

# Multipath Routing in Delay Tolerant Networks Using Hypercube Based Social Feature

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**Abstract:** In our day to day life it has now become very important to send or receive data over large distance within limited time and to process this for further use. The delay tolerant networks gives facility for this type data sending and receiving methods using different protocols and various types of networks using various routing strategies. This consist study of existing methods for routing in delay tolerant networks. We propose the algorithm for routing which obtains confidence and reliability of nodes in network. Formulating confidence the best nodes are chosen to send data from source to destination in order to reduce delay, delivery rate and latency.

**Keywords:** delay, packet delivery rate, delay tolerant network, latency, social feature.

## 1. Introduction

In day to day life is now very important to send or receive data correctly and within time to destination or from source. Therefore to transfer it through network it can be some time erroneous or may introduce with some useless part to damage it. Recently the data can be send through delay tolerant networks using various different approaches and using different routing methods. The recent work in sending data consist of various results considering various parameters like delay , throughput, latency, number of nodes in a network, types of networks used, topology, algorithms to send on networks, etc. A delay tolerant network is communication network designed to withstand long delays. It is capable of storing packets in intermediate nodes until such time as an end-to-end route can be established. There is no end-to-end path between some or all of the nodes in Delay Tolerant Networks, which makes routing quite different from other types of wireless networks. In a delay-tolerant network, traffic can be classified in three ways, as expedited, normal and bulk. The need of delay tolerant or disturbance tolerant networks came in picture from 1970's, where in 1980 the use of ad hoc networking is and in 1990's the use of MANET was started for routing.

## 2. Related Work

The routing in delay tolerant networks has many protocols among them some can be named as Epidemic routing and two-hop forwarding routing , Spray and Wait routing , Spray-and-Focus , efficient adaptive routing etc. And considering them in different networks such fully cooperative, non-cooperative, and probabilistic cooperative. The Uichin Lee, Soon Young Oh, Kang-Won Lee, Gerla analyzed Delay tolerant networks for impact of various parameters like buffer size, multi-user diversity among multicast receivers, and delay constraints on the throughput [1]. In case of routing performance in cooperative networks the delivery delay and communication cost observed and expressed in terms of numbers of copies of a packet circulating in the network at the time of delivery. These characteristics of routing process applied to stateless delay tolerant protocols such as epidemic, two-hops, and spray and wait. Resta, G. Santi, consider fully cooperative, non-cooperative, and probabilistic cooperative scenarios, and derive expressions of the packet delivery rate (PDR) under certain framework. [3] In delay tolerant networks one concept was introduced which defines social feature of a node. These social features are considered to be very important which compares node with human's social feature that people come into contact more frequently they have more social features in common [9]. The efficient adaptive routing (EAR) allocates bandwidth (or forwarding opportunities) between its multi-hop forwarding component and its mobility-assisted routing component dynamically to improve bandwidth utility [5].

The method to proposed by Yong-Pyo Kim, Ja-II Koo, Euihyun Jung, can resolve the disadvantages of Spray and Wait routing protocol with the use of the an ACK message and message forwarding based on the delivery probability to improve a forwarding decision and the buffer management scheme [7]. Sarbazi-Azad H., Karlsson G. investigated a class of mobile wireless sensor networks that are consist of combination of delay tolerate networks (DTN) and wireless sensor networks which consult about terms of Routing, data gathering, and neighbor discovery[10]. In large space where

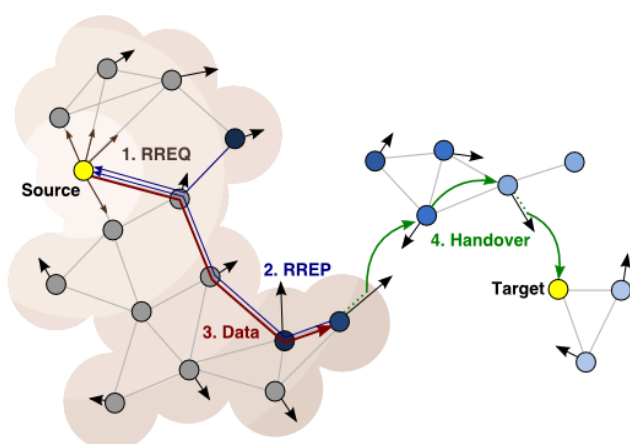


Figure 1: Delay Tolerant Networks.

nodes are in sparse network and are separated into different zones and where finding mobility is difficult to find communication path for sending data, can be achieved using two parameters History contact between the mobile nodes and the frequency of visiting different zones of the network, given by Sammou [11].

Chen I., Bao F., design and validate a dynamic trust management protocol for secure routing optimization in DTN environments in the presence of well-behaved, selfish and malicious nodes for dynamically changing network conditions to minimize trust bias and to maximize the routing application performance. The routing protocol was checked against trust-based and non-trust based routing protocol which shows new proposed trust-based routing protocol can effectively trade off message overhead and message delay for a significant gain in delivery ratio [12].

In case of loaded network it is necessary to decide which message is to be forwarded & which is to be stored in buffer or dropped in case of buffer is full. Thus in this case the forwarding/dropping decision can be made at a node during each contact for either optimal message delivery ratio or message delivery delay [13]. Some work in area of use of social features of node in routing was done to improve delivery rate and latency by using hypercube-based routing. And these factors are also considered under different path conditions like single/multipath and difference resolutions with/without shortcuts. Some work to overcome disadvantages of frequent network disconnection in mobile ad hoc network with group mobility model the routing method based on epidemic routing group-epidemic routing was improved to perform more effectively for group mobility model, in which the whole group is behaved as a single node. While in changing or a frequent network partitioning it is was challenging to maintain end-to-end path between source and destination nodes.

The various routing protocols such as epidemic routing where data replication techniques used over multiple paths for reliable data delivery, which creates a large number of duplicated packets in the network. Thus Hyunwoo Kang makes use of vector routing using the vector of node movements [14]. In vector routing, the direction and velocity of nodes are calculated from the location information of nodes, and then nodes efficiently decide which nodes should take replicated packets as well as the number of packets to replicate. For Delay-Tolerant Mobile Networks (DTMNs) a cluster-based routing which groups nodes with similar mobility pattern into a cluster, which can then share their resources such as buffer space for overhead reduction and load balancing, to achieve efficient and scalable routing in DTMN.

In distributed clustering due lack of continuous communications among mobile nodes and possible errors in the estimation of nodal contact probability, convergence and stability one scheme named exponentially weighted moving average employed for on-line updating nodal contact probability, with its mean proven to converge to the true contact probability.

Considering energy of node Energy-Efficient n-Epidemic Routing Protocol was introduced by Xiaofeng Lu, Pan Hui. They proposed n-epidemic routing protocol which transmit only when the number of neighbors reaching a certain threshold and shows that this routing protocol can increase the delivery performance of basic epidemic-routing by some extents. Articulation nodes are the articulation points or cut vertices of this local sub-graph, and are the nodes whose removal will disconnect the graph. Thus, these articulation nodes are more likely to be able to deliver messages outside the local cluster. Packets will be buffered in these nodes and forwarded to other articulation nodes when they meet. The process repeats until messages reach their destinations. The simulation results by Li Ding, Bo Gu, Xiaoyan Hong, Dixon B show that Articulation Node Based Routing algorithm performs better than related protocols in terms of delivery rate and efficiency. The node cooperation shows effect on performance of routing protocols for delay tolerant networks. The epidemic and two-hops routing perform under the fully cooperative node behavior and shows some results in terms of packet delivery rate under some standard conditions. Resta G., Santi, P. Sensor shows results that epidemic routing provides the better packet delivery rate under all degrees of network cooperation, binary SW routing can achieve comparable performance, with the potential of significantly reducing message overhead. According to Yi Xian, Chin-Tser Huang, Cobb J. a Look-Ahead Routing and Message Scheduling approach (ALARMS) using a variation of the well-known ferry model, showing results for existing routing protocols as epidemic routing, spray-and-wait, and spray-and-focus, in terms of delay time, delivery ratio, and overhead.

### 3. Original Work

#### 3.1 Idea of Proposed System

The proposed system will consist of number of nodes in networks where there will source node and destination node from which data will be send and other side data will received. The each node in network is considered as human in social networks. As social networks have various features we will assign 3 features to each node as Language, Position and Gender. Nodes are grouped under social features as vertices of Hypercube to form the paths as node by node i.e. hope by hope, by two hope and by four hope.

Node by node means data will traverse from all nodes in path. By two hope means data will jump to third node omitting one intermediate node in path. And by four hope means data will send to fourth node omitting three intermediate nodes.

Thus to find better path among all available connections between various nodes and to transfer data, one should check for reliability and power of node to transfer data to its neighbor node and thus forwarding capacity of node in terms of confidence of a node. Each node is assigned with three parameters as position, gender, and language. These parameters are randomly set by random generator in term of 0 or 1 value. According to that each node will have some

values to these 3 parameters which will make it different from each other. This parameters and confidence of path is deciding factor to choose selected paths from all available paths. The confidence of a path is nothing but average of confidence of all node forming that path. Means paths with higher confidence nodes will only get selected as selected path on the basis of confidence. The selected path will have nodes with confidence above some threshold value and that path is confident path and that is only short listed. The data is send over these paths to calculate latency, delay, and packet delivery ratio. The latency describe the total time it take a data packet to travel from one node to another. Delay in the network path due to waiting at queue, waiting for buffer to get free, waiting on path to become conjunction free etc. Packet delivery ratio is ratio of input and output. Means how much data is received out of how much data was sent over the path.

### 3.2 Proposed algorithms

Finding confidence of node in delay tolerant networks using mathematical model design as:

Let N be total number of nodes in the delay tolerant network.

$N = \{1, 2, 3 \dots n\}$

Let L, P, G, be the features of node as language, position, gender respectively.

Let count be a integer,

Confidence is a integer,

Now comparing node 1 and node 2,

if (node1.gender.equals(node2.gender))

```
{
count++;
}
```

if (node1.language.equals(node2.language))

```
{
count++;
}
```

if (node1.position.equals(node2.position))

```
{
count++;
}
```

Then total count is : count;

if (count >= 2)

```
{
Then increase the confidence of node
confidence++;
}
```

Like vise compare node 1 with node 3 up to n,

Compare node 2 with n nodes,

Thus we get confidence of each node with other n nodes.

Finding dependable and reliable paths in delay tolerant networks on the basis of confidence of nodes in a path using mathematical model design as:

Let x be total all possible paths in a delay tolerant network,

Let n be total nodes in a path,

Let threshold be integer,

For x(all) paths generated in network

```
{
If confidence of n > threshold;
```

```
{
Then confidence of path is increased;
}
Print that path as selected path among all generated paths
}
```

Thus we will get all paths having confident nodes in it.

Thus we get confident paths to send data.

Using algorithms we can find faulty nodes whose confidence is below some limit and having less social behavior and less communication path with other nodes, so these node can't send data to destination node successfully. The paths containing this type of node are not able to send data within small time thus increasing delay these nodes are not selected while finding various combinations paths selecting non-faulty nodes in path from source node to destination node. Thus only selected paths are considered to send data those having good confidence. So that delay and latency is reduced using social features and packet delivery ratio is increased.

### 4. Data Sending with Non Shortcut Method

The non-shortcut method means sending data hope-by- hope. In this method data is send over all selected paths obtained on confidence basis. The random generated array list is send and latency, delay is calculated in milliseconds. Each integer value in an array is considered as a packet send and whole array as data. The latency is time difference between receiving data at each node. The delay is time taken to send data from source to destination along with waiting in buffer, waiting in queue, waiting in network for path to get free. The latency and delay of path is low for most efficient path that is selected path 1.As well as delivery ratio is 100% for that path. The best path generated is shown by dotted lines during execution of hope by hope method that is best path of non-shortcut method.

### 5. Data Sending with Shortcut Methods

To send data with shortcut method we have two procedures as by two hope method and by four hope method.

Sending data with two hope method:

This shortcut method consist of sending data by two hopes means the data is send to node omitting one node to third node on the generated path.

For example generated path is as below

[2, 3, 12, 11, 10, 6, 1, 7, 0, 13, 14, 5, 8, 9, 15]

Where 2 is source node and 15 is destination node.

Then by two hope path data will send over path taking jump to direct third node and that will be next intermediate node by two hope method.

Then by hope above path will become as

[2, 12, 10, 1, 0, 13, 5, 9, 15]

Due to two hope method data is send faster than hope by hope hence latency and delay is low than hope by hope method. Short cut using two hope reduces path distance to half as number of node to visit and send data over that is recued to half.

Sending data with four hope method:

In this method data is send directly to fourth immediate node after sender node i.e. omitting three intermediate nodes.

For example generated path is as below  
 [2, 3, 12, 11, 10, 6, 1, 7, 0, 13, 14, 5, 8, 9, 15]  
 Where 2 is source node and 15 is destination node.  
 Then by four hope data will traverse as  
 [2, 10, 0, 13, 8, 15]

The advantage of this method over hope by hope and two hope is that data reach to destination within minimum jumps and instead of visiting each node or alternate node it direct jump to fourth node hence latency and delay is reduced packet delivery ratio is maximized. Distance of path is reduced so that data is send faster to destination.

## 6. Results

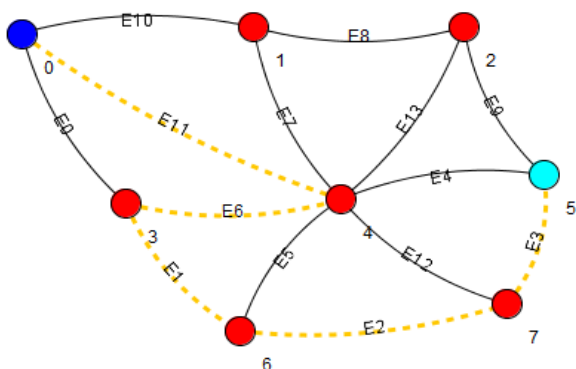
The results that we expect from this system are best routing path selecting best confidence nodes to consume less time in the system. Thus selected path will able to send data through nodes with maximum confidence to reduce latency and delay, increasing packet delivery ratio.

### 6.1 Result from hope by hope method

The hope by hope method will send data node by node and graph is generated with latency delay and packet delivery ratio is obtained. The path shown in network is path having 100% packet delivery ratio.

Ex. The Sending of a Data Through  
 [0, 4, 3, 6, 7, 5] hope by hope

The path shown in network as below: shown by yellow dotted lines where 0 is source and 5 is destination.



**Figure 2:** Delay tolerant network with hope by hope path

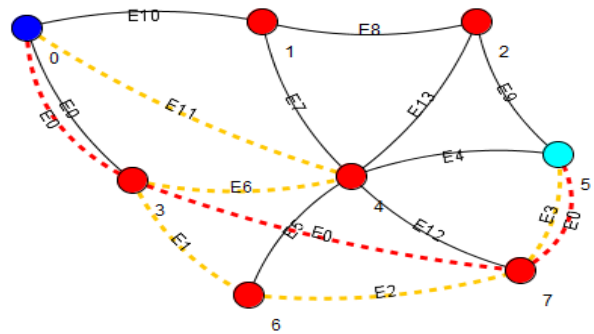
The Latency to Receive the data is: 284 ms  
 The Delay to Receive the data is: 254 ms  
 The Packet Delivery Ratio is: 100.0%

### 6.2 Result from two hope method:

The two hope sending for same above path will be as with red dotted line.

Applying two hope method to this path [0, 4, 3, 6, 7, 5]

The two hope path will be as [0, 3, 7, 5] with same source and destination

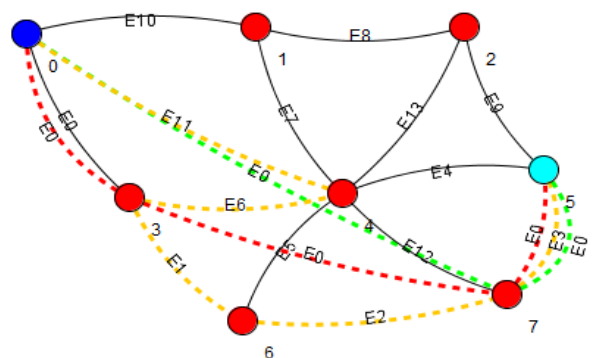


**Figure 3:** Delay tolerant network with two hope path

The Latency to Receive the data is: 253 ms  
 The Delay to Receive the data is: 49 ms  
 The Packet Delivery Ratio is: 100.0%

### 6.3 Result from four hope method:

The four hope method considering same source destination path will be shown by green dotted line as below:  
 [0, 7, 5]



**Figure 4:** Delay tolerant network with four hope path

The Latency to Receive the data is: 220 ms  
 The Delay to Receive the data is: 25 ms  
 The Packet Delivery Ratio is: 100.0%

## 7. Comparison of shortcut and non shortcut method with graphs

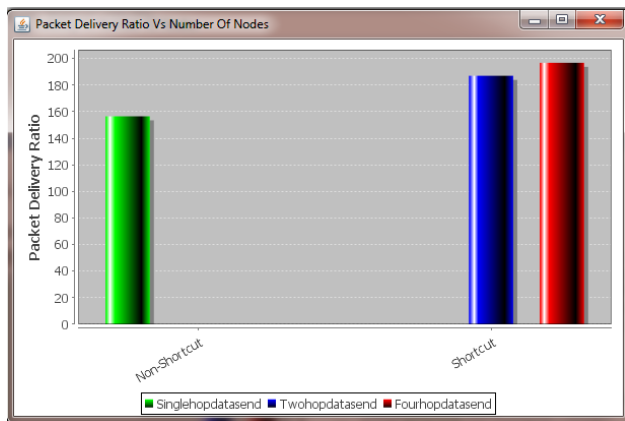
Latency in three methods



**Figure 5:** Graph of comparison of latency in shortcut & nonshortcut schemes.



Packet delivery ratio in three methods



**Figure 6:** Comparison of packet delivery ratio in shortcut and non shortcut method

The study about using Multipath in sending data so as to increase packet delivery ratio and reduce latency and delay taking shortcuts where more social nodes i.e. more confident nodes and more confident paths where selected. This shows comparisons in table taking shortcut and without shortcut.

**Table 1:** Comparison of Shortcut and Non shortcut in the Delay tolerant network

	Path confidence	Most confident path	more confident path	less confident path	Least confident path
Delivery rate	Non-shortcut	100%	92%	84%	76%
	Shortcut	100%	96%	92%	85%
Latency (ms)	Non-shortcut	461	553	603	668
	Shortcut	211	276	428	556
Delay (ms)	Non-shortcut	198	251	395	480
	Shortcut	150	173	298	350

## 8. Conclusion and Future Enhancement

The comparisons of two methods show that shortcut method is more efficient than non shortcut method in terms of packet delivery ratio, latency and delay. The two hop and four hop methods increase packet delivery ratio reducing latency and delay. Thus shortcut method is better than non shortcut in all concern. Thus due to shortcut methods latency and delay is reduced increasing packet delivery ratio.

The future enhancement can be done in area of retuning latency delay increasing hop count and finding source to destination path only on considering source destination position and area where they are located.

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