

A Review on DTN Routing Protocol

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Abstract—DTN- Delay Tolerant Network works well in the severe conditions where other wireless adhoc networks fail to exist. It works well even where there does not exist any end to end connectivity i.e. intermittent connectivity. It works on the Store-Carry-and-Forward principle. This principle makes it possible for DTN to work in the regions of intermittent connectivity. It is implemented by Bundle protocol. The bundles of message are replicated, forwarded to the intermediate nodes with the help of various routing and replication strategies offered by various routing protocols of DTN. ONE simulator is designed to offer a wide range of DTN routing protocols. DTN routing protocols are Epidemic, Prophet, MaxProp, Spray-and-wait and Rapid. Rapid is considered best in terms of delivery probability and buffer time average.

Index Terms - Opportunistic Network Environment, Delay

Tolerant Network, Routing.

1. INTRODUCTION

DTN, Disruption Tolerant Network is a networking architecture where nodes do not have contemporaneous connections i.e. nodes are not always connected but have scheduled intermittent connections. It is based on Store-Carry-Forward principle. This principle is similar to postal system in which whole message (entire blocks of application-program user data) is forwarded from one node's storage place to another node's storage place along a path that ultimately reaches the destination. This facilitates more delay tolerant capabilities in DTN as compared to TCP/IP [3] Store carry and Forward principle provides communications in an unstable environment where network is subjected to long lasting delays, asymmetric data rates and high error rates most of the time.(e.g. Internet for planets etc.). The main objective of DTN Routing is to build a network with minimum delay and good delivery probability. ONE - Opportunistic network Environment is specially designed simulator to offer a broad set of DTN Protocol simulation capabilities in a single framework. The ONE simulator is designed in a modular way, allowing extensions of virtually all functions to be implemented using well defined interfaces. The main function of ONE simulator are modeling of node movement, inter-node contacts, routing and message handling.[8]Here routing protocols are based on replication strategies i.e. the number of copies of a message are created and are forwarded. Different

routing protocols used here are Epidemic Routing Protocol, Prophet, Spray and wait, MaxProp, Rapid Routing protocol [13].

2. LITERATURE REVIEW

Tomoaki Miyakawa and Akio Koyama, proposed a spray-and-wait and PROPHET Hybrid routing method, which replaced the blind forwarding to replicated node in spray-and-wait by the checking delivery predictability of the replicated node and forwarding the message in spray-and-wait manner to only those replicating nodes which have high delivery predictability for destination node. As a result of making and hybrid, the arrival rate got improved.[1]

Bijal Patel *et.al.*, compared the performance of spray and wait, epidemic and direct delivery routing protocols and checked number of packets delivered, delivery probability, average latency, buffer time, hop count and overhead ratio. The results shows that the spray and wait protocol has high delivery probability, high latency and overhead ratio and concluded epidemic and spray and wait protocol can perform in real time applications but direct delivery routing protocol cannot.[2] Shally *et.al.*, checked the performance of different routing protocols under different number of black hole attacking nodes. The analysis indicates that there is decrease in delivery probability, hop count average and buffer time average. The overhead ration increases using spray and wait protocol but decreases if rapid protocol is used upon increasing the black hole attacking nodes[3]

Anders Lindergren *et.al.*, proposed a prophet routing protocol that performs better than epidemic routing protocol. It calculates the delivery predictability of encountered node i.e. the likelihood of message delivery through this encountered node. Transitive property and aging factors are also associated to decide the impact. This strategy forwards the packet rather than doing replication. It provides low communication overhead and performance than epidemic routing protocol.[4] Daru Pan *et.al.*, proposed a DTN hybrid scheme i.e. Spray and Wait with Probability Choice (SWPC) routing, in which spray and wait doesn't blindly forward the L/2 copies to the encountered node but it set up a delivery probability function for forwarding the packets and ultimately delivering them to

destination. As a result of this enhancement in spray-and-wait routing protocol delivery rate increases, average delay and overhead decreases.[5]

Harminder Singh Bindra and A.L.Sangal, compared the performance of three different routing protocols Rapid , Epidemic and Prophet protocol against varying message TTL. ONE Simulator to check the performance of three metric delivery probability, overhead ratio and average latency for three protocol and rapid protocol gives best performance.[6]

El Mastapha Sammou and Abdelmounaim Abdali, proposed an improved Prophet routing protocol with custody transfer. It is an enhancement in prophet routing protocol where the carrier nodes are included these intelligent nodes act as a carriers with planned movement between zones that increases the chance of delivery of message to destination and minimizing delay with less network resources consumption. The proposed approach improves the shortcoming of DTN i.e. a network where several zones are present and when the destination is not in the same region of source. The custody

transfer in prophet routing protocol improves the routing results.[7]

Ari Keranen et.al., discussed about the most efficient simulation tool for DTN i.e. ONE (Opportunistic Network Simulator). It is a java based tool in which top section provides the different pause button to pause simulation, fast forward button to fast forward the simulation and many other buttons to alter the speed of simulation. It's main section gives a complete view of the simulation, highlighting the node movement, message handling etc among the different interacting nodes. The right section gives an overview of the nodes in simulation and buttons for inspecting node. The lower section gives a view of message exchanges between interacting nodes.[8]

Uichin Lee et.al., proposed a RelayCast routing scheme in DTN. This scheme is extended from the two-hop relay algorithm in the multicast scenario. They took a case of N_s sources, each of which have an associated random destinations N_d . As a result the upper bound throughput is achieved. The impact of different routing parameters and strategies on throughput and delay scaling properties of RelayCast were analyzed.[9]

Aruna Balasubramanian et.al., discussed the routing protocol Rapid. Unlike other protocols rapid is an intentional packet routing protocol. It replicates the packet by checking the utility of a packet i.e. inferring packets, average delay and missed deadlines. This nature of explicitly calculating the consequences of replication provides a good performance gain over existing protocols. Rapid shows delivery probability 40% more.[10]

John Burgess et.al., discussed the routing protocol scheme MaxProp. It is a protocol based on prioritizing the packets to be dropped and the packets to be transmitted to other peers

based on some historical data and prevent propagating the data to same node twice. The parameter for selection is hop count value of a message and delivery likelihood. The path likelihood based routing protocol shows the performance better than the protocols that have an access to an oracle where meeting schedules between nodes are already known.[11]

Thrasyvoulos spyropoulos et.al., discussed the routing scheme spray-and-wait. In the normal spray-and-wait a node sprays the number of copies to the network and wait till one of these nodes meets the destination. In the binary spray-and-wait scheme a node that has number of messages i.e. $n > 1$, will forward $\lfloor n/2 \rfloor$ copies of message to the encountered node that has no copies of that message and will keep rest $\lfloor n/2 \rfloor$ keeps with itself and when the nodes are left with only one copy they will then shift to wait phase and will wait for direct delivery to the destination. As a result it outperforms epidemic routing protocol in terms of number of transmissions and delivery delays.[12]

Sushant Jain et.al., surveyed the performance of different routing protocols on the basis of amount of knowledge, they gather about network topology. They compared the different algorithms such as first contact, minimum expected delay, early delivery with local queue, earliest delivery with all queue and linear programming. They discovered that the algorithm which uses less knowledge usually perform poorly and algorithms with limited additional knowledge can be made efficient by constructing a routing in such a scenario[13]

Scott Burleigh et.al., studied the flexibility of temporarily connected networks, and the existence of an Adhoc network which do not demand for end to end connectivity. In the severe conditions where there are long propagation delays, high error rates, internet protocols such as TCP/UDP fail to exist. Delay tolerant network with its store-carry-and-forward principle can provide communications despite of intermittent connectivity. Different protocols of DTN are enabled for effective communication.[14]

A.Vahdat et.al., defined epidemic protocol in Adhoc network, where a source node creates replicas of message and it simply forwards the replicas to all encountered nodes. The encountered node keeps the copy of message if it has buffer space and if a copy of message is not present in the node. It doesn't need predefined network information to retransmit replica of the message and past encounters of node. This protocol yields good delivery probability but overhead gets high due to utilization of buffer space.[15]

A. Principle of DTN

DTN is an Adhoc wireless network which does not demands end to end node connectivity, it is based on store-carry-and-forward principle. Ferry node has associated storage memory and has DTN bundle protocol. It forms a network connection between source and destination through intermediate connectivity.[14] The nodes which are not in direct contact with each other can transmit message through intermediate

connectivity of ferry DTN nodes that have persistent storage to queue the received packets for few seconds and carry it along the way forwards to the other DTN node based of different routing protocols. DTN system can be related to postal systems. With the growing number of communication devices and optimal routing protocol can yield good performance results. The communicating nodes may have predictable time scheduled contact (e.g.: In space) while other may be random in routine network.

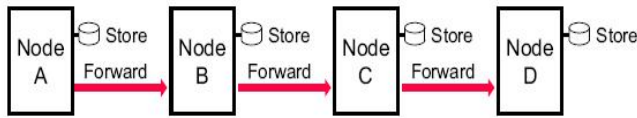


Figure 1. Principle of DTN [14]

B. Applications of DTN

The Disruption Tolerant Networking (DTN) program is a incrementing step toward building a reliable Interplanetary Internet. The experiment creates a long-term communications test bed on the International Space Station (ISS), which transmits test messages between the ground stations and ISS. Delay- and disruption-tolerant networks can improve communications by storing data in their buffer when a connection is interrupted, and forwarding it to its destination using relay stations. DTN can provide various applications in the area where there is limited infrastructure, unexpected intermediate connections and noisy, interference. The unique technique of ferry node working on the principle of store carry and forward principle provides the data delivery without existing infrastructure. An inspired work if DTN is DAKNET which provided cheap Internet services in the rural areas of India. It describes physical ferry node for delivering messages in rural areas.

C. Tool for DTN

The ONE i.e. Opportunistic Network Environment simulator provides simulating framework for node mobility, event generation and message exchange. Mobility generator are also available in Ns2 and Ns3 but they provide specific support for MANET, JANE etc. and for DTN simulation the generic support is fairly limited. So a complete package for DTN network, where a node has a radio interface, persistent storage, node movement and a message routing without end to end connectivity.[8] The ONE simulator models the node movement, intermediate node contacts, message handling and various routing protocols. The source code of ONE simulator is in Java language. The GUI module displays the simulation status through locations, active contacts and replica message carried by nodes. The figure2 provides the visual of ONE simulation tool and reports the output of the simulation result can be checked through reports (e.g.: event log report, message status report). The ONE is an easeful simulator with lot many inbuilt features for mobility. ONE is a suitable tool

for DTN as DTN nodes and their characteristics could be easily implemented with ONE simulator. The Java platform of ONE is easeful for node movement and other features of DTN network nodes. A screenshot of ONE simulator depicts the view of the simulator and is just a generalized theoretical view of simulator in figure 2.

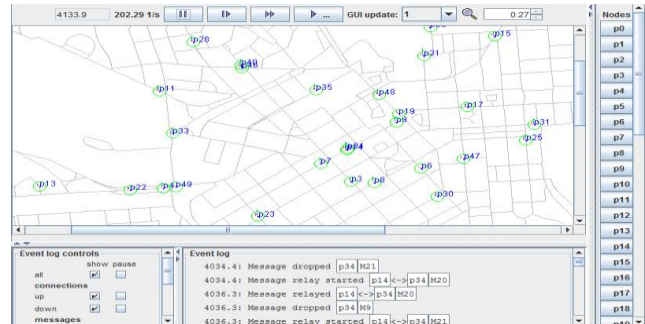


Figure 2: Screenshot of ONE Simulation

Table 1 Table Comparative Analysis

Ref - erence no.	Routing	Band width	Storage	Technique Used	Results
[15]	Replication	Unlimited	Unlimited	Encouragement replication without any constraint routing strategy.	Good delivery probability with high network resource usage.
[11]	Replication	Finite	Finite	Buffer management scheme on the basis of hop count of a message.	Performs better than the protocols which have an access to oracle. Improves the performance of path likelihood.
[2]	Replication	Unlimited	Unlimited	Create specified number of L replicas, in spray phase it forwards the [L/2] replicas to L different / encountered	Spray-and-wait provides good delivery reliability with less delay.

				nodes and when L=1 nodes enter into wait phase and performs direct delivery.	
[4]	Forwarding	Unlimited	Finite	Prophet protocol forwards the packet to encountered nodes on the basis of delivery predictability of encountered. It associates delivery predictability with aging and transitive property for routing message.	Pro good performance with protocol with communication overhead.

protocols of DTN are discussed and theoretically compared below based on recent researches:

[10]	Replication	Finite	Finite	It limits the replication factor by inferring message.	Rapid channel utilization and delivery rate. It outperforms all protocols.
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D. Advantages of DTN

1. Faster transfer : DTN new capability has speeded up the transfer of data back to Earth from ISS by about four times, says BioServe’s Kevin Gifford
2. Information chain: If data passing between computers using TCP/IP goes missing the communication between a computer in space craft and a computer on the earth goes on to-ing and fro-ing which is impractical in space communication. With DTN data is relayed in chain and should only be transmitted once.
3. Growing network: NASA aims to have the DTN fully implemented and ready for use on future space craft. The NASA team also discussed the possibility of adding two nodes to the network in European and Japanese module on station [16].

3. DISCUSSION

Each protocol differs from other in terms of techniques used and the results obtained on applying them are different and thus can be compared, the following table contains the Each protocol differs from other in terms of techniques used and the results obtained on applying them are different and thus can be compared, the following table contains the comparative analysis of various researches done in terms of DTN. Various protocols have been compared, no doubt the goodness of every protocol may get enhanced when made a hybrid, moreover this paper emphasis just on the theoretical review of the existing DTN routing protocol techniques Root basic

4. CONCLUSION

DTN-Delay Tolerant Network is basically used in sparse adhoc network. It is used to increase the delivery probability. Unlike TCP/IP it does not demand end to end connectivity. Various routing protocols are classified according to their replication and forwarding strategies. Discussed scenarios concludes Rapid routing protocol as best routing protocol that gives good delivery probability as compared to other existing routing protocol , Spray-and-Wait routing protocol has high buffer time average as compared to other protocols. Overhaed ratio is less for Spray-and-Wait but more for RAPID, Maxprop and PROPHET protocol. Epidemic protocol is not suitable for real word scenario with limited resources. In future performance evaluation of routing protocols in adverse (malicious nodes) scenarios will be discussed.

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