

Survey on Characteristic Performance of DTNs Protocols

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Abstract— Delay Tolerant Networks are intermittently connected networks in which nodes are lacking for end to end connection due to nodes mobility. DTN nodes uses store and carry forward mechanism where DTN nodes store and carry the data packets they stored until they come into contact with other node. To increase the delivery probability no of copies of messages are spread in the network. DTN applications includes Mobile Ad hoc Network, IPN wireless sensor networks, and other challenged network environments. There are many protocols for DTN. In these paper we characterize DTN protocols based on no of replicas they are transferring, mechanism they used to select next node .These paper include survey of characteristics of DTN routing protocols like Epidemic, Prophet ,Spray and wait and Max-prop.

Key words: DTN-Delay Tolerant Network, Blind Routing, Guided Routing, Routing Criteria, Mobile Network

I. INTRODUCTION

In delay tolerant network many fascinating application have been experimented and tested like vehicular ad-hoc networks for road safety and commercial application, mobile social network based on human mobility, sensor network for wildlife tracking, deep space interplanetary networks. The intermittent connection in DTN creates a new and challenging environment that has not been used before in wireless and wired network. The challenges in DTN is large transmission delay, network partitioning, capability to operate frequently disconnected routing, links are available opportunistically, heterogeneous underlying network technologies (including non IP based internet) [1,2]and application structure and security mechanism fit for constraining system access before Information transmit in a situation where round-excursion time may be vast that can't be handle by our genuine TCP/IP protocol suit. In Delay tolerant network end to end continuous path from source to destination is not always possible because of the density of sparse node, wireless propagation effects and other adverse factor. For DTN conventional routing protocols are not working successfully because they all use end to end paths connectivity. Therefore, a new routing mechanism called store carry and forward was proposed to provide communication. In store carry and forward mechanism DTN node is required to store data packets for long periods of time until it becomes in the communication range of other nodes.

DTN uses two types of routing approach 1)Guided routing and 2)Blind routing . In guided routing approach DTN restricts data packets forwarding to relay node. After gathering collected information they guide packet copies to their destination by selecting relay nodes. The drawback of this mechanism is that it fails whenever network topology is changes faster than the rate of information gathering. In blind approach without using selection criteria it simply forward packet copies to node with which they come in contact. There is also full network flooding and partial flooding. If there is enough storage and resources are provided then it gives higher delivery ratio.

There are several trades-offs to be considered in a DTN protocol design from the analysis of current DTN routing protocols: A trade-off between minimizing the number of transmissions and maximizing packet delivery ratio in the network. To maximize delivery ratio it requires no of packet copies spread throughout the network to increase the probability of reaching destination. In the other hand, minimizing the no of transmissions decreases the number of packet copies but reduces energy consumption and network overhead. Another trade-off is between collecting information to use it in selecting forwarding nodes or not collecting network information and randomly forwarding the packets. Collecting information from the network helps find better routes to destinations, but requires time to collect the information, which increases packet delays. On the other hand, not collecting information leads to spreading the packet copies blindly, and decreases the probability of reaching the destination unless a large number of copies are spread. [3]

The paper is organized as follows: In next section DTN characteristics will be discussed, furthermore routing issues, routing protocols and its comparisons will be discussed.

II. CHARACTERISTICS OF DTN

DTN is considered as unstable topology where end to end path does not exist. Compared to traditional Internet, mobile ad hoc networks, WLAN, DTN network have the following basic features.

A. *Intermittent Connectivity*

DTN frequently disconnects, as the node's mobility and energy are limited, thus resulting in continue change in DTN topology. The network keeps the status of intermittent connection and partial connection so that there is no guarantee to achieve end-to-end route.

B. *Limited Resources*

Node's computing and processing ability, communication ability and storage space is weaker than the function of an ordinary computer due to the constraints of price, volume and power. In addition, the limited storage space resulted in higher packet loss rate because DTN nodes have to store the data to be transmitted until the new node come in contact so buffer is required. However more buffer space is required when new data arrived.

C. *High Delays, low efficiency, and high queue delay*

End-to-end delay indicates that the sum of the total delay of each hop on the route. The delay is consisted of waiting time, queuing time, and transmission time [4]. due to the fact that DTN intermittent connection keeps unreachable in a very long time, Each hop delay might be very high and thus further leading to a lower data rate and showing the asymmetric features in up-down link data rate. In addition, queuing delay plays a main role in end-to-end delay and frequent fragmentations in DTN make queuing delay increasing.

D. *Limited Life time of node*

In some unique condition of the network, at the state of unfriendly environment or in brutal condition, node has to use battery power which will reduce the life time of node. It is possible that power is gone at the time of message transferring so node cannot do normal work.

E. *Dynamic topology*

Energy depletion, environmental changes or other failure in the network leads to dynamically change DTN topology. Because of dynamic topology node can drop many messages.

F. *Poor Security*

In general, DTN is vulnerable to--besides threats of wireless communication network--eavesdropping, message modification, routing spoofing, Denial of Service (Do's), and other security threats, etc., due to the lack of specialized services and maintenance in real-world. [5]

III. DTN APPLICATION

A. *Inter- Planet Satellite Communication Networks*

The objective of the interplanetary Internet was to define the architecture and protocols for interoperation of the internet resident on the earth with over remotely located residents on other planets or space crafts. The Earth's Internet is basically a network of interconnected networks. This network is may therefore be thought of as a network of disconnected Internets.

B. *Space Mobile Ad Hoc Networks*

This network may have unexpectedly intermittent connection due to mobility or space deployment. At times sporadic connectivity in the network could be periodic or predictable.

C. *Country-Side Area Networks*

With limited or non-existing infrastructures, DTN can bring digital connectivity to rural areas and other environments. To provide relaying messages by moving around and delivering messages to various nodes, scenarios transportation system like cars, buses and boats are used.

D. *Military Battlefield Networks*

In a military setting DTN allows for a rich set of applications including dissemination of mission-critical information in battlefield. These type of applications, the delay tolerant protocol should transmit messages across multi-hop network consists of different sun networks based on network parameters such as delay and loss.

E. *Wireless Sensor Networks*

Wireless sensor networks are often characterized by limited end-node resources including energy, memory and CPU power. Communication within these networks is often aimed at limited usage of these resources. Lack of infrastructure may force sensor network gateways to be intermittently connected to operator's network. Scheduled down time, interference, or environmental hostility may cause the interruption of operable communication links.

IV. ROUTING CRITERIA OF DTN PROTOCOL

In Mobile Ad-hoc Networks if path among nodes fails for short period of time so first needs to find the path between sender and receiver nodes or routing protocols built with the assumption that path among nodes always exist. If the route

between both nodes is not available the protocol will not succeed. Thus the protocol used in Mobile Ad-hoc Networks (MANET) are not convenient for DTN [6].

DTN protocols are classified with the method they are using for delivery of message. Some protocol spreads message randomly and some uses information of network topology [7] Properties of DTN which raise many issues in routing are as follows:

A. Routing Objective

The main objective of DTN is Minimize the utilization of resources and maximizes the message delivery ratio.

B. Buffer Space.

DTN have intermittent connection so to deal with it buffer space is required. Messages are stored in the buffer for long interval until node comes in contact of other node. Thus there is relation between number of pending messages and buffer space. Higher number of message in the buffer required the higher buffer size.

C. Resource Allocation

The routing protocols should maintain the goal of DTN to maintain stability between minimizing resource utilization and maximizing message delivery they may conflict each other. For example when we can ensure the delivery of messages then it is unnecessary to store multiple copies of messages on the different nodes. On the other way we can increase probability of delivering message by increasing the copies of the message in the network.

D. Reliability

Routing protocols in DTN should have some knowledge data delivered reliably to guarantee successful and stable delivery of data. As an example some acknowledgement should carried back from destination to source as and when message is delivered to ensure reliability.

E. Energy

The protocol should be designed energy efficient because nodes in DTN suffer low due to mobility and difficulties in connection to power station. The energy consumed utilized in message storing, receiving, sending and processing messages.

DTN concept emerged when traditionally used protocols fails to work in extreme environment. No constant end to end connection, interruption in frequency, resources limitation is called extreme environment. Thus the routing of messages in DTN are mainly store carry and forward base. It store the messages in buffer till it come in contact to other node. Thus routing is the main issue in overall performance of DTN network in terms of data delivery and consumption of resource.

V. ROUTING TECHNIQUES

Routing techniques are classified in two categories: Knowledge or prediction based techniques and replication or opportunistic technique. 1. Knowledge technique: To collect information of network for creating temporary paths Knowledge technique uses particular devices 2. Replication technique: IN this technique node simply replicates message and send to other encounter node to increase forwarding nodes numbers because it relates to message delivery probability. [8]

A. Opportunistic/Replication Routing Technique

In this approach the multiple copies of messages are forwarded blindly as and when nodes come in contact of other node to increase probability of delivery. Due to multiple replica of a same message in network it cause flooding in the network. Thus higher storage space, Resources and energy or power are required to overcome flooding problem.

1) Epidemic Routing Protocol

Epidemic routing protocol is used for sparse networks. The each copy generated by node has given an unique ID this remains associated with packet till it delivered to destination or drop. The list of packet IDs in stored in node buffer space called as summary vectors. When nodes come in a contact with other node they shares their summary vector to each other. All the packets which are present in one node and not in other is transmitted on the basis of FCFS. The packets transmitted until the packet duration. Assuming that long enough contact duration, big buffer size, unlimited lifetime of packet are given then all uncommon packets will be transferred to each other and nodes will have same summary vector now [9]. Epidemic guaranteed to deliver packet to their destinations. In addition it guarantee lowest packet delay because it spreads packet in all possible ways so there will be a shortest path in it also.

The main disadvantage or drawback of epidemic routing protocol is huge amount of power or energy consumption, large buffer space is required.

2) Spray and Wait Routing Protocol

Saving of energy is the main objective of DTNs instruments so that it involves energy sensitive instruments. In transmission and reception energy is mainly consumed. So energy transmission and reception should be decreased to reduce energy consumption. To overcome this problem Spray and Wait routing protocol is proposed. The goal of Spray and Wait routing protocol is to limit the number of packets in the network. The distribution of packet copy is depend on allowed number. Going from one node to another node this number is decreases. When allowed number reaches at a certain value it stops creating further copy until either it reaches destination or drops due to expiry of lifetime or buffer overflow. A

binary version of Spray and Wait is proposed in [10], in which only half the number of copies of a packet is allowed to use by a node other half are left for the receiving node receiver nodes. The proposed algorithm provides better performance as a result shown.

To improve Snow in [12] has proposed a new Spray and Dynamic. It is by combining the model of transfer by delegation and Maypop. Spread and Wait protocol, proved to perform well than the Epidemic full flooding protocol in terms of energy consumption, average packet delay. However this Spread and Wait Protocol also suffers from blind choosing of next hop which can decrease the packet delivery ratio.

B. Prediction Routing Technique

In prediction Technique prediction about next node is done using information about network. These techniques includes Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET) [13] and the MaxProp [14].

1) Prophet Routing Protocol

This protocol degrade the uses of resources and try to provide best routing by using history of encounters and transitive property only rather than forwarding messages to all nodes in the network. Prophet is proposed in [13]. The predictability $P(A, B)$ at each node A for each destination B is estimated by this protocol. When two nodes meet, they update their delivery predictability towards each other. They update their predictability by exchanging delivery predictability data using following equations.

a) Direct update

$$P(A, B)_{new} = P(A, B)_{old} + (1 - P(A, B)_{old}) \times P_{init} \quad (1)$$

Where $P(A, B)_{old}$ is the value of $P(A, B)$ before updating, initialization constant is $P_{init} \in (0, 1)$ This updation done when two nodes comes in a direct contact of each other.

b) Transitive Update

$$P(A, C) = P(A, C)_{old} + (1 - P(A, C)_{old}) \times P(A, B) \times P(B, C) \times \beta \quad (2)$$

Where $\beta \in [0, 1]$ is a scaling constant that decides how large impact the transitivity should have on the delivery predictability. Delivery predictability of node A is updated towards B through the transitive contact between A and C.

c) Aging

$$P(A, B) = P(A, B)_{old} \times \gamma^k \quad (3)$$

Where $\gamma \in (0, 1]$ is an aging constant k is a number of times that units have been elapsed since the last time the metric was aged. This equation decreases the predictability of delivery by the time passed without direct between nodes A and B.

PRoPHET provides does not provide full guideline but it provides full guideline by tracing the contacts between nodes and those contacts are assigned by weights directly or indirectly through intermediate nodes. Therefore PRoPHET performs better in than blind protocols in delivery ratio. However average packet delay increases due to waiting for the next good node in the path.

2) Maxprop Routing Protocol

MAXPROP protocol is proposed in [14] estimates predictability metric $P(A, B)$ of a node similarly as PRoPHET protocol. A link between two nodes is stronger when they come in contact of each other by adding a constant α which is set as 1 in the protocol. Then the delivery predictability of two nodes divided towards all the nodes including each other by $1 + \alpha$ so that all delivery predictability some remains 1.

$$P(A, B) = P(A, B)_{old} \times \alpha \quad (4)$$

$$P(A, C) = P(A, B)_{old} / (1 + \alpha) \quad (5)$$

Where $\alpha \in [0, 1]$ is updating constant, set as 1 and C is every other node including B.

The main contribution Of MAXPROP is management of buffer. Packets in the node are stored according to their hop count if the hop count is below certain threshold value. Otherwise packets sorted by their delivery predictability. In the way MAXPROP prioritize packets with lower hop count to spread in the network.

Characteristics	Mechanism	No. of copies of a packet	Metrics of Forwarding	Replication of message	Advantages	Drawbacks
Epidemic	blind-routing full-flooding	Unlimited	Flooding based	High	<ul style="list-style-type: none"> delivery ratio is higher always find optimal path 	<ul style="list-style-type: none"> Consume huge resources, such as node buffer, energy, and contact durations.
Spray and Wait	blind-routing partial-flooding	N- Copies	Simple spray and wait	Moderate	<ul style="list-style-type: none"> Less resource and energy consumption gives better performance as compared to full flooding algorithm 	<ul style="list-style-type: none"> suffers from the blind selection of the next- hop
PRoPHET	guided routing protocol with a first-in first-out (FIFO) packet selection	Multiple Copies	Probabilistic and transitivity metrics	Moderate	<ul style="list-style-type: none"> Less resource and consumption 	<ul style="list-style-type: none"> average packet delay may increase due to waiting for a good next node in the path Expected to outperform the blind protocols in delivery ratio.

MAXPROP	Guided-routing protocol that favours packets with minimum number of hops.	Limited Copies	Hop count using historical data	Low	- Better management based on buffer hope count	- Higher Processing cost
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Table 1. Characteristic Comparison of DTN Protocols

VI. CONCLUSION

In Delay Tolerant Networks nodes are intermittently connected so that it lacks end to end connection between source and destination. DTN routing protocols varies by amount of network information used in decision making for routing. Epidemic routing protocol which does not collect any network information therefore this does not have a selection mechanism. It simply use Full flooding mechanism so that we can always get optimal path with higher delivery ratio but it also suffers with higher energy and resource consumption drawback. SNW protocol has better delivery ratio and less delivery cost as compared to others. PROPHET and MAX PROP perform as blind routing protocol in terms of delivery ratio. MAXPROP using efficient node section mechanism so that it has less end to end delay than PROPHET routing protocol. EPIDEMIC is full flooding opportunistic technique protocol example. SnW is partial-flooding opportunistic technique protocol example. PROPHET is an example of predication routing technique protocol with FIFO packet selection mechanism. MAXPROP is also an example of predication routing technique protocol that select the packet favours packet having minimum number of hops. In this article, we discussed characteristics of DTN, application of DTN and routing criteria in DTN. We also presented and compared four well known protocols of DTN. Each protocol has its own advantages and disadvantages that are deliberated in the comparative table. An efficient routing protocol should integrate packet selection, node selection and buffer management mechanism to obtain the best performance.

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