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Survey of Various Routing Protocols Used for Delay Tolerant Networks

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ABSTRACT

Current wireless network has provided a wide range of application making it possible to interconnect devices and system successfully all around the world. The widespread availability of wireless devices and ubiquitous access to various services via wireless network rapidly makes it as indispensable part of our life. But there are some wireless network application where the connectivity between nodes has intermittent property due to challenged working environments such as dynamic topology, resource constraints etc. This paper describes a survey of the existing routing algorithms with their comparison used in DTN.

Keywords: DTN, Routing, Latency, Replication, Flooding, Forwarding

I. INTRODUCTION

Challenged network environment where nodes are characterized by opportunistic connectivity are termed as Delay Tolerant Network (DTN).The DTN works in stressful environment [1] in which link disruption may result in excessive delays in message transmission during communication. The node in the delay tolerant network has the added constraint of finite buffers and no end to end path may ever exist. The above situation leads the problem like High latency &low data rate(10kbps under water), end to end node Disconnection Problem, Long message queuing Times, as well as Limited resources in terms of limited memory and processing capability.

Applications of DTNs have been found in many challenging environments such as providing delay-tolerant Internet services in suburban and rural areas. This project has been implemented by First Mile Solutions with a system called DakNet [2]. Vehicular networking is a wide and growing field of DTNs, where many applications are being explored [3]. One of these applications is to provide Internet access to vehicles by connecting to roadside wireless base stations [4]. Non-commercial applications include monitoring and tracking wildlife animals [5], and environmental monitoring, such as lake water quality monitoring and roadside noise monitoring [6]. DTNs can be applied in a variety of other fields ranging from healthcare to education to economic efficiency.

The remainder of paper is organized as follows. Section II discusses characteristics of Delay Tolerant Network. Section III discusses related literature review along with comparison and finally, section IV concludes the paper.

II. CHARACTERISTICS OF DELAY TOLERANT NETWORKS

1. **High latency & Low Data Rate** – As DTN are made of sparsely connected node that may never meet to each other which leads to high latency as well as low data transmission rate (up to 10kbps under water).
2. **Disconnection Problem**- In delay tolerant network scenario, end-to-end path does not exist, node disconnection problem is much common as compared to conventional network.
3. **Long Queuing Times**- As the delay tolerant network make the use of store carry forward mechanism a message may be need to store for a long time in a buffer of a node before forwarding it. Also, the queuing delay may vary depending upon

the node meeting probability; means the queuing delay may be extremely large I worst case.

4. **Interoperability Consideration**-Delay tolerant network tend to be comparatively simple and local in scope.
5. **Limited Resources** - resource constraints such as limited buffer capacity, processing capability, battery exhaustion of a node as well as end-to-end delay due to unexpected environment in between sender and receiver limits the availability or survivability of a node.

III. LITERATURE SURVEY

T. Spyropoulos et al. in 2004 et al. [7] proposes two types of routing scheme that was single-copy routing scheme and multi-copy routing scheme [8]. A single copy routing scheme uses single custody for each message throughout the network. A single custody implies that a single copy of message exist at particular time.

A current message holding node forward a copy to appropriate next node until the message reaches its destination. The example of single copy routing scheme includes randomized routing algorithm in which the message is handed over to the encountered node with probability P, utility based routing algorithm [9] defines a utility function which is maintained by each node for every other node for indicating the usefulness of message delivery as well as a hybrid routing algorithm termed as seek and focus routing algorithm which makes the use of both of the above algorithm i.e. randomized as well as utility based routing algorithm.

On the other hand, multiple-copy routing schemes may be defined as a scheme in which multiple copies of message is spread throughout the network for the purpose of increasing efficiency as well as robustness. Further the multi copy routing scheme may be categorized into two groups based on the restrictions imposed on the no. of copies that is extremely flooding and controlled flooding. The scenario of multi copy scheme may use flooding-based approach or restricted flooding based approach for example "Spray and Wait" Routing algorithm .first of all this routing algorithm spreads sufficient no. of message copies under the guarantee that at least one of them will reach the destination in a manner similar to epidemic routing. After that it stops and wait until each node carrying a copy perform direct transmission.

L. K. Choudhary, M. K. Ahirwar and U. Chaurasia et al. [10] (On the basis of Routing Dimensions) On the basis of the no. of message copy replicated throughout the network. The routing in intermittently connected network has been widely discussed in recent years. The traditional ad-hoc network routing protocol do not fit in the opportunistic network environment because of many limitations such as high node mobility, end to end delay etc. Due to this inherent adversity of opportunistic network, most of the delay tolerant routing protocols falls under three categories, based on the number of copies of same message created throughout the network i.e. forwarding based routing protocol, quote or replication based routing protocol and flooding based routing protocol.

Y. Lin, B. Liang and B. Liet al. [11] Under flooding scheme, Epidemic routing protocol was one of the earliest in which encountering node first exchange a summery vector in between them. Here the summary vector contains the metadata regarding the message stored at node's buffer. By comparing a summary vector a node learns about new messages or information stored at the neighbor.

The other flooding based routing protocol includes Prophet [12], MaxProp [13], RAPID [14] etc. Although the flooding based routing protocols are well suited to the opportunistic network environment, it suffers from high congestion overhead because of its policy to replicate as many copies of message as resource permits. To deal with the problem of greedy use of network resources as flooding based routing protocol does, forwarding based routing scheme is introduced. Here, single copy of the message is injected into a network and is forwarded towards the destination through successive intermediate nodes. Forwarding routing protocol though saves network resources but present low delivery probability unless frequent connectivity is present in the network. The various proposed forwarding routing protocols are MEED, SimBet etc. which makes the use of different types of knowledge oracle to forward the packet towards the destination.

To mitigate the problem of forwarding and flooding based routing scheme [15], a replication based

approach [16] comes into existence. The first routing protocol from replication based routing family was Spray and Wait (Spyropoulos et.al.2005).

T. Spyropoulos, K. Psounis and C. Raghavendraet al. [17] Spray and Wait routing protocol break routing operation in two phases. In the first phase also known as spray phase identical message copies are disseminated throughout the network and in second phase i.e. wait phase, nodes with single copy of message directly transmit it to the destination when encounters.

T. Spyropoulos, K. Psounis, and C. S. Raghavendra et al. [18] A very slight modification in spray and wait routing protocol was done by (Spyropoulos et. al. 2007) named spray and focus routing protocol. Here the spray phase uses same binary quota allocation function and in focus phase, a node with only single copy of message performs utility based forwarding in order to maximize utility function. With this modification in second phase overhead ratio decreases up to 20 times and the delivery probability increases up to two times.

Further this replication strategy can be classified into two broad categories i.e. one which uses the static quota allocation function for example spray and wait routing protocol which makes the use of binary function to limit the no. of message replicas that has to be injected into the network and the other which makes the use of dynamic characteristics of the network such as requirement and availability of resources or knowledge to decide the no. of message replicas throughout the network. Another flavor of Replication based routing protocol is also proposed such as EBR [19], Dynamic congestion control based routing [20] etc. Overall, the replication function should aware of the network conditions such as traffic load distribution, resource constraints [21] etc.

Sushant Jain et al. [22] has classified these knowledge oracle into four categories that is contact summery oracle which provide average waiting time until the next contact for an edge, contact oracle which specifies contact between two nodes at any point of time, queuing oracle which makes the use of knowledge regarding buffer occupancy of a node and at last traffic demand oracle which can answer any question regarding present or future traffic demands and inject message according to the network traffic.

Z. Zhang and Q. Zhanget al. [23] (On the basis of decision type used) As DTN suffer from intermittent connectivity where the nodes are sparsely distributed. The source node may use the source routing to determine the complete path of a message and encode this information some how in the messages. Thus the route is determined once and does not change during the traversal of the message throughout out the network.

W. Zhao, M. H. Ammar and E. Zegura et al. [24] On the other hand in per hop routing the next hop of a message is determined at each intermediate hop. Here the message uses the local information regarding available contacts and queuing status of each node .The per hop routing may enhance the network performance but it may lead to loops when nodes have different topological views.

A. Keränen, J. Ott, and T. Kärkkäinen et al. [25] Approach and Roam (AaR) uses historical information suchas, location and moving speed of the destination, to calculate movement range. In this scheme, there are two phases, Approach and Roam. In the Approach phase, the objective is to make faster transmission of message towards the estimated movement range, and in the Roam phase, guaranteed message replication occurs within this range. But the scheme suffers from local maximum problem. The same group of researchers solves the above-described local maximum problem based on the idea proposed in Delegation Geographic Routing (DGR). DGR scheme makes routing decisions considering a new metric Time-To-Intersect (TTI). It compares TTI among all current neighbors. The local maximum problem is solved using Delegation Forwarding (DF) optimization policy, by updating the TTI of the selected relay node after successful message delivery.

T. Spyropoulos, K. Psounis and C. Raghavendra et al. [26] Geographic-based Spray-and-Relay (GSaR) forwards messages with a predefined number of replications. Using the historical location, movement speed and inter contact time recorded in the past, the movement range of the destination is calculated using the method proposed in [25].

U. Shevade, H. H. Song, L. Qiu and Y. Zhang et al. [27] propose distance-based energy efficient opportunistic forwarding (DEEOF) scheme which maximize energy

efficiency and delivery ratio. In DEEOF, potential relay node with minimum distance is selected from the set of contacted neighbors. After that, future delivery predictability and energy efficiency of the selected relay node are estimated and compared with predefined threshold which acts as a trade-off between energy efficiency and delivery ratio.

V. Conan, J. Leguay and T. Friedman et al. [28], the authors propose reference architecture for Delay-Tolerant Networking (DTN) routing protocols and a thorough quantitative evaluation of many protocols proposed in the literature. They categorize DTN protocols according to their use of the three techniques that are the key elements of our reference architecture: queue management, forwarding and replication.

X. Chen, J. Shen, T. Groves and J. Wu et al. [29], authors have compared epidemic routing protocol and spray and wait protocol on the basis of end-to-end delay, packet delivery ratio and bundle hop count. Based on this analysis they found that epidemic routing performs well. However, if one set the buffer size dynamically, the packet delivery ratio of epidemic routing can be improved.

TABLE I

COMPARISON OF THE FLOODING FAMILIES

	Hop Count	**Resource Usage**	**Delivery Ratio**	**Routing Table**	**Multipath Support**	**Effectiveness**	**Latency**
Direct Contact	1	Low	Min	No	No	Bad	Long
Two-hop Relay	2	Low	Low	No	Yes	Bad	Long
Tree-based Flooding	Many	High	Low	No	Yes	Bad	Long
Epidemic Routing	Many	Max	Max	Yes	Yes	Normal	Long
Prioritized Epidemic Routing	Many	Limited	Normal	Yes	Yes	Good	Normal
Probabilistic Routing	Many	Limited	Normal	Yes	No	Good	Normal
RUNES	Many	Limited	Normal	Yes	Maybe	Good	Long

TABLE II

COMPARISON OF THE FORWARDING FAMILIES

	Flexibility	**Resource Consumption**	**Information Usage**	**Routing Table**	**Scalability**	**Loop-free**	**Effectiveness**	**Delivery Ratio**	**Latency**
Location based Routing	Bad	Low	Little	No	Bad	Yes	Bad	Min	Normal
Source Routing	Bad	Normal	Normal	No	Bad	Yes	Bad	Low	Long
Per-hop Routing	Bad	Normal	Normal	No	Bad	Yes	Bad	Low	Long
Per-contact Routing	Good	Many	Many	Yes	Bad	No	Normal	Normal	Normal
Hierarchical Routing	Good	Many	Many	Yes	Good	Yes	Good	Max	Normal

IV. CONCLUSION

After studying all the related reference paper, we have underlined some problems that have to be considered during a routing protocol design. When we try to maximize packet delivery ratio we need to shift silently from flooding based approach to forwarding approach in order to reduce the network congestion because of limited buffer availability or due to access discarding of packet. From here, we have motivated to make a new routing protocol or to modify existing one that may efficiently handle the above trade-off.

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