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Encounter Based Routing in DTN: A Review

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ABSTRACT
Delay tolerant-network (DTN) is emerging technology in wireless communication. This network is useful in scenarios where no end-to-end path exists from source to destination. Current work in routing protocols for delay and disruption tolerant networks leverage epidemic-style algorithms that trade off injecting many copies of messages into the network for increased probability of message delivery. However, such techniques can cause a large amount of contention in the network, increase overall delays, and drain each mobile node's limited battery supply. We present a new DTN routing algorithm, called Encounter-Based Routing (EBR), which maximizes delivery ratios while minimizing overhead and delay. This paper presents the work done by researchers to enhance the routing techniques in DTN.
Keywords:- DTN, EBR, Routing**.**

I. INTRODUCTION

Delay tolerant networking [1] has received considerable attention from the research Community in recent years. Advances in wireless and mobile technologies have enabled new networked systems where intermittent disconnections are not exceptional. Examples include sparse mobile ad hoc networks. The traditional Internet model assumes low error rates, low propagation delays and, most importantly, a steady end-to-end connection between any source/destination pair of nodes.

Delay tolerant networks (DTNs) represent a class of infrastructure-less wireless systems that support the functionality of networks experiencing frequent and long lasting partitions. DTNs are intended to deal with scenarios involving heterogeneity of standards, intermittent connectivity between adjacent nodes. The key issue of routing for DTN is to find an opportunistic connectivity between the nodes and transmit data to the nodes when they meet with each other if possible [2] [3]. Some methods have been proposed to achieve opportunistic communication in such challenged networks, trying to achieve the higher delivery ratio with the shorter delivery delay. Each of them has its own pros and cons.

In Delay Tolerant Networks, the network may not be connected at any given point of time. The packets are delivered in a store – carry – forward model. Each node along the path receives the packets from the previous node as it comes in contact with that particular node. After that this node stores the packet locally until it encounters next intermediate node. And when encounter occurs the packet is sent to next intermediate node. This procedure is followed until the destination is reached.

When two nodes come in contact with each other, they may exchange the packets and such an opportunity is known as encounter. In case of traditional networks, the network is connected at any given point of time. Therefore there are no partitions in such a network. But the traditional network fails to consider several real life applications like wildlife and habitat monitoring, deep space communication, underwater infrastructure etc. That's why the delay tolerant network comes into existence, to take into account the above applications [4] [5].

The DTNRG has developed architecture for Delay-tolerant networking that has emerged from the efforts on Interplanetary Internet (IPI). There are many Bundle Protocol implementations, but the most famous protocol is DTN2, that is developed by Intel and at present it is maintained by Dublin Trinity College, and ION (Interplanetary Overlay Network) [6] [7]. The DTN architecture and its protocol stack are shown in Figure 1.

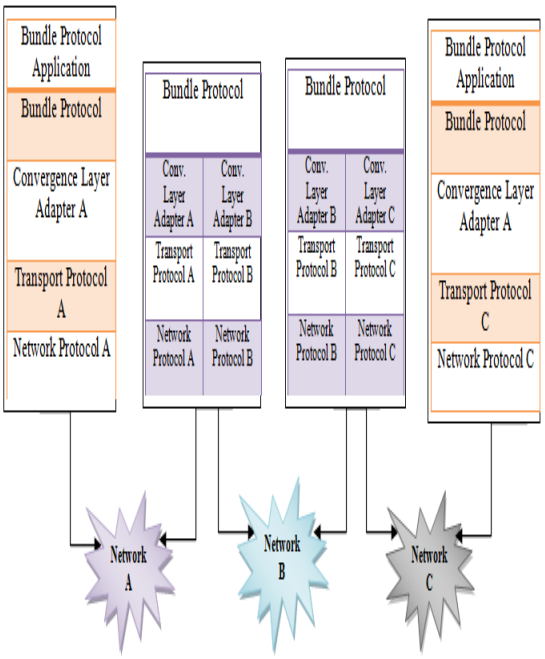

Figure 1: DTN architecture and protocol stack.

II. ENCOUNTER BASED ROUTING (EBR)

The primary goal of a DTN routing protocol is to obtain high message delivery ratios and good latency performance, while maintaining low overhead, Encounter-Based Routing (EBR), uses an encounter-based metric for optimization of message passing that maximizes message delivery ratio while minimizing overhead both in terms of extra traffic injected into the network and control overhead, as well as minimizing latency as a second order metric.[8]

Encounter-based Routing (EBR), a quota-based DTN routing protocol that achieves high delivery ratios comparable to flooding-based protocols, while maintaining low network overhead. This improvement in delivery ratio is accomplished by taking advantage of the following observed mobility property of certain networks: the future rate of node encounters can be roughly predicted by past data. This property is useful because nodes that experience a large number of encounters are more likely to successfully pass the message along to the final destination than those nodes who only infrequently encounter others. Many networks experience this phenomenon; examples include disaster recovery networks, where ambulances and police tend to be more mobile and bridge more cluster gaps than civilians, and vehicular-based networks, where certain vehicles take popular routes. Since EBR is a quota-based routing protocol, it limits the number of replicas of any message in the system, minimizing network resource usage. EBR bases routing decisions on nodes' rates of encounters, showing preference to message exchanges with nodes that have high encounter rates. These routing decisions result in higher probability of message delivery, avoiding routes that may never result in delivery and so reducing the total number of message exchanges. In EBR, information about a node's rate of encounter is a purely local metric and can be tracked using a small number of variables.[8]

DTN routing protocols can be classified as either forwarding-based or replication-based.

Forwarding-Based

Forwarding-based protocols keep one copy of a message in the network and attempt to forward that copy toward the destination at each encounter.

Replication-Based

Replication-based protocols insert multiple copies, or replicas, of a message into the network to increase the probability of message delivery. Essentially, replication based protocols leverage a trade-off between resource usage (*e.g.*, node memory and bandwidth) and probability of message delivery. Although all replication-based protocols take advantage of this trade-off, these protocols can be further separated into two classes based on the number of replicas created: quota-based and flooding-based.

Flooding-based protocols

Flooding-based protocols send a replica of each message to as many nodes as possible, whereas quota-based protocols intentionally limit the number of replicas. Assume that m_t indicates the maximum number of unique messages (excluding replicas) that have been created prior to some time t. Then, an upper bound on the total number of messages (including replicas) in the network at time t is $mt \cdot L$, where L is the maximum number of replicas for any given message. L can be a probabilistic or discrete variable.

Quota-based routing protocol

Quota-based routing protocol can be defined as follows: A replication-based routing protocol is quota-based if and only if L is independent of the number of nodes in the network (assuming the characteristics of the network, such as storage, bandwidth, and mobility, allow for every node to have a replica of every message). Conversely, any replication-based protocol where L is dependent on the number of nodes in the network is defined to be flooding-based. [8], [23]

III. LITERATURE SURVEY

Samuel C. Nelson, Mehedi Bakht, and Robin Kravets[8], proposed Encounter-Based Routing (EBR), to maximize delivery ratios while minimizing overhead and delay. EBR only considers the current rate of encounters and averages this rate using an exponentially weighted average to account for both older and newer data. EBR achieves up to a 40% improvement in message delivery over the current state-of-the-art, as well as achieving up to a 145% increase in good put.

Xiang FaGuo,MunChoonChan[9], present an efficient routing algorithm, *Plankton*, for Delay/Disruptive Tolerant Network (DTN).Plankton utilizes replica control to reduce overhead and contact probability estimates to improve performance. Plankton's evaluation shows that substantial overhead reduction can be achieved without loss in delivery ratios and latencies. Our work provides a technique that integrates highly reliable contact predictions and replica controls.

SaeidIranmanesh, RaadRaad, Kwan-Wu Chin [10], presents an algorithm to achieve high delivery ratio of packets/bundles at the lowest possible bandwidth cost, buffer space and energy. There is need of protocol which uses less resource to achieve high delivery ratio and low latency is an open . This paper proposes a quota-based protocol which confines the number of replicas and forwards them based on the meeting history of nodes.

Mohammad Boudguig, AbdelmounaimAbdali[11], this paper present a new algorithm based on the predictability concept since it introduces better resources management in terms of bandwidth, messages delivery compared to other routing algorithms for DTN. It is prove by large-scale simulations, the effectiveness of our algorithm in terms of eventually delivered messages, failed transmissions, dropped messages between nodes, buffer time and hop count enhancement. Paper focused on the improvement of the prophet routing protocol through a new approach by implementing the predictability improved factor. Its approach has proved a clear improvement of the predictability concept.

Mohammad Rahmatullah, Dr. PriyankaTripathi[12], this paper have proposed a new buffer management policy based on message forwarding and message replication on the network. It introduced two utility functions. These functions are to find which message will be dropped when buffer overflow occurs. is a special protocol named Bundle Protocol (BP) that is not in TCP/IP. Bundle protocol (BP) provides store-carry forward mechanism that means when node is not in then message is hold by the node and when node comes in range then message will be forwarded. This policy utilize the properties of each message such as number of replicas of particular message , remaining time-to-live and the age to calculate the utility value of each message. With this utility value node decides which message is to be deleted from buffer whenever the buffer overflows.

Pan Hui, Jon Crowcroft, EikoYoneki[13], this paper seek to improve our understanding of human mobility in terms of social structures, and to use these structures in the design of forwarding algorithms for Pocket Switched Networks(PSNs).It propose a social based forwarding algorithm, BUBBLE, which is shown empirically to improve the forwarding efficiency significantly compared to oblivious forwarding schemes and to PROPHET algorithm. It also show how this algorithm can be implemented in a distributed way, which demonstrates that it is applicable in the decentralised environment of PSNs

Vasco N.G.J. Soares, Joel J.P.C. Rodrigues, FaridFarahmand[14], purposed Vehicular delay-tolerant network (VDTN) which assumes asynchronous, bundle-oriented communication, and a store-carry-and-forward routing paradigm It proposes a VDTN routing protocol, called , which takes routing decisions based on geographical location data, and combines

a hybrid approach between multiple-copy and single copy schemes.

Y. Xi, M. Chuah[15], this paper explore an encounter-based multicast routing (EBMR) scheme for DTNs. Scheme uses fewer hops for message delivery. It present an analytical framework for estimating the delivery performance of the EBMR scheme, and present some analytical and simulation results to show that the EBMR scheme can achieve higher delivery ratio while maintaining high data transmission efficiency compared to other multicast strategies. It has presented an encounter-based multicast routing scheme for DTNs. EBMR scheme allows nodes to cache the data until a good next-hop node can be found to relay the messages destinations. EBMR scheme takes fewer number of hops to delivery multicast packets. It demonstrated that this scheme can achieve high delivery ratio with reasonable data efficiency.

Eyuphan Bulut and Boleslaw K. Szymanski [16], this paper consider DTNs in which malicious nodes are present, to which we refer to as compromised DTNs. It discuss and analyse the effects of presence of malicious nodes in the compromised DTN on routing of messages. It propose a two period routing approach which aims to achieve desired delivery ratio by a given delivery deadline in presence of malicious nodes. Results show that, with proper parameter setting, the desired delivery ratio by a given delivery deadline can be achieved most of the time by the proposed method. It focused on the problem of routing in compromised delay tolerant networks in presence of malicious nodes. Assuming that, with certain probability, the nodes in the network are open to coalition with these malicious nodes, it discussed and analysed several message distribution schemes in terms of secure delivery of messages.

Long Vu, Quang Do, KlaraNahrstedt[17], this paper present 3R routing protocol, which leverages the regularity of fine-grained encounter pattern among mobile nodes to maximize message delivery probability while preserving message delivery deadline. It evaluates and compares 3R with Prophet and Epidemic routing protocols over the collected trace. Evaluation results show that3R outperforms other alternatives considerably by improving message delivery while reducing message overhead. It shows that the fine-grained encounter pattern of people is regular. 3R exploits the regularity of fine-grained encounter pattern and provides a totally distributed routing solution to expedite message routing in Delay Tolerant Networks.

Sapna Grover, Aditya Pancholi, SonikaArora [18],this paper uses ferry-based mechanism for providing security and maintaining consistency throughout the network. Security issues have thus become more challenging in these networks due to its dynamic nature. Thus these networks are vulnerable to different kinds of attacks because of which security has always been a major concern. This paper presented a ferry-based secure algorithm for routing in DTNs. The algorithm effectively finds the shortest available path to the destination with the help of a centralized mechanism. The algorithm also provides security against malicious node in the network with the help of certain certified ferry nodes.

Daru Pan, Mu Lin, Liangjie Chen and JiapingSun [19], this paper proposes the Spray and Wait with Probability Choice (SWPC) routing, where continuous encounter time is used to describe the encounter opportunity; a delivery probability function is set up to direct the different number of copies to the destination during the spray phase; and a forwarding scheme is implemented in the wait phase. In this paper, it propose the Spray and Wait routing with Probability Choice (SWPC) for opportunistic networks. In SWPC, encounter time is used to describe the encounter opportunity, a delivery probability function is set up to direct the different number of copies to the destination during the spray phase; and the last one copy is directly delivered to the node with higher delivery probability to destination in the wait phase.

Ahmed Elwhishi, pin Han Ho , K. NaiK, and Basem Shihaday [20], this paper introduces a novel multi-copy routing protocol, called Self Adaptive Utility-based Routing Protocol(SAURP), for Delay Tolerant Networks (DTNs) that are possibly composed of a vast number of miniature devices smart phones, hand-held devices, and sensors mounted in fixed or mobile objects. SAURP aims to explore the possibility of taking mobile nodes as message carriers in order for end-to-end delivery of the messages. The best carrier for a message is determined by the prediction result using a novel contact model, where the network status, including wireless link condition and nodal buffer availability, are jointly considered. The paper argues and proves that the nodal movement

and the predicted collocation with the message recipient can serve as meaningful information to achieve an intelligent message forwarding decision at each node. The paper introduced a novel multi-copy routing scheme called SAUPR, for intermittently connected mobile networks.

John Burgess Brian Gallagher David Jensen Brian Neil Levine [21], this paper propose MaxProp, a protocol for effective routing of DTN messages. MaxProp is based on prioritizing both the schedule of packets transmitted to other peers and the schedule of packets to be dropped. These priorities are based on the path likelihoods to peers according to historical data and also on several complementary mechanisms, including acknowledgments, a head-start for new packets, and lists of previous intermediaries. It has proposed MaxProp as an effective protocol for DTN routing, particularly for the context of our real DTN deployment. MaxProp unifies the problem of scheduling packets for transmission to other peers and determining which packets should be deleted when buffers are low on space. Additionally, it has identified several complementary mechanisms for improving the performance of path-likelihood based routing.

Aruna Balasubramanian, Brian Neil Levine and ArunVenkataramani [22], this paper present rapid, an intentional DTN routing protocol that can optimize a specific routing metric such as worst-case delivery delay or the fraction of packets that are delivered within a deadline. It evaluate rapid rigorously through a prototype deployed over a vehicular DTN test bed of 40 buses and simulations based on real traces we have proposed a routing protocol for DTNs that intentionally maximizes the performance of a specific routing metric. This protocol, rapid, treats DTN routing as a resource allocation problem, making use of an in-band control channel to propagated metadata.

The below table shows the summary various DTN protocol.

Sr. No.	**TITLE**	**YEAR OF PUBLIC-ATION**	**PARAM-ETER USED**	**TECHNIQ-UE USED**
1.	Encounter–Based Routing in DTNs	2009	Message delivery ratio	Epidemic Style Algorithm
2.	A novel destination-based routing protocol (DBRP) in DTNs	2012	Message delivery ratio, bandwidth, buffer size, energy	DBRP, quota based protocol
3	A New Approach of Enhanced Buffer Management Policy in Delay Tolerant Network (DTN)	2014	buffer management	Epidemic routing,Bundle protocol
4	3R: Fine-grained Encounter-based Routing in Delay Tolerant Networks	2010	Message delivery ratio, message overhead	Prophet and Epidemic routing protocol
5	BUBBLE Rap: Social-based Forwarding in Delay Tolerant Networks	2008	Efficiency	Pocket Switched Networks(PSN)
6	Plankton: An Efficient DTN Routing Algorithm	2013	Communication overhead, prediction accuracy	Plankton algorithm
7	New DTN Routing Algorithm	2013	Better resource management	Prophet algorithm

8	GeoSpray: A geographic routing protocol for vehicular delay-tolerant networks	2011	Best routing from source to destination	GeoSpray protocol
9	An Improved Spray and Wait with Probability Choice Routing for Opportunistic Networks	2012	Delivery probability and delays	epidemic routing and probabilistic routing
10	MaxProp: Routing for Vehicle-Based Disruption-Tolerant Networks	2008	Effective routing	MaxProp

Table1. Various DTN Protocols

IV. CONCLUSION

This paper presents a review of work done by different researchers in DTN. Each protocol has its own pros and cons. EBR protocol is best in message delivery ratio, MaxProp is better in routing path way, PRoPHET is better in resource management and so on. This review sets a platform for developing a new algorithm which reduce the drop packets, increase throughput, reduce redundancy and average message delay. In future there can be improvement in the parameters like buffer size, security management, energy efficiency, time management, etc.

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