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# Survey Paper on the Performance Analysis of Routing Protocols in DTN

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## Abstract

The main objective is to survey the routing performance and comparison of routing protocols in Delay Tolerant Network. Some performance metrics are used to measure the routing performance: (i) delivery rate: the average delivery ratio of the routing packet; (ii) latency: the average duration between a packet's generation and the arrival time, (iii) Overhead, (iv) Number of nodes, (v) Cost. Delay-tolerant network is a network designed to operate effectively over extreme distances such as those encountered in space communications or on an interplanetary scale.

***Index Terms***—Delay tolerant networks, Epidemic, SimBet, BUBBLE Rap, Multicasting, Spray and Focus, Delegation Forwarding, BlueCube, Relaycast, RAPID, PROPHET, Hypercube-Based Social Feature Multipath.

## I.   INTRODUCTION

Delay-tolerant networking (DTN) is an approach to computer network architecture that seeks to address the technical issues in heterogeneous networks that may lack continuous network connectivity. Examples of such networks are those operating in mobile or extreme terrestrial environments, or planned networks in space. DTN is used to solve the lack of continuous network connectivity. Delay-tolerant networks use a message oriented overlay that supports intermittent connectivity, overcomes communication disruptions and delays. Transmission of data between source and destination nonexistent for the time of a communication is also allowed. All aforementioned features are achieved by using store-and-forward message method. Services the method provides are very similar to electronic mail, but with improved naming, routing and security capabilities.

DTNs can be applied to wireless sensor networks using intermittent connectivity, terrestrials wireless networks with no end-to-end connectivity. DTN is an intermittent connectivity and high node mobility, can allow for much-needed connectivity and other settings with limited or no existing infrastructures. There is no end-to-end path between some or all of the nodes in DTNs, which makes routing quite different from other types of wireless networks. The Delay Tolerant Network is showed in fig.1.

Mobile social network [13] is a new type of DTNs in which social features play an important role and where individuals move around and interact at each contact based on their common interests through Smartphone. Most of the social-behavior-based DTN routing schemes [2], [3], [6], [8], [9], [10] that have been proposed recently do not consider the real social features of each node.
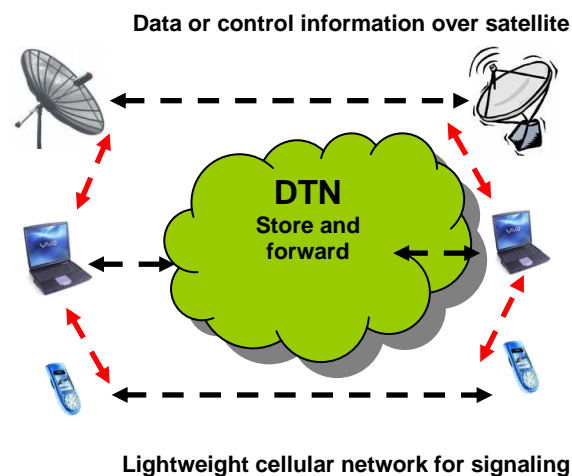
**Data or control information over satellite**



**Lightweight cellular network for signaling**

**Fig.1. Delay Tolerant Network**

The Potential Applications of DTNs are telemedicine for developing regions, DTN-based social network service, and communication in the presence of oppressive governments, file sharing and bulk data transfer, share air minutes. The telemedicine for developing regions improves the possibility for doctors to give correct diagnose and prescribe treatment from remote location. The file sharing and bulk data transfer use the cellular network to transmit the request for some content, and then use delay tolerant techniques to deliver the data to the mobile device.

The key properties of DTNs are high latency, low data rate, disconnection, long queueing delay, limited resources, short range contact and Dynamic Network Topology. In high latency and low data rate, the frequent and random mobility of the networks doom that any two nodes in the networks may never meet each other for a long time and the transmit rate of data would maintain at a low level. The transmit rate may be considerably low and largely asymmetric with the long latency of data delivery. In disconnection, most cases it is impossible to have an end-to-end path. Hence, disconnection is more usual than connection. Normally, the disconnection may be mainly caused by network partition as well as unexpected fault. In DTNs, the queueing delay is aggravated because the disconnection is more common compared to the conventional networks. It implies that the queueing delay could be extremely large which may take some hours or days in the worst cases. In general, the nodes in DTNs are mobile and battery operated with wireless connection and, thus, they have limited resources. In Short Range Contact, only one-hop communication is guaranteed. In dynamic network topology, different types of user behavior will result in dramatically different network conditions

Delay tolerant network can be defined as a "Network of Regional Networks". It can also be viewed as an overlay on top of regional networks. DTN protocols provide robustness against the issues mentioned above by introducing tolerance for delays and intermittent connectivity. In theory, DTN's can handle nodes or links being unavailable for several days while still being able to provide reliable data transfer. DTN provides an intermittent connectivity: If there is no end-to-end path between source and destination called network partitioning end-to-end communication using the TCP/IP protocols does not work. Other protocols are required.

Rest of the work is organized as follows. The routing protocols are summarized in terms of major features and characteristics in Section 2, and they are compared and discussed in Section 3. Finally, the conclusions are covered in Section 4.

## II. ROUTING PROTOCOLS

In this section, the pros and cons as well as performance are discussed and compared for the routing protocols.

### 2.1 Epidemic routing

In Epidemic routing, each relay forwards the data to all the contacted nodes. It can significantly reduce the data forwarding cost measured by the number of relays used. All the nodes can become the carrier, and it is ensured that messages can be delivered with a high probability. All the nodes can

become the carrier, and it is ensured that messages can be delivered with a high probability. However, the network resources are consumed heavily. A node copies a message to every new node it encounters that hasn't got a copy already. It is a highly resource consumption. When the traffic load is very low, it is able to achieve minimum delivery delay [9, 12, and 16].

### 2.2 SimBet Routing

SimBet Routing results in delivery performance close to Epidemic Routing but with significantly reduced overhead. The ultimate goal of the SimBet Routing design is to achieve delivery performance as close to Epidemic routing as possible. This is because Epidemic Routing always finds the best possible path to the destination and therefore represents the baseline for the best possible delivery performance. SimBet Routing achieves delivery performance comparable to Epidemic Routing, without the additional overhead. It improves the delivery performance and reduces the over head. It does not use the social information of each node [10].

### 2.3 BUBBLE Rap

Each node belongs to at least one community. Here we allow single node communities to exist. Each node has a global ranking across the whole system, and also a local ranking within its local community. It may also belong to multiple communities and hence may have multiple local rankings. BUBBLE combines the knowledge of community structure with the knowledge of node centrality to make forwarding decisions. It minimizes the delivery path and to improves the forwarding efficiency. It increases the computational complexity [7].

### 2.4 Multicasting

In Multicasting, it is expected to forward data to as many destinations as possible. The cumulative probability for a relay to forward data to multiple destinations therefore needs to be calculated, and such calculation may require global knowledge of social relations among nodes. It improves the cost-effectiveness of multicast in DTNs. It achieves similar delivery ratio and delay. It also reduces the forwarding cost. It gives the poor resource usage [9].

### 2.5 Spray and Focus

In Spray and Focus, it distributes a small number of copies to few relays [8]. However, each relay can then forward its copy further using a single-copy utility-based scheme, instead of naively waiting to deliver it to the destination itself. It takes advantage of potential opportunities to forward a message "closer" to its destination, according to an appropriately designed utility function. It is able to

identify appropriate forwarding opportunities that could deliver the message faster and significantly it reduces the overhead. Such models usually assume that all nodes have the same mobility characteristics.

## 2.6 Delegation Forwarding

Delegation Forwarding is explicitly designed to reduce costs while achieving high performance. The main idea of delegation forwarding is as follows. We assume each node has an associated quality metric. A node will forward a message only if it encounters another node whose quality metric is greater than any seen by the message so far. Delegation forwarding reduces expected costs dramatically while still ensuring that messages reach the highest quality nodes. Node transmission load, which is the number of message replicas a node, has to forward. Node memory load, which is the number of message replicas a node, has to store in its buffer [11].

## 2.7 BlueCube

A BlueCube protocol is proposed for constructing a hypercube structure by linking various Bluetooth machines. In the constructed BlueCube structure, machines are able to communicate with each other efficiently and utilize the wireless bandwidth and thus, increase the potential of parallel computing and communication. A three-phase protocol is proposed to enable Bluetooth devices to construct a parallel computing and communication environment. It performs parallel computing, provides disjoint paths and reduces the transmission delay. It increases the traffic load in the scatternet and increases the device failure ratio [3].

## 2.8 Relaycast: 2-Hop Relay based DTN Multicast routing

DTN multicast protocol called RelayCast whose operations are based on 2-hop relay DTN routing. For each time slot a cell becomes active if it contains at least a pair of nodes that are within the radio range of each other. In each active cell, we randomly select a pair of nodes and perform either of the following operations. The transmission has two hops between source and destination. When a source has a bundle to send to a destination, it forwards it once to the first devices that it meets. This first device is either a relay device or the destination itself. If it is the destination, the bundle is delivered in one hop, otherwise the device acts as a relay and stores the bundle in a queue corresponding to this destination. Bundles from this queue will be delivered when the relay device meets the destination. Bundles for the same destination are delivered by a relay device in a first-come-first-served order [2, 14].

## 2.9 RAPID

In RAPID routing, a protocol designed to explicitly optimize an administrator-specified routing metric. RAPID "routes" a packet by opportunistically replicating it until a copy reaches the destination. Rapid translates the routing metric to per packet utilities that determine at every transfer opportunity if the marginal utility of replicating a packet justifies the resources used. Rapid models DTN routing as a utility-driven resource allocation problem. A packet is routed by replicating it until a copy reaches the destination. RAPID delivers more packets better. It gives the unlimited resource consumption and minimizes average delay of packets. Compare than other protocols it provides the higher overhead and no performance guarantees [15, 16].

## 2.10 Prophet

In PROPHET, a Probabilistic Routing Protocol using History of Encounters and Transitivity. The Prophet routing protocol was one of the first routing protocols to be defined in the early days of DTN research. Prophet [21] is a DTN routing protocol aiming at using knowledge obtained from past encounters with other nodes to optimize the packet delivery. Each node keeps a vector of delivery predictability estimates, and uses it to decide whether an encountered node were carrier for a DTN packet. The predictability estimates are increased every time a node encounters another node, and they are decayed exponentially. The PROPHET protocol also includes a transitivity mechanism for dealing with the case where two nodes rarely meet, but there is another node that frequently meets both of these nodes. PROPHET is able to deliver more messages than Epidemic Routing with a lower communication overhead.

## 2.11 Hypercube-Based Social Feature Multipath routing

In hypercube-based social feature multipath routing protocol, we use the internal social features of each node in the network for routing guidance. This approach is motivated from several real social contact networks, which show that people contact each other more when they have more social features in common. This routing scheme converts a routing problem in a highly mobile and unstructured contact space to a static and structured feature space.

The multipath routing process is a hypercube-based feature matching process where the social feature differences are resolved step-by-step. Hypercube-based social feature routing scheme is a multipath routing scheme with the objective of reaching the destination quickly, while maximizing the delivery rate. The number of copies of the packet in the whole routing process can be controlled in multipath routing. In other words, the overhead is

constant. The main objective is to distribute the copies of a packet in a cost effective way. The hypercube based social feature multipath routing protocol is used to improve the efficiency of the routing process, increases the delivery rate of the routing, reduces the latency of the routing. Compare than routing protocols here the overhead is constant. It is one of the cost effective way [1, 4, and 5].

## III. COMPARISON

We compare the routing protocols from the given table. We evaluate the important performance metrics like delivery rate and latency, overhead, number of nodes, cost. The given table summarizes the comparison results of the routing protocols. The fig.2 shows the comparison graph for delivery rate of the routing protocols. From the comparison table and our comparative analysis, some conclusive comments can be inferred. From the comparison the Hypercube-Based Social Feature Multipath routing is the best of the routing protocols. Each individual can be represented by its social features. Multipath routing scheme converts a routing problem in a highly mobile and unstructured contact space to a static and structured feature space.

**Table: Comparison of the routing protocols**

| Sl.No | Routing Protocols | Delivery Rate | Latency | Overhead | Number of nodes | Cost |
|-------|-------------------|---------------|---------|----------|-----------------|------|
| 1 | BUBBLE Rap | 55 | Average | Higher | 100 | Average |
| 2 | Epidemic Routing | 60 | Average | Higher | 126 | Average |
| 3 | SimBet Routing | 60 | Min | Normal | 100 | Average |
| 4 | Relaycast:2-Hop Relay based DTN Multicast routing | 70 | Long | - | 10 to 100 | Average |
| 5 | Delegation Forwarding | 80 | Average | Normal | 100 | Low |
| 6 | Blue Cube | 80 | Average | Lower | 10 to 80 | Average |
| 7 | Multicasting | 80 | Average | - | 41 or 97 | Low |
| 8 | RAPID | 88 | Average | Higher | 40 or 126 | Average |
| 9 | Spray and Focus | 90 | Min | Lower | 100 | Average |
| 10 | Prophet | 94 | Min | Lower | 100 | - |
| 11 | Hypercube-Based Social Feature Multipath Routing | 96 | Min | Constant | n | Low |

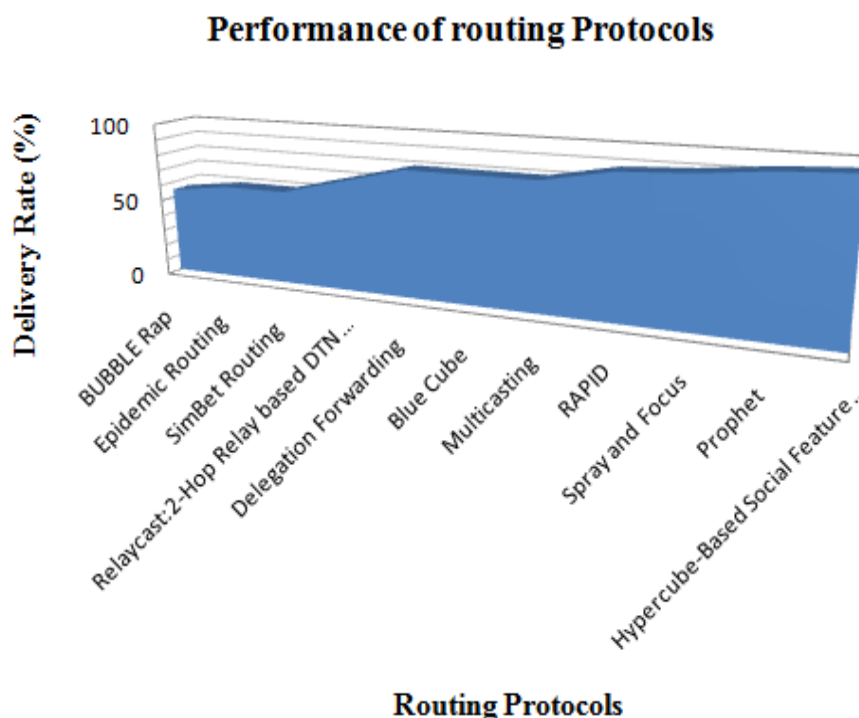## Performance of routing Protocols



**Fig.2. Comparison graph for delivery rate**

## IV. CONCLUSION

Routing in DTNs is a new area of research, with a limited but rapidly growing set of research results. The routing protocols have the common objective of trying to increase the delivery rate while decreasing the latency. We have presented a comparative survey of various routing techniques in DTNs. The advantages and disadvantages of the routing protocols have been discussed with comparison results as well. Compare than other routing protocols the hypercube routing scheme provides the maximum delivery rate and lower latency. In most of the DTN routing schemes, the routing problem considers in a highly mobile and unstructured contact space. In hypercube-based social feature multipath routing the routing scheme converts a routing problem in a highly mobile and unstructured contact space to a static and structured feature space. Overhead is constant in hypercube based social feature multipath routing.

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