1].

B. Social Network Analysis for Routing in Disconnected Delay-Tolerant MANETs [2]

In this paper [2], nodes centrality in graph theory can be stated as qualification of relative importance of node in network. Estimation of nodes centrality is done to identify the bridges in the network. Central node has higher capability of connecting other network nodes. There are three methods to measure centrality of the node are Freeman's degree, closeness and betweenness measures. Degree centrality can be calculated as number of direct ties with other nodes. Node with higher degree centrality has higher contacts with other node. Central node may act as conduit between the networks. Degree centrality for given node can be calculated as,

Closeness centrality defines the time taken by information to spread in network. Betweenness centrality is calculated by number of nodes which are indirectly connected to the ego node. Ego network is defined as single node and number of links connected to it.

Here in this algorithm, next node is selected depends upon centrality and similarity of the node. Consider node A and node B. in this algorithm communication between the two nodes that node A and node B is shown. When nodes B receives hello message from node A then it verifies that node A is the new neighbor. Then node B send messages which are destined to node A and also send encounter request. Then node A sends list of nodes it has encountered. This list is then used to update betweenness value and similarity value on node B. Both node exchange a summary vector containing a list of destination nodes they are currently carrying messages for and along with their own locally determined betweenness and similarity value for each destination. For each destination in summary vector, node B calculates the SimBet utility of node B and node A. SimBet utility is calculated by centrality and similarity of the node. SimBet utility is calculated by the following equation. The similarity utility SimUtiln and the betweenness utility BetUtiln of node n for delivering a message to destination node d compared to node m is given by:

$$SimUtiln\,(d) = \frac{\mathrm{Simn\,(d)}}{\mathrm{Simn\,(d) + Simm\,(d)}}$$

$$BetUtiln = \frac{\mathrm{Betn}}{\mathrm{Betn + Betm}}$$

If node B has higher utility than node A, then node B add all the destination to the destination vector for which messages are requested. If all the destination are compared then node B sends message request list to node A. node A then sends all the messages which are requested by node B. after receiving transfer message from node A the message is added to message queue of node B [2].

C. Socially-Aware Routing for Publish-Subscribe in Delay-Tolerant Mobile Ad Hoc Networks [3]

In this paper [3], publish/subscribe concept is used. Node may act as publisher or subscriber. Both publisher and subscriber are not aware of each others in a network. Information producer is publisher. Information producer sends message in a network. But in publish subscribe concept, messages are send to subscribed node only. Here in this algorithm, selection of relay node is based on utility. This algorithm enables the store-and-forward communication. . To know the good carrier of the node n with respect to matching i is the utility of node with respect to interest i. The main aim of socialCast is to use of carrier for messages hosts which have been co-located often with the interest subscribers. There are three phases in this socialCast routing as interest dissemination, carrier selection, and message dissemination. These phase of execution repeats after T units and which executes one after the other. There is no need of synchronization between nodes. Utility value in socialCast is calculated by using movement patterns and colocation with other hosts.

Control messages are broadcasted in the first phase that is interest dissemination which contains list of its interests of its 1-hop neighbors. Also list of utility values is also broadcasted in this phase. These values are recomputed on the node itself. This information is important to take the decision of message forwarding. This information is stored in routing tables of the neighbors. In this phase, piggybacking of identifiers of last λ messages are also received on utility message. In the second phase that is in carrier selection, recomputation of utility of the local node Ui for interest i is done. This utility for each interest i is compared with the highest utility among those communicated by neighbors. That is Un,i > Ui + e this means that for interest i, node n is better carrier than the local node. e is an hypothesis threshold. This threshold forbids that the message is bounced back and forward between hosts with similar fluctuating utilities. Local node is best carrier for messages tagged with i. [3]

In this phase are by using new subscription and utilities, content of the buffer is re-evaluated. A copy of messages matching an interest i is immediately sent to all neighbors whose subscriptions contain i. this only ensures that messages are sent to nearby interested node and this doesn't mean these nodes becomes next carrier for the message. That is these messages are not inserted into the nodes buffer but delivered to the application layer.

Message is forwarded to the recipient who doesn't get the message before which avoids unnecessary traffic. This is done by last message list. The last phase is message publishing, here in this phase, insertion of published message into buffer this message in the buffer is sent to the interested subscriber and also moved to better carrier. This socialCast works on the data in the buffer but not how much content is there in buffer got inserted. Publish can duplicate message and it duplicates at the time of publish. Publish operation inserts γ copies of the message to ensure high delivery ratio. Whenever better carrier is found then node removes one copy from the local buffer and sent to that new carrier this ensures that the message copies are spread over time and space across the system. Hence, network contains γ instance of message.

D. SMART: A Social and Mobile Aware Routing Strategy for Disruption Networks *[4]*

In this paper [4], community based routing strategy has been proposed. To form a community or to form a group of nodes dynamic community partitioning process that is m-partition is applied. Nodes are grouped in to communities as C={C1,C2,….,Cm}

Here in this, each node maintains two tables: local contact table and remote contact table. Each node has unique community id Ci and set $\pi(Ci) = \{nj \mid \forall nj \text{ in } Ci\}$ which indicates members from same community. Local contacts contains node from the same community that is from the local community and remote contacts are from different communities.

N1	N2	N3	..	Ni	Nn
Ci1	Ci2	Ci3		-1	Cin

Table no.1 Local contact table

Here, Cij (j=1,2,3,…,N). Nj(j=1,2,…,N)
Cij=-1.indiactes contact with itself which is not countable. Contact frequency is calculated by number of encounters over the time period ΔT.

$$x = \frac{\sum_{t=0}^{T} X(t)ij}{\Delta T}$$

C1	C2	C3	…	Ci	Cm
Ni1	Ni2	Ni3		-1	Nim

Table no. 2 remote contact table

Cj (j = 1; 2; _ _ _ ;M) is community id.
Nij (j = 1; 2; _ _ _ ;M) is the sum of encounters that ni with nodes in Cj over ΔT.
Cj = Ci here local contacts are not reflected into remote contact table.

Source s wants to send the message to destination node D. if both node S and node D are from same community then apply intra-community communication process .if both the nodes are from different community then inter-community communication process is applied.

Intra community process: here in intra community based that is both are from same community then utility based strategy is used for data forwarding. But to avoid blind spot and dead end problem, social feature and decay function is used. Social centrality and social similarity are the two factors of social network. Social centrality can be calculated as number of common friends between the pair of nodes and social centrality can be calculated as structural importance of node in a network.
Sij(t)=|Fi(t) ∩ Fi(t)|+1
Fi(t) (Fj(t)) is set of friends of node ni (nj) at time t. intersection is fro common and addition of is to eliminate the effect of zero.

$$Ci(t) = \frac{\sum_{k=1}^{N} dik(t)}{N}$$

N= number of nodes in community.
Dik(t)=1 if direct link between ni and nj at time t.
These both can be calculated locally in DTN.
Social similarity is used to encounter effect between the two nodes.

$$Ui,d(T) = \sum_{t=0}^{T} X(t)id * Sid(t) * Di(T-t) \qquad \text{----------1}$$

X(t)id=1 when t=0.

In Intra community routing principle, by calculating from equation 1, node which has higher value is selected as forwarder.

Inter community communication:
Fringe node acts as agent. These fringe node acts as bridge nodes for inter-communities. Fringe node is capable of communicating between the communities. Selection of fringe node is done by

$$Sc = \sum_{k=1}^{M} \phi\ (nik, njk)$$

Sc>1 then ni has better connection than nj. Hence ni becomes new fringe node and tells it to other nodes in the local community.

Source node s wants to send message to destination node d and if both are from different community then fringe node from source checks if there is direct connection between source fringe node and destination fringe node. if there is direct connection is present then source fringe node can directly send the message to destination fringe node. if one or more fringe node contains the connection with the destination fringe node then select the fringe node which has more encounters with the destination fringe. If there is no direct connection between source fringe node and destination fringe node then select fringe node which has maximum number of encounters with outside the community by using remote contact table. Then, source node forwards the message to selected fringe node by using intra community routing strategy. Then new fringe node uses utility function as in intra community routing to send the message to destination.

The utility function is as follows:

$$\mathrm{Uf,c'(T)} = \sum_{n=0}^{T} \mathrm{X(T)fc'} * \mathrm{Sf,c'(T)} * \mathrm{Dt(T-t)}$$

X(T)fc'=1

According to this utility function, fringe node selects the next relay by using higher utility value with the destination. This will continue until message reaches to destination.

3. Conclusion

DTN is delay tolerant network in which there is no end to end path. Hence routing in such network is difficult. In this paper we have discussed different routing algorithm in delay tolerant network. Routing algorithm such as social based routing where nodes social network is created. Each node maintains its social map of surrounding social network. Social network is used to select the forwarder in a network. This algorithm selects better forwarder than the other routing algorithms.

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