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Routing algorithms classification & Proposed Routing Algorithm for DTN

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ABSTRACT : This paper provides an introduction to Delay Tolerant Networks (DTN)alogorithms and would touch upon some basic classification. Continuous connectivity is difficult in today's wireless world. The data preservation and security in challenged and intermittent network, is of paramount importance. In this paper, we will see how DTN provides detail classification and discription for further studies & application.an effective alternative. Security of data becomes important in disrupted networks; this paper would also discuss Praposed Routing algorithms with DTNs.

Keywords: *Bundle Protocol, Contact Patterns, DTN, Flooding, Forwarding, Routing*

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In the literature of DTN, the routing protocols are categorized into two broad categories :

I) Flooding based routing approaches
II)Forwarding based routing approaches

In the literature, there exists a variety of routing algorithms for DTN. Here we have discussed some of them.

I) Flooding based routing approach

This type of routing strategy can be opted even when the nodes have no knowledge about the nodes in the network. In such case, epidemic routing algorithm is chosen in which the sender node replicates the message to each node it met so far. Replication based routing can comparatively give better results but it consumes more network resources because for a single message to be delivered the whole network could be holding so many copies of that message. The Flooding based routing is further classified into two types:

- **Replication Based:** Replication based routing allows the network nodes to create the replicas of the received message. The maximum number of replicas generated within a network for a particular message could be n-1, where n denotes the number of nodes in the network.
- **Quota Based:** In Quota based routing each message is assigned with fixed quota i.e. the number of replicas for a particular message is limited.

1) **Direct Contact**

In Direct Contact [21] routing algorithm, the source node will directly forward the
bundle to the destination node. The source node first creates the bundle and then waits for the destination node. As the algorithm does not require any information about the network so it falls in the category of flooding based routing. The amount of delay incurred in delivery of bundle is very high and the cost involved in routing the bundle is very low.

2) **Epidemic Routing**

In Epidemic routing [22] each node replicates the message to every other node it
met if the other node is not having the message copy. The message replication is done after checking the summary vector. The summary vector is maintained at each node that stores the information about all the messages that are passed by that node or currently stored in its buffer. In the literature, different enhancements were proposed to the original Epidemic routing algorithm such as prioritized epidemic and immunity based [23] epidemic.

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3) **Two-Hop Relay**

In this approach [19], the source node replicates the message to a large number of relay nodes. In this approach a message will be delivered to the destination within two hops only i.e. either the source node directly delivers the message to destination or the relay node. Relay nodes will not further replicate it to any other node except the destination node i.e. after one hop transmission of message, the direct contact delivery approach is used and the relay node wait for the destination to come in contact.

4) Tree Based Flooding

T. Small et al [24] have given the concept of binary tree based algorithm. The algorithm works upon the concept that the source node must be limit with the number of replicas to control the width and depth of the tree i.e. when the nodes are limit with number of copies then they can go in depth up to a certain level. Each node can have max of two child nodes so the replicas are equally distributed in between them. After this receiving phase, the nodes start offloading the message to collection stations so to reach the destination.

5) Spray and Wait

The Spray and Wait [25] algorithm is the advanced version of the epidemic routing.
In this algorithm the nodes are not distributing the replicas to each and every node but an optimal number of nodes (say m) are selected to which the source node will relay the message. There are two phases in this approach: Spray and Wait. In Spray phase, the source node replicates the message to the m nodes and these m nodes will further relay the message to m relay nodes. If the destination is not found in spray phase then the

Protocol	Number of Messages generated	Message delivery Ratio	Average delay	Resource consump-tion
Direct Contact	Single	Low	High	Less
Epidemic	N-1	High	Low	High
Two-hop	K	Medium	Medium	Less
Three-based	1+log(N/2)	Medium	High	Medium
Spray and Wait	>=K	Medium	Medium	Medium

Table 1: Comparison of flooding based routing algorithms

II) Forwarding based routing approach

This type of routing takes place when nodes have some relevant knowledge about the other nodes in the network. In this type of routing no node will generate replicates of the messages. Each node will search for the best suitable relay nodes and forwards the message to them. This approach reduces the extra resource consumption as replication of messages is not permitted. This type of routing is used when the network resources are limited such as buffer size at each node, battery life, etc..

1) NECTAR

The NECTAR [26] algorithm has given the concept of neighborhood index table that is maintained at each of the node. This table stores the information about the meeting frequency of the node with every other node in the network. The node with higher meeting frequency will be assigned a higher index value. When a node needs to forward the message to a particular destination, then it will select one of the relay nodes that

Routing algorithms classification have highest index value for the respective destination.

2) Source Routing

The Source routing [27] consist of two phases i.e. route discovery phase and route maintenance phase. Initially a route is discovered by sending control packets towards a destination node. Each of the intermediate nodes will append its address in the packet. Each node also maintains a cache for the routes that the node has learnt over time. When the packet reaches at the destination the entire route is appended in the packet only. In route

maintenance phase if a link failure is detected then a route error message is broadcasted by the source node.

3) Per-Hop Routing

In Per-Hop routing [28], each intermediate node will decide the next node to which the packet is to be forwarded for a particular destination. This approach has better performance than Source routing because the more updated information is used than Source Routing. The source node sends the message to all the connected nodes, then these nodes search for the closeness of the destination node and the node have the destination node as closest will further broadcast it. This process goes on and thus the refinement of routes keep going.

4) Per-Contact Routing

The most updated information is being used in Per-Contact Routing [29] because when any intermediate node receives any message for a particular destination then it will update its routing table and will check the current up contacts and select the appropriate node for relaying the message and forward the message to the most appropriate node.

Protocol	Information maintenance	Message delivery ratio	Average delay	Resource consumption
NECTAR	Medium	High	Normal	Medium
Per-hop	Medium	Medium	Medium	Low
Per-contact	Medium	High	Low	Medium
Source	Normal	Low	High	Low
CRHC	High	High	Normal	Medium

Table 2: Comparison of forwarding based routing algorithms

5) Hierarchical Forwarding and Cluster Control Routing

This approach introduces the concept of clustering (i.e. grouping) of nodes on the basis of link property and communication characteristics. After formation of clusters,a cluster head is selected depending upon some criteria. In [30], the cluster head node is selected based on the higher stability or the higher quality among all nodes within the cluster. The routing decisions are then taken by the selected cluster head.

Delegation Forwarding

In Delegation Forwarding, the referenced papers [15] and [31] has given a concept to calculate a quality value of node. As per their algorithm every node has a quality value and a threshold value for each message. Initially the value of the threshold is equal to the value of the quality of the node generating the message. When this source node met with other node, it will compare its threshold value with the quality value of other node, and if found greater quality value, the node will update its threshold value equal to the quality value of the node and will forward the message to this available node if it is already not holding the message. Later on,Xiao et al has proposed the enhanced version of delegation forwarding [32].

Proposed Routing Algorithm for DTN

Problem Scenario

Consider a scenario in which numbers of nodes are randomly deployed over a certain region of interest. The nodes communicate with their neighbors by exchanging messages whenever they come in proximity with them. All the nodes make use of Bluetooth interface for communication with their neighbors. Here we are considering uniform range of transmission i.e. some group of nodes are taken, and the buffer size, speed of movement of nodes and the range of transmission each node from a particular group are same. These nodes communicates with similar power level and thus covering uniform area. Initially none of the node is aware of the geographical location of itself as well as of other nodes.

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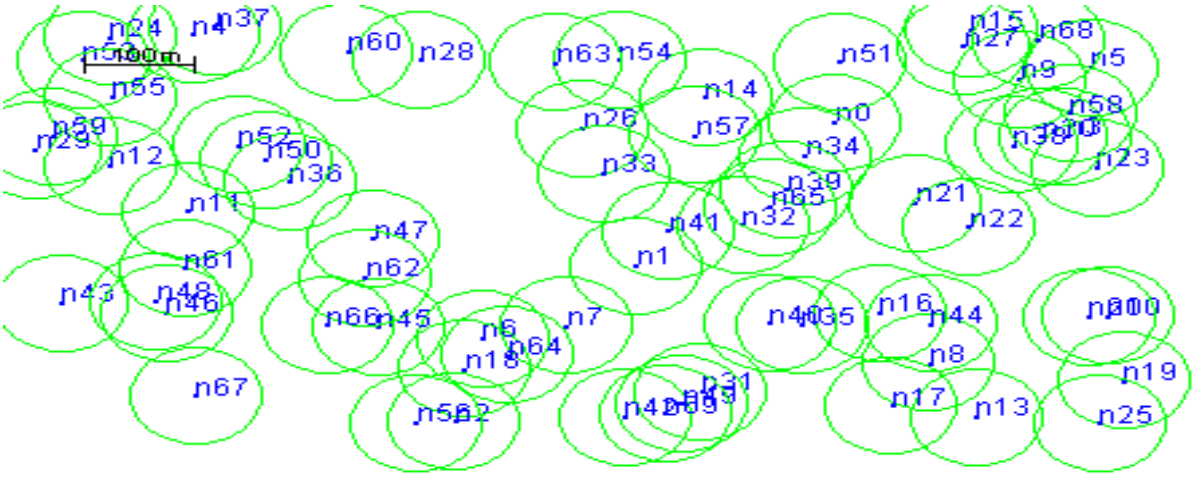

Figure 1: Randomly distributed nodes over a region

Approach

In DTN, if n nodes will store the information about all the n nodes in the network then overhead will be increased as to distribute this knowledge to all the nodes will consume the network resources. So it is better to group the nodes on some basis and then store the network information on only k nodes in n node network where k¡ n and all the nodes can be updated with the information when it will be needed.

Proposed Algorithm

In our protocol we have used following nomenclature.

- **Cluster:** The cluster is a group of closely situated nodes.
- **Cluster nodes:** The member nodes of a cluster.
- **Cluster-Head:** The node having the highest Nodal degree among all the cluster member nodes.

Node-Id

- **Gateway node:** A node associated with two or more than two cluster-head.

In our approach, we create clusters on the basis of node’ s Nodal Degree. Nodal Degree can be defined as the number of other nodes a node can hear at a particular time.The cluster is being created by the highest degree node which announces for becoming Cluster Head(CH) and all the nodes which can hear the this highest degree node(CH)would get themselves associated with this CH and create a cluster. The lower degree nodes will always accept the broadcast of higher degree nodes of being CH. There are three phases in this algorithm:

1. Neighbor identification and cluster formation
2. Information sharing
3. Message forwarding

1)Neighbor identification and Cluster formation

1. Initially at the time of start up, every node will broadcast a Hello packet with its Id because the degree of node will be zero and then start maintaining a Neighbor degree table. This broadcasting is done to identify the neighbors.

2. As per the table created, nodes will calculate their degree and broadcast this updated degree to form a cluster.

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Subsequently nodes will keep updating their degree after a time span.

Node-Id	Nodal Degree	neighbor nodes	Associated CH-Id

Table : Neighbor identification

Node-Id	**Nodal Degree**	**neighbor nodes**	**Associated CH-Id**
A1	3	A2,A5,B2	B2
Own	-	-	-

Table : Neighbor information maintenance

3. After broadcasting , nodes will listen and maintain a Neighbor Information table of adjacent nodes and their nodal degree.

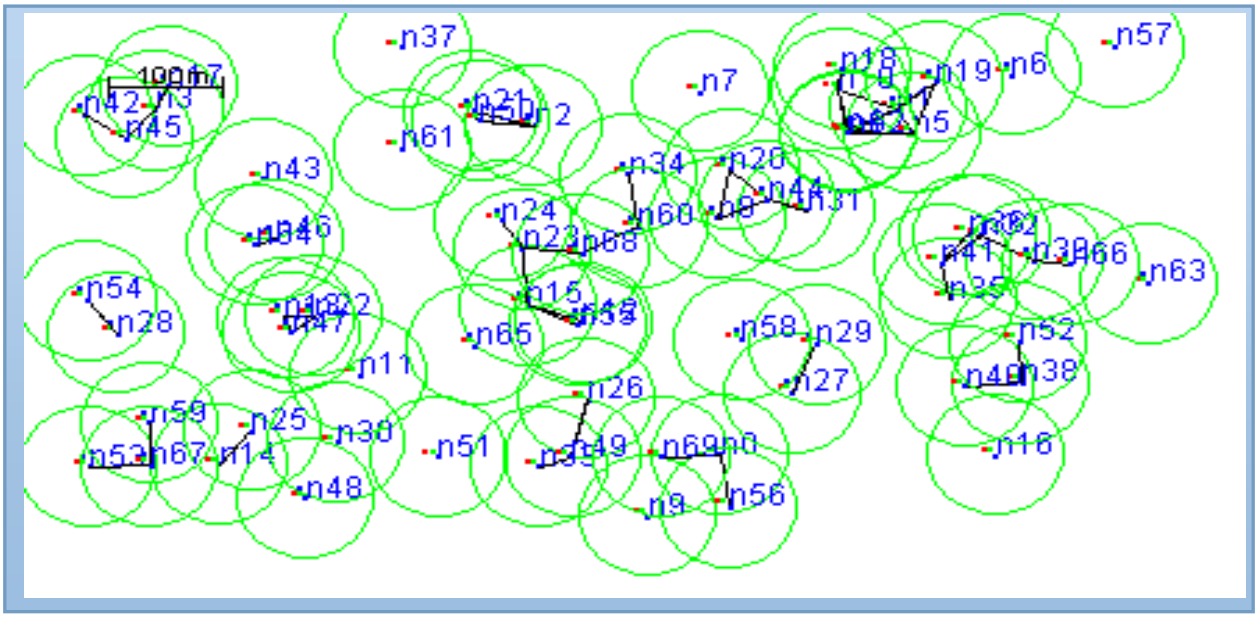

Figure : Cluster formation

4. Every node will look up its degree table and compare its degree with other nodes.For any node i, Ni is the node Id, NDi is the node degree and NDmax(i) is the highest degree in the table of Ni. Based upon this comparison there will be three cases:

- Case 1: ND i >ND max(i) i.e. Node itself has the highest degree compared to any other node in its table

  - Node will announce for being Cluster-Head.

- Case 2: ND i <ND max(i) i.e. Node has other higher degree nodes , in the table, than its own
  - Node will wait for other node to broadcast and will get associated with every node which has broadcasted for being

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Cluster-Head

– Node may have two or more equal higher degree nodes in it’s table and thus waiting for broadcast from those higher degree nodes but these higher degree node belongs to some other CH then this node will become leaf node.

• Case 3: ND i = ND max(i) i.e. Node has other nodes with the degree equal to its own

– Every equal degree node will broadcast for being cluster head and will get associated with other equal degree cluster head.

2) Information Sharing

• After the clusters have been created, every CH will maintain a Neighbor Informa-tion table .
• Every node will maintain two tables
– Neighbor Information table
– History table

3) Forwarding Part

• Any node (S) which wants to send any message to a set of destinations , will send the message (M) to its CH with the destination EID.

Node	Meeting Frequency
-	-

Table : Meeting history

Destination Id	Meeting Frequency
-	-

Table: Destination look up

• CH will check if the destinations are within the cluster or out of its cluster nodes.
• If the destinations are within the same CH, then the CH will directly forward the message to the destinations.

•Otherwise CHs will broadcast a message to know about which cluster node has met with the destinations with what frequency. CH will maintain this history update of its Cluster nodes and forward the replicas to the nodes having the highest meeting frequency with destinations.

•Then the CH will check the Nieghbor Information table and find out which nodes belong to other CH, then CH will forward the replicas to these nodes so that the message get quickly distributed over the network region.

4) Motivation

DTN is a sparse network and it faces frequent disconnections, but to reduce the number of replicas for delivering a particular message is also important because thenumber of replicas present in the network is directly count as the cost of delivery for that particular message. In DTN, if n nodes will store the information about all the n nodes in the network then overhead will be increased as to distribute this knowledge to all the nodes will consume the network resources. So it is better to group the nodes on some basis and then store the network information on only k nodes in n node network where k < n and all the nodes can be updated with the information when it will be needed.

Conclusion

In the proposed algorithm, we are using the current availability of nodes as well as the meeting frequency. This algorithm is suitable for the environment where the nodes have a limited mobility speed or the nodes come in contact with a each other for a while. The cluster based approach has a main advantage that it is better to store the n node information at k nodes only. Where n is the total number of nodes in the network and k is the number of cluster-Head nodes in the network. So this algorithm proposes the idea to consume less network resources in the form of buffer storage.

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