Abstract- This paper does a comparative study of different routing protocols used in Delay-Tolerant Networks (DTNs). The basic idea is to compare the different routing protocols and to find out the relative merits and demerits of each method. Protocols for DTN can be broadly classified into data-centric and cluster-based. In data-centric models every node plays a similar role in routing. Cluster-based routing protocols group mobile nodes with similar mobility patterns into a cluster, which can then interchangeably share their resources for overhead reduction and load balancing. Data-centric protocols are relatively simple and easy to implement whereas the cluster-based methods are more complex but relatively efficient.

Index Terms - Delay-tolerant networks, data-centric protocols, Cluster-based routing protocols

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. The important characteristics of Delay Tolerant Networks include low data rate, disconnection, long queuing times, interoperability considerations etc. Most DTN protocols [1]–[8] are "data-centric," where every node plays a similar role in routing. This architecture is simple and effective in small networks, but not scalable to large size DTNs. Clustering [12] has long been considered as an effective approach to reduce network overhead and improve scalability. The protocols in delay tolerant mobile networks are mainly classified into flat or data-centric protocols and cluster-based protocols. The important data-centric protocols include epidemic, spray and wait, ferrying, SWIM, context-aware routing (CAR), MoVe [11], Mobyspace, PROPHET etc. The cluster-based routing protocols in delay tolerant mobile networks are classified into deterministic and probabilistic. Cluster-based protocols include Hierarchical Routing protocol (using multi-level clustering) and clustering using different schemes such as exponentially weighted moving average (EWMA). A comparative study of the different protocols in delay tolerant mobile networks is done in this paper.

II. DATA-CENTRIC ROUTING PROTOCOLS

Some of the data-centric models discussed in this paper are Epidemic, Spray and wait, Message Ferrying, SWIM, CAR, PROPHET, MoVe and Mobyspace. In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data.

A. Epidemic Routing

In epidemic routing a message copy is forwarded to every node encountered. Epidemic routing in its simplest form will continue to exchange messages even well after the message is delivered to its destination. Xiaofeng Lu [13] proposes n-epidemic routing protocol, an energy-efficient routing protocol for DTN. The n-epidemic routing protocol is based on the reasoning that in order to reach a large audience with low number of transmissions, it is better to transmit only when the number of neighbors reaching a certain threshold.

B. Spray and Wait

Another flat protocol discussed is the Spray and Wait protocol. Here a new routing scheme that sprays a number of copies in to the network and then waits till one of these nodes meets the destination. Xiaofeng Lu [13] proposes n-epidemic routing protocol, an energy-efficient routing protocol for DTN. The n-epidemic routing protocol is based on the reasoning that in order to reach a large audience with low number of transmissions, it is better to transmit only when the number of neighbors reaching a certain threshold.

C. Message Ferrying

In message ferrying we use special mobile nodes (Ferry nodes) and designed trajectory for providing communication.
The main idea behind the MF approach is to introduce non-randomness in the movement of nodes and exploit such non-randomness to help deliver data.\[1\]

**D. Context Aware Routing (CAR)**

Context is defined as the set of attributes that describes the aspects of the system that can be used to optimize the process of message delivery. Each host uses local prediction of delivery probabilities between updates of information. The host sends the message to the host in the cloud that has the highest mobility.

**E. PROPHET**

Probabilistic Routing Protocol using History of Encounters and Transitivity (PROPHET) is another flat routing protocol used for intermittently connected networks. When two nodes meet, they exchange a delivery predictability vector containing the delivery predictability information for destinations known by the nodes. Also, they will update the probability between them.

**F. Motion Vector (MoVe)**

MoVe is another flat routing protocol used in delay tolerant mobile networks. The Motion vector (MoVe) scheme leverages the knowledge of relative velocities of a Mobile router and its neighboring nodes to predict the closest distance they are predicted to get to the destination.

**G. Limitations of Data Centric Protocols**

Almost all the data centric models suffer from problems of scalability. These methods generally give reasonable performance in small networks, where as when applied to large networks the performance drastically comes down. In addition the delivery performance is not good in large networks.

**III. CLUSTER BASED ROUTING PROTOCOLS**

Clustering is defined as the procedure of systematizing objects into group whose constituents are analogous in some way. The essential idea of clustering is to group numerous nodes with similar domain pattern into a cluster which can then interchangeably share their possessions such as cache space for overhead diminution and load harmonizing aiming to achieve proficient routing. Clustering based methods can be broadly classified in to Probabilistic and deterministic models.

**A. Hierarchial Clustering**

It is a method of deterministic clustering in which the nodes in this network periodically switch on and then transmits the data of interest. Thus, they provide a picture of the pertinent parameters at regular intervals. They are well suited for applications requiring episodic data monitoring .All the nodes in the network are homogeneous and begin with the same initial energy and the BS however has a constant power supply and so, has no energy constraints.

a) *Intra Cluster Routing:*- If Nodes i and j are in the identical cluster, they have elevated chance to meet each other, thus Node i will transmit the data message to Node j when they meet.

b) *Solitary Hop Inter Cluster Routing:*- If they are not in the same cluster, node i look up gateway information to Node j’s cluster in its gateway table. If an entry is found, Node i send the data message to that gateway. Upon receiving the data message, the gateway will forward it to any node, e.g., Node k, in Node b’s cluster. Node b in turn delivers the data message to Node j via Intra-cluster Routing .

The CCP of a Gateway comprises its cluster ID and a list of clusters to which it serves as gateway along with analogous contact probabilities. Such information can be readily obtained from the gateway table. Once a gateway node accumulates a sufficient set of CCP’s, it constructs a network graph.

d) *Disseminated clustering:*- Each node learns unswerving contact probabilities to other nodes. It is not necessary that a node stores contact information of all other nodes in network. Since our purpose is to group all nodes with elevated pair-wise contact probabilities together, a node joins a cluster only if its couple incisive contact probabilities to all existing members are greater than average.

**B. Clustering Using EWMA**

The routing protocol proposed by Ha Dang[12] is the first effort to investigate the clustering problem and cluster based routing in a non deterministic intermittent environment. The basic idea group mobile nodes with similar mobility pattern in to a cluster which can share their resources for overhead reduction and load balancing. An exponentially weighted moving average (EWAM) is used for updating nodal contact probability. Based on nodal contact probabilities a
set of functions are devised for cluster formation and gateway selection.

IV. CONCLUSIONS

DTN routing appears to be a rich and challenging problem. In this paper we compared the different flat routing protocols and cluster based routing protocols in delay tolerant mobile networks. Data centric routing protocols have many disadvantages compared to cluster based routing protocols. Cluster based routing protocols outperform data-centric routing protocols in terms of scalability and effectiveness. In this paper an attempt has been made to investigate different protocols in handling Delay tolerant Networks. The cluster based scheme manages to overcome many of the shortcomings of and improve routing performance in DTN.

REFERENCES

[8] Utility based multipoint relay flooding in heterogenous mobile Ad Hoc Networks – Lipmaman, Boustead