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An Extensive Literature Review of Various Routing Protocols in Delay Tolerant Networks

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Abstract – *Delay tolerant network (DTN) is one of the latest developments in the field challenged networks. DTNs are the networks that have very high delays and connectivity is available only intermittently. These are wireless networks and nodes are mobile in these networks. End to end connectivity is a big issue in these networks and this type of connectivity is either not available at all or available for short periods only. These networks follow the mechanism known by the name SCF. SCF stands for store-carry and forward mechanism. It means that a node will receive message from any node and stores the message in its buffer memory and then carries this message. The node then passes the message to a particular node based on routing protocol used. There are different routing mechanisms used in these networks. Some of most commonly used protocols are first contact, direct delivery, epidemic, spray and wait etc. Different routing protocols have their advantages and disadvantages. In this paper we discuss various routing schemes along with their pros and cons. Various routings are compared along with their specialty and shortcomings. DTNs are simulated using a simulator developed with the support of Nokia Research Center and known by the name ONE (Opportunistic Network Environment).*

Key Words: Delay Tolerant Networks, CONHIS, ONE Simulator, Contact, Mobile nodes, intermittent connectivity,

1. INTRODUCTION

Delay tolerant networks or DTNs in short is a class of networks that that have very high delays and connectivity is available only intermittently. These are wireless networks and nodes are mobiles in these networks. End to end connectivity is a big issue in these networks and this type of connectivity is either not available at all or available for short periods only. These networks follow the mechanism known by the name SCF. SCF stands for store-carry and forward mechanism. It means that a node will receive message from any node and stores the message in its buffer memory and then carries this message. The node then passes the message to a particular node based on routing protocol used. In this type of network message delivery is made possible with the help of intermediate nodes. Intermediate nodes carry the message to the destination. In challenged networks, DTN is an alternate to Internet. Different space agencies are trying to develop internet like connectivity in the space based on DTN.

1.1 Architecture of DTN

It contains a new protocol which sits above transport layer. This additional protocol is known by the name bundle protocol. There is same bundle protocol for the entire network while other protocols vary as per communication scenario followed [1].

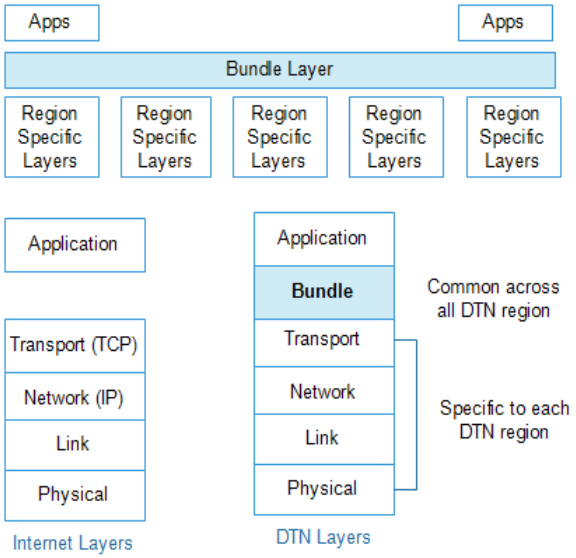

Fig -1: DTN Architecture [1]

1.2 Routing Protocols

Delay tolerant networks have different routing protocols that are used for delivering messages. Some of most commonly used routing protocols are first contact, direct delivery, epidemic, spray and wait, prophet etc.
In first contact the message is delivered by the source to any node that comes in the range of source node.
In direct delivery the message is delivered by the source to only the destination node. No intermediate node is given the message.
Epidemic routing follows the mechanism of flooding. Source node floods all the nodes it encounters. The chances of delivery of messages are almost guaranteed in this protocol.
Spray and wait follows controlled flooding. This routing is combination of spray phase and wait phase.
Prophet routing used history of encounters of nodes and a metric known as delivery predictability is used [2].

1.3 Movement Models

DTNs have mobile nodes and hence these have number of movement models for the transfer of messages between nodes. Some of movement models are Random Way Point model, Shortest Path Map Based movement model and Map Based movement model.
In Random Way Point model, a node chooses its destination randomly and then that node moves to its destination randomly without having any restrictions.
Nodes follow predetermined path in Map Based Movement Model. A predefined map determines the path to be followed by the nodes.
Maps are also used in Shortest Path Map Based model. The destination is chosen randomly in this model. Destination can also be chosen from Points of Interest. After choosing the path, shortest path is used for reaching destination [3].

1.4 Issues in DTN

DTN is not a traditional network. Some of the key issues associated with DTN are encounter schedules, network capacity, congestion control, reliability issues, energy consumption and storage capacity. These issues need to be addressed while dealing with DTNs. These issues are taken care of while designing the network.

2. RELATED WORK

Nelson et al. [4] proposed encounter based routing. The authors used only local observations regarding node's environment. The proposed protocol used encounter based metrics to optimize message passing to maximize delivery ratio while minimizing overhead.

Nguyen and Giordano [5] have proposed social context-based routing that takes into consideration special and temporal dimensions of nodes' activities to predict the pattern in mobile nodes that is base on back propagation neural network model. Through simulation it found that if node density is increased, the message delay improves considerably.

Pan et al. [6] have proposed a routing protocol in which direction of transmission and number of copies can be controlled dynamically based on information of distribution rate of nodes in the network. The results show that the proposed scheme is feasible in complex DTNs. The parameters compared are delivery ratio, overhead and average delay.

Li et al. [7] proposed social energy based routing (SEBAR) protocol. It considers social energy of encountering nodes. The authors have exploited social characteristics of the DTNs in order to make better decisions in message forwarding. They have compared proposed routing with several existing routings. Simulation confirmed the effectiveness of proposed mechanism.

Cheng et al. [8] have presented social characteristics based routing protocol. Human mobility pattern is very important for the performance of protocols in networks. However current routings do not consider the social character. The authors have proposed SONR (Social opportunistic network routing). The proposed protocol is compared with epidemic and Spray-and-wait protocols. Results show that SONR improves performance of different metrics like delivery latency, delivery ratio and overhead.

Penurkar and Deshpande [9] proposed contact history based routing algorithm for VDTN. Existing routings do not take into account the past history of node encounters. The proposed scheme exploited the history of the nodes to find the most suitable candidate relay to take decision to forward the message to its destination. The source node and the mobile nodes maintain history about the encounters in the past with different relay nodes of the network. In proposed algorithm all the nodes may create and store the history. The message may be forwarded to a node having highest number of encounters with different relay nodes. The proposed algorithm is divided into two phases. In first phase, history is created for the relay node counts or for updating it. History is initialized to Null in the beginning. When different nodes pass by the relay nodes, the history is updated accordingly. In second phase, message transmission takes place. In this phase when source node encounters any mobile node, the history is checked and the message is forwarded to the node having highest relay count. The results of simulation showed that as the density of node is increased, the contacts made by the nodes with the relay nodes increase and hence relay count increases. Relay count is proportional to delivery ratio. So the delivery ratio increased using proposed algorithm. CONHIS performed better in case of delivery latency when compared to other existing algorithms. It was found that proposed algorithm performed better than first contact and prophet routing in case of overhead ratio. CONHIS also performs well when compared to spray-and-wait for performance metrics average delivery latency and delivery ratio, but overhead ratio increased in proposed algorithm. The authors have proposed to consider the contact duration parameter for further improving the performance metrics

Zhu et al. [10] discussed about mobile social networks that are a kind of DTNs. The nodes in this type of network are mobile with social characteristics. In these networks social metrics like social centrality, mobility pattern, community etc are considered in forwarding message. The authors have investigated social metrics. They have also presented some other social metrics like social features, social properties etc. The authors have discussed issues for data routing including limitations of metrics, collection of information, social security and future applications of mobile social networks.

Le et al. [11] proposed a novel strategy for buffer management in DTN that is based on power law distributed contacts. The authors have focused on reducing message delay in delivering messages to the desired destination. They have considered two issues. The first issue is the order of message replication that should be followed in case bandwidth is limited. The second key issue is the selection of message to be dropped when buffer space is full. The authors

have developed a utility function to calculate average delay per packet. Scheduling of messages to be dropped is done based on the proposed utility function. The proposed scheme has reduced message delay and the delivery ratio has increased.

Kurniawan et al. [12] have discussed a routing protocol named Dlife. This protocol uses two utility functions for deciding forwarding strategy. These functions are Time-Evolving Contact Duration i.e TEDC and TEDC importance. The authors have studied the performance of Dlife routing in the context of the buffer size and the message size. The authors observed that increase in buffer size decreases the overhead ratio. It happened because increase in buffer allows more messages to be stored in intermediate nodes. The increase in message size caused the increase in overhead ratio. This is due to the fact that if message size is large then the number of messages to be forwarded will be lesser. The authors also observed that increase in the message size decreases the delivery probability.

Kang and Chung [13] have proposed routing protocol that is energy-efficient. Authors have taken in consideration the remaining battery life and delivery predictability of prophet routing. The performance of proposed mechanism is analyzed and compared with prophet routing using different performance metrics. The results show that the proposed protocol has give better results in terms of delivery predictability and the overhead ratio than the prophet routing. The performance of delivery latency could not be better in proposed mechanism.

Bhattacharjee et al. [14] have proposed a new protocol to ensure delivery of emergency messages that are crucial for disaster relief programs. They have discussed about the use of smart phone as a device to be used in DTNs. There are number of messages in the networks, but some of them may have only emotional sentiments. These types of messages are not important in disaster management keeping in view that the resources are constrained. The delivery of emergency related messages is important in such scenario. The authors have proposed an approach that consists of two steps. First step is to segregate crucial messages through filtering based on natural language processing. Second step is forwarding of filtered messages using Priority enhanced prophet routing. The proposed mechanism successfully achieved message prioritization and also ensured delivery of crucial messages. The proposed routing was evaluated using ONE simulator. From results it is clear that proposed mechanism performs better than existing protocols taking in account delivery ratio and overhead ratio.

Burleigh et al. [15] have discussed about unified routing framework for DTNs. There is a dichotomy between the solutions that are developed for deterministic networks designed for space flight etc and the protocols used for terrestrial networks. The authors have presented extension of CGR i.e. Contact Graph Routing. They try to remove the dichotomy through the proposal of unified approach for all DTN environments.

Das et al. [16] have iterated that present schemes use only location related information to forward data to next node. The existing schemes do not consider energy-constraints of nodes participating in message transfer. They have proposed a scheme that will use residual energy of the nodes along with location to choose the next node for message forwarding. Authors have compared performance of proposed and existing schemes. Results show that they have achieved increase in delivery ratio and longer network life through the use of proposed mechanism.

Chen and Lou [17] have presented a new routing protocol called as GAR. The nodes in DTN having common interest form groups and move together. This feature may help in designing resource constraint networks. The authors have proposed to maximize message delivery probability by using group feature. In proposed scheme, design of message transfer priorities is done in a way to maximize delivery probability. The performance of Gar is compared with other seven protocols. GAR achieves second shortest latency and delivery ratio has also improved in proposed routing.

Vendramin et al. [18) proposed Cultural Greedy Ant protocol to increase delivery ratio in DTNs. CGrAnt is based on cultural algorithms, ant colony optimization and operational metrics characterizing social connectivity between users. The authors used greedy transition rule that is based on information collected locally and globally from DTN environment. The results show that proposed routing performs better in terms of delivery ratio and the message replication is lowest when compared to epidemic and prophet routing.

Sharma et al. [19] presented paper on the process of configuring ONE simulator using eclipse. The simulator can be used to create new routing schemes. It can be also used to create new movement models. The code can be developed using Eclipse which is a Java based tool that is used for programming purpose. The authors have provided detailed procedure to configure the ONE with eclipse. Eclipse has number of inbuilt functions. It also helps in running multiple projects in ONE simulator. The authors have explained in detail the steps starting from installing JDK to creating new project and from building path to adding external library files.

3. CONCLUSIONS

In this paper we have observed that Delay Tolerant Network is a challenging and new field. It is still in development phase. There are different routing protocols developed in DTNs. These routing protocols have their advantages and disadvantages. There are certain issues in these types of networks. We have discussed different algorithms or approaches proposed by different authors.

The authors have used the encounter value between nodes' contacts, replication copy methods, history of encounters etc. parameters to select the most appropriate node for forwarding the message.

It has not been studied about the duration of contacts between nodes during their encounter with each other in these research papers. The nodes are in the range of each other for different durations and the duration measurement

may be an important parameter for selecting the most appropriate node for message forwarding. The contact duration may be an important parameter to reduce replication in order to increase delivery ratio and hence reduce the overhead ratio in DTNs.

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