

# DELAY TOLERANT NETWORK ROUTING PROTOCOL: A COMPREHENSIVE SURVEY WITH HYBRID TECHNIQUE

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## Abstract

Delay-disruption Tolerant networks are sparse wireless network which is recently being used by the existing /current network for the purpose to connect devices or the underdeveloped area of the world that works in challenging environment. In DTN there majority of time does not exist the total path from source to target which is leads to the difficulty of how to route the packet in such environment. A communications network which is accomplished of storing packets temporarily in intermediate nodes, until the time an end-to-end route is re-established or regenerated is known as a delay tolerant networks. Routing in such network is very difficult and for that different routing protocols are developed. In this Survey paper we discuss about various routing Strategy and at the end compared the different routing protocol with their various performance metrics.

**Keywords:** Delay tolerant networks (DTNs), Erasure coding, Replication, Routing.

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## 1. INTRODUCTION

Due to the rigorous operation condition and the lack of continuous network connectivity, there is a large spectrum of application which prioritizes eventual message delivery over the message delay. Network serving these kind of application are generalized as Delay Tolerant Network (DTN). kavin fall, a member of intel research group introduced the Delay Tolerant network in( 2002) [6] in which they provide a network architecture and an application interface to synchronize forwarding of messages within a partition based network in which topology changes continuously and provides long delays. It is a infrastructure less wireless network. It also experiences frequent and higher duration partitions due to nodes in DTN are intermittently connected. DTN network provides no guarantee that a path from source to destination will remain same at every time instance by which we can end that two nodes will never exist in a one connected portion of the network.

As compared to Traditional Internet TCP/IP protocol which is used to set up an end to end communication path between source to destination and which assumes low error rates, low propagation delays, the maximum round trip time between any node pair in the network is not excessive and Packet drop probability is small. Unfortunately, this communication standard is not suitable in challenged or opportunistic environment such as underdeveloped region, deep space and interplanetary network in which communications are area under discussion to delays and disruption, such networks

Generally familiarity from frequent conditional partition and are known as intermittently connected networks (ICNs). Popular examples of such intermittently connected networks (ICNs) scenarios are satellites, deep space probes, Mobile

Wireless Sensor Networks (MWSNs) and Sensor/Actuator Networks (SANs) deployed in extreme regions[6]. Mobile Ad-Hoc Networks (MANETs) typically consisting of nodes (e.g. GPSs, PDAs, Cellular Phones, Tracking devices, Laptops, etc). Delay tolerant networking Research Group (DTNRG) [4] study the DTN connected standards. While communication the packet transmission might consequence the extreme delays in the delay tolerant network. Also the node has extra limitation of restrict buffer and there is no guarantee that a path from source to destination will remain same at every time. The exceeding circumstances construct the difficulty [5] for instance end to end disconnection, Long queuing message Times, High latency, small data rate and restricted resources in terms of partial memory.

Store carry and forward conception used to provides the communication among nodes in the delay tolerant network. By this, a node in the network transfer data from one node to another. By this, any node in the network wants to send data it has to accumulate and buffered the data in the form of package. After that it carry the data until it deliver to other node successfully when they are available. for the period of the communication in DTN the reliability is accomplished by using the conception of Custody transfer mechanism. In the recent years researchers have been focused on routing problem of DTN. We have tried to categorize the different routing protocol with its advantage and drawbacks.

The rest of this paper structured as follows. In section II we discussed key properties and Application of DTN. Section III includes issues and evaluation measure of DTN. Section IV describes various routing protocol strategy and also present the comparative survey of various routing protocol with its advantage and drawbacks in table form. Section V includes conclusion.

## 2 KEY PROPERTIES AND APPLICATIONS OF DTN

### 2.1 Key Properties of DTN

#### 2.1.1 Opportunistic Communication

Contact between two nodes in DTN is opportunistic due to end to end disconnection problem. In such scenario, data delivery only happens when two nodes are in contact.

#### 2.1.2 Intermittent Connection

DTN is sparse mobile network in which it lacks end to end connection between nodes. This is occur due to mobility, limited resource and network partition.

#### 2.1.3 High Latency

In Delay tolerant network scenario, two node may never meet each other for long time[6] due to which high latency is occur.

#### 2.1.4 Low Data Rate

When two nodes may never meet each other for long time in the network, the transmission rate of data may be considerably low and largely asymmetric with long latency of data delivery.

#### 2.1.5 Long Queuing Delay

In DTNs, the Disconnection problem is high as compared to the conventional network. The queuing delay is the time it take to drain the queue messages ahead of the tagged on. The queuing delay also depend on the data rate and the amount of competing traffic traversing network, means queuing delay may be extremely large in worst cases e.g. : minutes, hours, and days.

### 2.2 Applications

There are various real-life application area that make use of the DTN concepts where wireless nodes, mobile or stationary, are focused to undergo extreme operational condition and/or wait for extended interval of time that exceed traditional IP forwarding times before being able to forward their data to next hop. There are many real-life applications where wireless nodes, –mobile or stationary-, are forced to undergo extreme operational conditions and/or wait for extended intervals of time that exceed traditional IP forwarding times (that are usually measured in milliseconds) before being able to forward their data to next hops. Some of these applications are

#### 2.2.1 Inter-planetary Communication [5]

Interplanetary communication is the excessive cases in which DTN can be apply. The DTN application of interplanetary network beats the traditional perimeter of TCP. The

enormous space separating global artificial purposes restrict the conventional method to swap data among them or with base-stations on earth. The scientist from base location on earth can manage the action of a robot working on Mars.

#### 2.2.2 Wildlife Monitoring [17]

The Zebranet project has installed a global positioning system (GPS) in a zebra collar to study the habits of zebra activities, which is one of the early DTN project and was started in 2004. Collar start every few minute to record GPS location, and every 2 h open radio function, when two collars distance is in communication range they would exchange information . After a period of time, every horse collar stores the position information of other activities. Through the zebra net project zebra's mobility, migration and interspecies are going to be investigated.

#### 2.2.3 Village Network

There are many countryside communication projects in inaccessible village to make available the access to Internet. Some of the project use asynchronous transmission in order to reduce the cost of communication. The purpose of Daknet project is to enable connectivity to countryside villages with limited infrastructure established in booths in order to make available basic services such as E-mail, online banking facilities. In order to provide the communication services between village and close to town a connection enabled vehicle passes through villages are used.

#### 2.2.4 Military Application

In the Military network it can accepted in very Ad Hoc manner in which it can be used by allowing the recovery of vital information in mobile combat scenario using only irregularly connected network. To provide a standard communication in military camps which is located in very rough and difficult terrestrial spot where communication not easily possible, in such scenario DTN seems much fit to send out and accept data.

#### 2.2.5 Deep Space Exploration

In the next few decades, NASA and other agencies will plan a series of projects of lunar exploration, Mars exploration and others. In September, 2003, Cisco router (CL EO) was launched by satellite to monitor disaster in UK. Till to December 2008, CL EO has done a lot of routing tests in space environment including using Saratoga protocol of bundle layer instead of pervious protocol making full use of the link source to overcome serious asymmetry link conditions. The experiment shows it is feasible to use Bundle Protocol in space.

### 3. ISSUES AND EVALUATION MEASURES IN DTN

#### 3.1 Issues in DTN

There are many issues in Delay Tolerant Network. In which many researchers has been focused and they are

##### 3.1.1 Buffer Space

In DTN network suffer from long disconnection due to which node need to store the packet for long period of time. So that, they require enough buffer space to store all message that are waiting for communication opportunities. Therefore, if buffer space of node is limited, the node buffer will be overflow due to which packet will loss.

##### 3.1.2 Energy

The energy is an important problem in delay tolerant network that needs to be addressed. Nodes in network may have limited energy supplies due to either mobility or disconnectivity. Routing in DTN consumes significant amount of energy by sending, receiving, storing and as well as computation process than conventional routing technique. So that energy efficient routing protocol should be used.

##### 3.1.3 Encounter Schedule

In DTN when a node send the data from source to destination, it can wait till it encounter the destination node and after that forward the packet by direct delivery to the destination. This may take long time or may not happen because DTN suffer from disconnectivity problem [6], Network node try to communicate when opportunistic contact is obtainable. The encounter schedule is very important factor in Delay Tolerant Network. Because the delivery of messages is straightly depends upon the schedule of the encounter.

##### 3.1.4 Resource Allocation

Resource allocation is a major problem in DTN. As we know Delay tolerant Network work in stressful environment where there is lack of end to end connection. The main goal of DTN is to balance the maximizing message delivery and minimizing resource consumption which are clash with each other. For example when to increase the packet delivery ratio from source to destination the best way is to distribute the multiple copies of the message in the network. But it consumes more buffer space to store each data in the node.

##### 3.1.5 Reliability

Reliable delivery of packet can be achieved by ensure the triumphant and steady delivery of packet by any routing protocol that have some acknowledgement. When a packet reaches to the destination, some accepted message should be sent back from destination to source.

### 3.2 Evaluation Measure

#### 3.2.1 Delivery Ratio

The most important performance metric of DTN is Delivery ratio. In which messages are generally lost due to delivery of message to the destination not done in a given particular time period, this is because the end to end disconnection problem in DTN. The delivery ratio is distinct as the relative amount of produced message at the source to the suitably delivered message at the destination inside a known time period. Improvement of the Packet delivery ratio is the task of superior routing protocol. Thus specialized routing protocol should be used to raise the packet delivery proportion.

#### 3.2.2 Latency

One most significant network performance metrics is Latency. It is used to determine the time between when the message is created and when it is received. It generally defines the end to end delay, means two nodes may not at all meet each other. Thus the delay should be reduce.

#### 3.2.3 Transmission

It is used to determine the requirement of computational resources. Dissimilar routing protocol use various routing strategy in which Flooding based routing scheme generated multiple copies of data and distributed it all over the network, thus make use of additional resources as compared to forwarding based routing scheme. In DTN each participating element has limited resources.

## 4. DIFFERENT ROUTING STRATEGY IN DELAY TOLERANT NETWORK

Many researchers has been extensively focused and discussed about routing in delay tolerant network, which is the main part in dtn. The major purpose of routing is to provide the maximum possibility of deliver messages. Routing consists of a series of self-sufficient, local forwarding decision. This is based on the present connectivity and prediction of future connectivity information [10]. Can also say node mobility needs to be broken in order to send a message to its target. There mobility is take advantage of in order to expand ability, while here it is used to beat the lack of end to end connectivity. It also depending on the numeral of copies of a lone message that may coexist in the system. Network topology in dtn can be roughly classified into two categories as deterministic and stochastic routing. In deterministic case the future network 'state/topology and/or its characteristics are predictable. The main thought in computing the optimal route from source to a destination in deterministic routing protocol is based on complete information or predictable information about nodes future mobility patterns and links availability among them. Oracles based, link state based, space time based, and tree based are the example of deterministic routing approaches and stochastic routing where no exact knowledge of future network topology is

assumed. When there is no knowledge about nodes mobility patterns obtained via deterministic predictions or historic information stochastic routing mechanisms need to be used. Epidemic routing, history based, model based, coding based and flooding based are the example of stochastic routing approaches.

T. Spyropoulos et.al. Introduces two types of routing that is single-copy scheme[15]and multi-copy scheme. In single copy routing scheme there is only one guardian for each message all over the network. When the present guardian forwards the copy to a suitable next hop, this turn into the message's new guardian and so on. The present guardian forwards the message until attained its destination. He is also introduces other single copy scheme for example randomized routing algorithm, utility based routing and as seek and focus routing algorithm.

Alternatively, multiple copy (or multi-copy) routing schemes the node carrying the message sends a copy to each encountered node. This is frequent until the target receives the message. In this case, the contacts are assumed to be totally opportunistic. Prophet protocol [3], epidemic routing protocol [2], and spray & wait routing protocol [16]are the use of this strategy. Due to low delivery ratio and long delay of the single-copy routing scheme, the multi-copy outing is the mainstream routing.

#### 4.1 DTN Routing Protocol Strategy can be classified into Three Broad Categories and they are Flooding, Replication and Forwarding.

Many challenges affect the routing in dtn such as the changing network topology, low delivery ratio and high delay. The problem can be mitigated by using different routing strategy. Many research interests focus on developing new approaches for routing in delay tolerant network environment. These routing schemes generally use the store-carry-and forward approach, where intermediate nodes keep message until encounter other nodes to set up new links in the path to the destination.

##### 4.1.1 Flooding

Flooding families are extended the number of copies of each message to a group of nodes, this node works like relays. The relays stock up the message pending they connect with the target, at which the message is deliver. With this strategy the flooding families increase the packet delivery ratio, also try to decrease the packet delivery delay. Epidemic routing, maxprop [18], prophet are the example of flooding routing protocol. Awareness about the network helps in deciding the best next hop. It is possible that the network has no knowledge about the network.

In such scenario, all nodes are made relay nodes. Such schemes are called epidemic routing scheme. The epidemic

routing is the simplest and earliest routing scheme for DTN. The basic concept of Epidemic routing is when two nodes encounter, they exchange messages each other and message will be propagated to the destination. It is based on Flooding delivery and the data delivery results in inefficient use of the network resources such as bandwidth, power and buffer space at each node. Fig: 1 in which the all nodes of network have the packet, where A and G are source and destination.

MaxProp Routing protocol uses the same routing as epidemic but improves buffer management. It is base on the agenda of packets transmit to other peers and the schedule of packets to be drop in delay tolerant networks.

PRoPHET [3] is a probabilistic protocol for routing in irregularly connected networks that is more sophisticated, using history of node contacts and transitivity to improve performance .

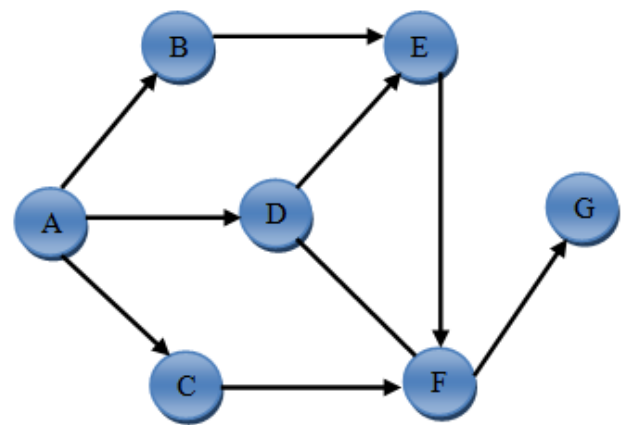


Fig: 1- Flooding strategy

##### 4.1.2 Replication

Replication scheme insert multiple copies, or replicas of message into the network in order to increase the probability of message delivery that one of them will finds its way to the destination. This scheme further separated into two classes based on the no. of replicas created: Quota based and flooding based. In quota based protocol purposely limit the no. of replicas of message in the network. The quota of message is decided based upon certain quota allocation function. This function may be static or dynamic. Spray and wait, And EBR are the example of replication routing scheme. Quota allocation function i.e. binary value is used by spray and wait routing protocol in which it consist of two phase: spray phase and wait phase. In first phase it spread the sufficient no. of message copies. The nodes transport a message copy does direct show in the wait phase if the destination is not reach in the spray stage. In fig: 2 all nodes of network have message except E.

In encounter based routing protocol (EBR)[19] is also a quota-based routing protocol. It minimizing network resource usage by limits the number of replicas of any

message in the network. EBR maintains an encounter value for each node, which is the average number of encounter with other nodes during an observation period.

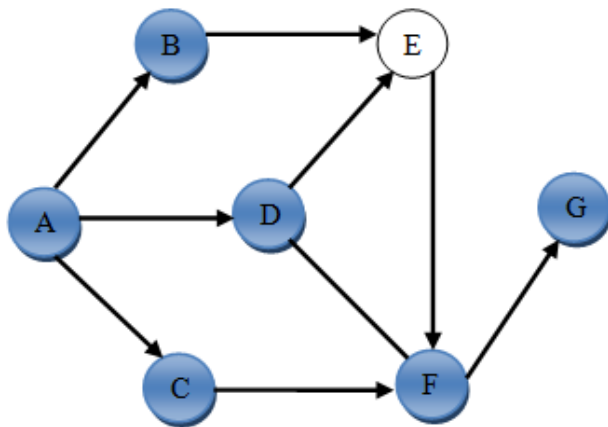


Fig: 2 Replication Strategy

### 4.1.3. Forwarding

In the Forwarding routing strategy, keep a single-copy message in the network and attempt to forward that copy through successive intermediate node to the destination. It takes more traditional approach on the basis of network topology knowledge to routing data in a DTN. And it select the best path to transmit message from node to node. A best route can be found by using Location-based routing, Per-hop routing, per-contact routing, and hierarchical routing protocol. Forwarding routing protocol such as MED, MEED

[11]and Simbet [20]. Fig: 3 represent the forwarding strategy in which A, D, F and G node have message.

Jain has introduced many routing algorithms, based on knowledge oracles. They introduce the Minimum Expected Delay (MED) protocol [11] that is based on the prospect contact schedule. Also Jones get better work by introducing Minimum Estimated Expected Delay (MEED) [11], in which the supposed delay is intended using the examiner contact history. Sliding window is used by every node in the network for tracing the connection and disconnection time of every contact. Like this, the most current information is obtainable for routing purpose, where MED has only offline.

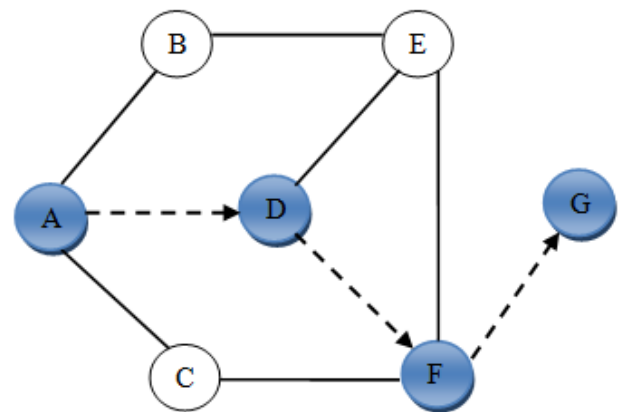


Fig: 3 Forwarding Strategy

Table1:- Comparition of different routing protocol

Routing Protocol	Knowledge Type	Message Type	Delivery Ratio	Information type	Advantages	Shortcomings
Epidemic [2]	None	Flooding	High	None	Maximum Delivery Ratio	High Resource Utilization
MaxProp[8]	Queuing	Flooding	Medium	Global	Good use of transmission Opportunity	Maximum Processing cost in huge scale network
PROPHET[3]	None	Flooding	Medium	Global	Limited Resource utilization	Less Scalability
Spray & Wait[16]	None	Replication	High	None	Less utilization of Resource	Random decision making
Spray & Focus	Contact Summary	Replication	High	Local	Low Latency and high Delivery Ratio	Use Static Quota based Allocation Function

Encounter Based Routing [19]	Contact	Replication	Medium	Local	Low resource utilization and minimize overhead	appropriate for network having little no. of hops.
Simbet	Contact	Forwarding	Medium	Local	Good Packet Delivery proportion	More Delay contrast to Epidemic and ProPhet
MED[11]	Contact	Forwarding	Low	Global	decrease common Waiting Time	No device to deal with overcrowding
Minimum estimated Expected Delay[11]	Contact History	Forwarding	Low	Global	Less consumption of buffer	Long Time consuming
Dynamic Quota based Routing[18]	Contact	Replication	Medium	Local	Low effective Latency	Generate traffic
Delegation Forwarding[22]	Contact	forwarding	Medium	Local	Reduce cost and Delay	Large no. of hop count

## 5. PROBLEM DEFINITION

In the current system we have a Quota based multicasting technique as the recent one where there is no encoding algorithm was applying and thus the message with the large block length and size are unable to propagate properly with the help of existing algorithm due to its less buffer size and buffer occupancy, thus we need an extra approach to work with and to find the solution in order to approach it best while multicasting in delay tolerant network.

## 6. CONCLUSION

Delay Tolerant Network is a new up-and-coming era of intermittenly connected wireless networks. Such network operates in extreme environment where end to end communication is area under discussion to delays and disruption. It can introduce the basic idea about the origin and nature of DTN. In this paper we have focused on various routing strategy and classified the routing protocols of Delay Tolerant network into three categories: Flooding, Replication and Forwarding .Also we have presented a comparative survey of various routing protocol with their advantages and drawbacks in table. Our survey and classification facilitated us to make the following observation while designing routing protocol in DTN. Firstly, use hybrid technique and instead of simply replication of a message in the network divide the long message into equal size of code block in order to accomplish a high delivery ratio with low utilization of resources. Secondly, routing protocol must be scalable, reliable, robust and transversely open diversity of networks in order to make available the satisfactory performance over a open diversity. The research and development of DTN will be

applied to the military war, underdeveloped region, disaster recovery, wild life tracking emergency rescue and other challenging environment.

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