

# Overhead Ratio Comparison of VDTN Routing Protocols

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**Abstract**— Delay tolerant network (DTN) has been utilized for intermittent network, where no. of hosts are movable, there is no fixed topology and connection is opportunistic. It is challenging to transmit data in such opportunistic environment. DTN is also applied in Vehicular nodes known as Vehicular delay tolerant network (VDTN). The message transmission in VDTN using different routing protocols needs to be improved as VDTN suffers from the high speed of vehicles, short contact time and unstable topology and very high delay for message passing. The objective of this paper is to do comparative analysis of five different protocols of VDTN with variance of various parameters and suggest one protocol for optimum performance concentrating Overhead Ratio. Overhead Ratio is compared on parameters - variation in no. of nodes, buffer size and transmission data rate. Rating system is used to analyze comparative study. All protocols are implemented using The ONE simulator.

**Index Terms**— DTN, VDTN, Epidemic Routing, Direct Delivery Routing, Spray and Wait Routing, Binary Spray and Wait Routing, Prophet Routing, Delivery Probability, Buffer Size, Transmission Speed, Number of Nodes

## I. Introduction

Delay Tolerant Network (DTN) is Mobile Network where nodes are movable and also known as an intermittently connected network. When your modem/router drops connection at random intervals is known as an intermittent connection. Delay tolerant network is wireless network where there is no end to end path available or the probability of an end to end path from source to destination is very low. In DTN all the nodes are movable so connectivity for transmission from source to destination is only possible when nodes come into transmission range of each other. Transmission mode can be any wireless media. (Infrared, Bluetooth, Wi-Fi, WI-Max). Nodes are continuously movable so in the DTN end to end transmission may not possible so DTN avails hop to hop transmission. If one node has a message to deliver, but not connected to destination, so it sends messages to first connected node, but if any other node is not in transmission range of the sender, it stores the message till the time an appropriate link is not established between the sender and another node. A communication opportunity between two nodes is called a contact in DTN's. [1]

DTN has different contact available as it is a large group of network. They are as below. [1]

- Persistent contact: Persistent contact means the contact is always available.
- On-demand contact: On-demand contact means a contact can be initiated when needed.
- Scheduled contact: Scheduled contact means the contact and its characteristics is known in advance.
- Opportunistic contact: Opportunistic contact means when nodes get the opportunity to connect, then only connections established. There is no guarantee of connection. It is called opportunistic DTN.

Protocols for Mobile ad hoc network (MANET) is designed with the idea that the network is fully connected and path between nodes exist always or if paths are down then they are only for a very short period of time. Routing protocols of MANET transmit messages only if full path is established between sender and receiver, if there is no path established protocol is failed to transmit data, but it is not possible for DTN because it is having intermittent connection and there is no surety to the establishment direct path between source and destination. So MANET protocols will not work for DTN. To overcome routing problems DTN provides Store – Carry and Forward (SCF) functionality. DTN nodes have buffers to store messages. DTN routing protocols use nodes movements and message buffering for transmission of messages from source to destination. [1]

Store and forward message switching is used to successfully transfer message with intermittent connection, long delay, variable data rate and high error rates. Actually, this is a very old method used in the postal system in ancient time, where whole message or the part (packets) of the message will be transferred to one node and then another and so on in the way of destination node and gradually it reaches to the destination.

Routers of DTN networks want persistent storage for their queues for below reasons: [2]

A communication link to the next node, possibly not available for a long period of time. There are chances to message may be transmitted again if there is an error while transmitting messages or if a contacted node doesn't accept of a forwarded message. When whole message is transferred, the message switching method provides the size of message with it so at that time there is a need of immediate storage space and bandwidth and also retransmission needed in some cases.

## II Problem definition and Scope

### Problem definition:

Since the nature of DTN is like opportunistic network connection, where there is no surety that message will reach to the destination with a certain delay. Many routing protocols are developed to meet the challenges of the opportunistic network to successful message transmission. Research on DTN and VDTN routing protocols is still in its infancy, it is unclear which protocol can be used in specific situations with the variance of different parameters to get optimum results in terms of Overhead ratio.

### Objective and Scope:

The objective is to compare performance of five routing protocols – Epidemic routing, Direct Delivery routing, Spray and Wait routing, Binary Spray and Wait routing and PRoPHET routing for VDTN with variance of three input metrics – number of nodes, buffer size and transmission speed. The Elaborative comparative and analytical study of routing protocols in VDTN may be useful to the network administrator who wants to implement protocols in real scenario to achieve optimum result. Through the study researcher can go for further research in the domain of VDTN protocols for the improvement of the protocol and to achieve more improved performance of the network.

## III. Routing protocols

### Direct Delivery Routing:

In direct delivery routing (DDR) does end to end message transmission. In DDR Source node stores message till the time it comes into direct contact with the destination node. Message delivery probability using DDR is extremely low as it needs end to end path between source and destination that too in such intermittent network. If source and destination contact is not established, then the message would not be delivered. [3]

### Epidemic Routing:

In Epidemic routing protocol the node which receives message will send a copy of message to nodes come into its contact. Each node who is having message will send the copy of it to encounter nodes such as the message will spread to all the nodes of the network. The epidemic routing algorithm may be the optimum efforts to reach message to the destination node. Each node maintains summary vector in its buffer which contains the actual message with its unique identifier. When any node comes to the transmission range of another node they compare summary vectors and transmit messages which are not available in current summary vector. Moreover, it is possible to sidestep to compare summary vector again and again with the same node when they encounter frequently, the history of recent contact is maintained in the node's buffer. Epidemic routing obtains the optimal path to a destination with the smallest delay if there are enough buffer size and communication bandwidth between nodes. Epidemic routing searches all possible path for message transmission to transmit messages and so that node failure doesn't harm. The main drawback of Epidemic routing is – It works on forwarding multiple copies of the same message so that there may be wastage of buffer, bandwidth and nodes energy. When resources are limited, there are high chances of message dropping. [3], [4]

### Spray and Wait routing:

In spray and wait there is restriction on making copies of the message. Only L number of copies are allowed which, depending on the number of available nodes in the network. There are two main stages of spray and wait routing protocol. 1) The spray phase and 2) The wait phase. One number is attached when message is created which shows maximum possible copies of the message. The source node is spread messages to different nodes. When a node receives a copy of the message it enters to wait phase. Nodes hold message till the time it directly meet to the next node/destination.

### Normal Spray and Wait

In vanilla version, the source node creates L no. of copies and it distributes one copy of that message to total L-1 nodes which first encounter it. Then each node goes to wait phase till the time it comes to the direct contact of destination.

### Binary Spray and Wait

In binary spray and wait source also makes the  $L$  copies of the created message. It transmits  $L/2$  of those copies to first node it intersects, and is again copying messages and gives to encountered nodes, then after each encountered node transmit half no. of total received copies to another encountered node, but it cannot copy messages. This process goes on till the time nodes are having single copy available. At this stage they go to wait phase. Each node which is having message will wait for direct transmission opportunities with the destination node.

### ProPhet routing (Probabilistic Routing Protocol uses History of Encounters and Transitivity)

In PROPHET routing protocol, it is presumed that all the mobile nodes have some pattern to move into network. All nodes have information about another nodes' probable movement on the bases of past encountered nodes. Because of this history nodes may have knowledge that which nodes are frequently or recently encountered. So it would be easy to determine prediction. Thus, in PROPHET movements of nodes is not totally unplanned but deterministic characteristics. PROPHET creates one probabilistic metric which is known as delivery predictability  $P(A, B)$ . This metric check the probability of node  $A$  will be able to transmit messages to destination node  $B$ . When one node encounters another node, it will pass summary vector to that node and this process will go on until message reach to the destination. It seems similar to Epidemic routing, but the only difference between Epidemic routing and PROPHET routing is a Prophet summary vector also contains delivery predictability value to reach to the destination node. When a message is being delivered to intermediate node, it will just share the delivery probability. Intermediate node will not update that probability to make out which node has highest delivery probability to the destination node. PROPHET method is having two phases. In the first phase it will calculate the delivery probability to send messages to the destination and in phase two it uses forwarding strategies.

### IV. Parameter explanation

- Transmission speed: The data rate at which message is sent and received across two or more nodes over a communications channel. (Kbps)
- Buffer size: Size of the message buffer. (Bytes)
- Number of nodes: Number of hosts in the group.
- Overhead Ratio: Overhead Ratio: Extra data about message that is stored and relayed by intermediary node.

**Table 1: Simulation Setup Information**

PARAMETERS	VALUE
Simulation Time	10000 (Sec)
Interface	Bluetooth Interface
Interface type	SimpleBroadcastInterface
Transmission range	10 (meter)
Transmission speed	100,200,300,400k,500 (kbps)
Buffer size	1,2,5,10,20 (MB)
No. of nodes	50,100,150,200,250
Message size	500 KB to 1 MB
Message TTL	300 minutes

## V. Experimental Result Analysis:

## A. Overhead Ratio with various buffer size.

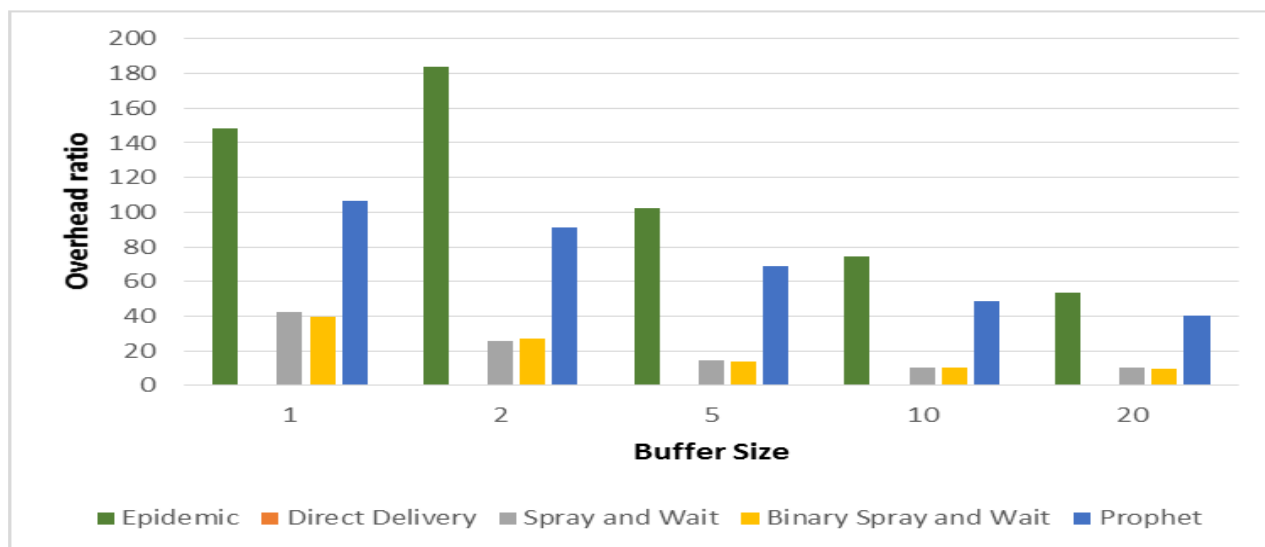


Figure 1. Comparison chart buffer size vs overhead ratio

Figure 1. clearly indicates two variables. Response variable – Overhead Ratio and explanatory variable – Buffer Size. The comparison chart of the Overhead Ratio for Epidemic Routing, Direct Delivery Routing, Spray and Wait Routing, Binary Spray and Wait Routing and Prophet Routing shows that with the increment of Buffer Size, Overhead Ratio decreases. For any network it is preferable to achieve lowest Overhead Ratio to get more Delivery Probability. It is noted through comparative results of simulation, Binary Spray and Wait Routing gives lowest Overhead Ratio with the increment of Buffer Size, while Epidemic Routing gives highest Overhead Ratio compare to other protocols with the increment in Buffer Size. Direct Delivery Routing is always having 0 Overhead Ratio due to its nature of end to end transmission. (Transmission Speed is 250 k and Number of Nodes are 40)

## B. Overhead ratio with various Transmission Speed

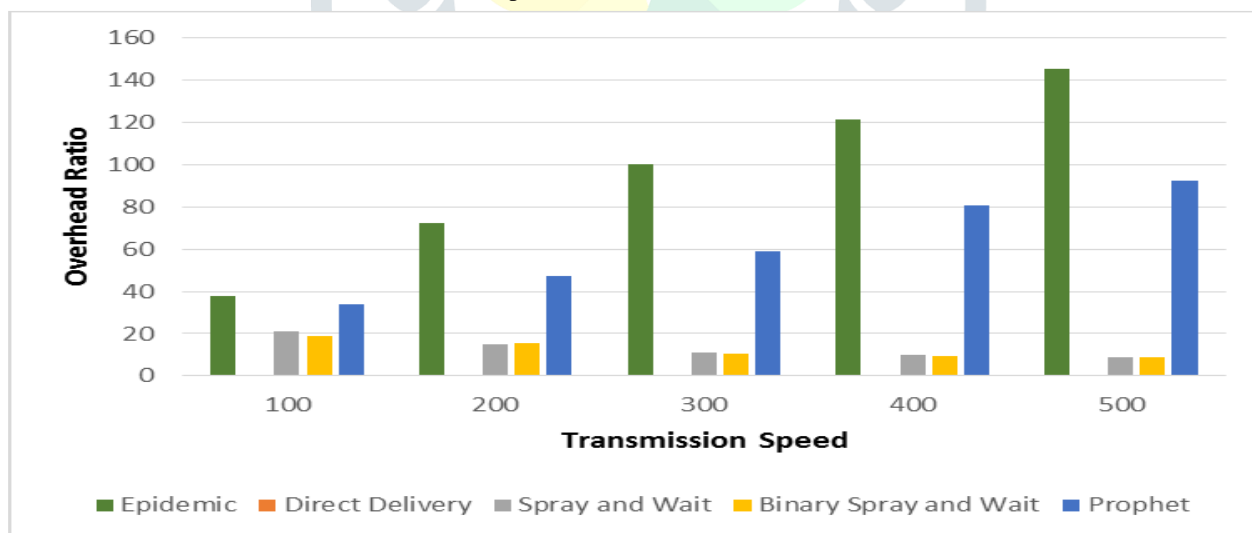


Figure 2. Comparison chart Transmission speed vs overhead ratio

Figure 2. clearly indicates two variables. Response variable – Overhead Ratio and explanatory variable – Transmission Speed. The comparison chart of the Overhead Ratio for Epidemic Routing, Direct Delivery Routing, Spray and Wait Routing, Binary Spray and Wait Routing and Prophet Routing shows that with the increment of Transmission Speed, Overhead Ratio increases. For any network it is preferable to achieve lowest overhead ratio to get more delivery probability. It is noted through comparative results of simulation, Binary Spray and Wait Routing gives lowest Overhead Ratio with the increment of Transmission Speed, while Epidemic Routing gives highest Overhead Ratio and Priphet Routing also gives higher Overhead Ratio compare to other Protocols with the increment in Transmission Speed. Direct delivery is always having 0 Overhead Ratio due to its nature of end to end transmission. (Buffer size is 5M and Number of Nodes are 40)

## C. overhead ratio with various Number of Nodes

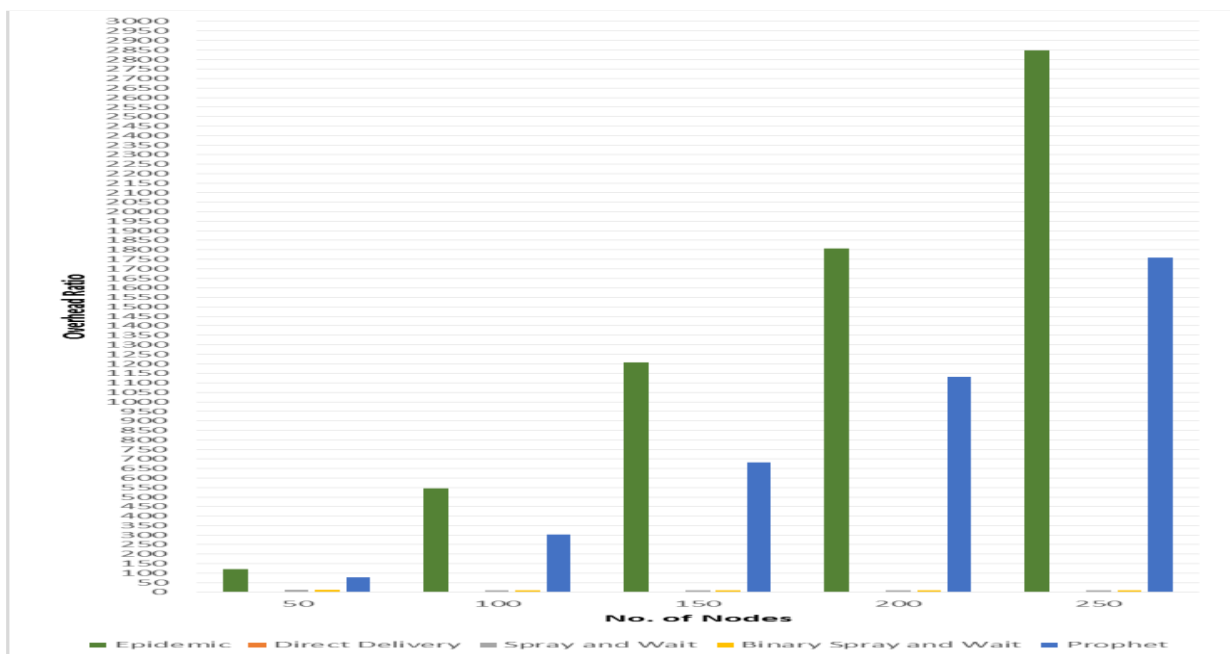


Figure 3. Comparison chart No. of nodes vs overhead ratio

Figure 3 clearly indicates two variables. Response variable – Overhead Ratio and explanatory variable – Number of Nodes. The comparison chart of the Overhead Ratio for Epidemic Routing, Direct Delivery Routing, Spray and Wait Routing, Binary Spray and Wait Routing and Prophet Routing shows that with the increment of Number of Nodes, Overhead Ratio increases for Epidemic Routing and Prophet Routing. For any network it is preferable to achieve lowest overhead ratio to get more delivery probability. It is noted through comparative results of simulation, Spray and Wait Routing and Binary Spray and Wait Routing gives lowest Overhead Ratio with the increment of Number of Nodes, both the protocols didn't give so much varying Overhead Ratio with the markable variance in Number of Nodes. Direct delivery is always having 0 Overhead Ratio due to its nature of end to end transmission. (Buffer size is 5M and Transmission Speed is 250k)

For exhaustive comparative study rating method is applied on the simulated value based results plotted in the above charts. Rating system works as mentioned in Table 2.

Table - 2 Rating Method concentrating Overhead Ratio

SR. NO	Readings	Rating
1	For lowest Overhead Ratio	5
2	For second lowest Overhead Ratio	4
3	For third lowest Overhead Ratio	3
4	For forth lowest Overhead Ratio	2
5	For highest Overhead Ratio	1

According to above rating criteria, rating is assigned to overhead ratio of all routing protocols with the variance of all three metrics to evaluate performance of routing protocols.

	Epidemic	Direct Delivery	Spray and Wait	Binary Spray and Wait	Prophet
Buffer size 1m	1	5	3	4	2
Buffer size 2m	1	5	4	3	2
Buffer size 5m	1	5	3	4	2
Buffer size 10m	1	5	3	4	2
Buffer size 20m	1	5	3	4	2
Trans. Speed100	1	5	3	4	2
Trans. Speed200	1	5	4	3	2
Trans. Speed300	1	5	3	4	2
Trans. Speed400	1	5	3	4	2
Trans. Speed500	1	5	3	4	2
No of nodes 50	1	5	4	3	2
No of nodes100	1	5	3	4	2
No of nodes150	1	5	3	4	2
No of nodes200	1	5	4	3	2
No of nodes250	1	5	4	3	2
<b>Total</b>	<b>15</b>	<b>75</b>	<b>50</b>	<b>55</b>	<b>30</b>
<b>Mean</b>	<b>1</b>	<b>5</b>	<b>3.33333333</b>	<b>3.66666666</b> <b>7</b>	<b>2</b>

Table - 3 Rating concentrating overhead ratio with total and mean

## VI. Conclusion and Future scope

Overhead Ratio comparison of all protocols using the variance of buffer size, transmission speed and number of nodes, it is clear that Binary Spray and Wait gives excellent performance in all scenarios shown in Table 3. Second optimum performance is of Spray and Wait Routing, Prophet Routing gives third optimum result, forth optimum result is of Epidemic Routing. Here it cannot be ignored that Direct Delivery Routing provides lowest overhead ratio compare to other routing protocols due to its nature to transfer message, but in real scenario probability of message delivered is very poor so next best result of binary spray and wait is being considered to optimum result.

The in depth comparison may useful to network administrator to install protocols in real scenario to gain optimum network performance. Still there is need to optimum delivery probability and minimum overhead ratio for better network performance.

In future researcher can derive rating based comparison of other parameters of VDTN to evaluate performance. Through such exhaustive comparison researcher may know which protocol should be improved to improve overall performance of the network and can carry on work on protocol providing optimum results with variance of different parameters and in different scenario.

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