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Delay Tolerant Network - A Survey

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Abstract: In recent years Delay Tolerant Networking (DTN) has emerged as a new area of research with many promising application. Delay tolerant networks are characterized by frequent network partitioning, intermittent network connectivity, long and variable delays, and high error rates. Such performance challenging conditions can be found in many different environments such as vehicular networks (VANET), in-the-field military or disaster-relief networks, satellite and deep-space interplanetary networks, terrestrial networks serving remote or rural areas. Interesting real-life experiments comprise bus-based DTN networks, sensor networks for wildlife tracking, internet access to remote villages in underdeveloped countries. In this paper an attempt has been made to survey on DTN having some basic features with new architecture which support a securable routing mechanism for an effective data packets forwarding. This paper also discussed about different types of protocols of delay tolerant network to support for the establishment of end-to-end connection effectively where mobile Adhoc networks fails.

Key words: DTN, Store-carry-forward, Forwarding, Flooding, Routing Protocol.

I. INTRODUCTION

Today's wireless network has a vital capacity to successfully interconnect communicating devices all around the world. The TCP/IP protocol suit has been made it possible. The basic certain characteristics of such networks:

a) End-to-end connection exists between source and destination during communication sessions.
b) Single route selection for achievement of acceptable communication performance between sender and receiver.
c) TCP/IP protocol is supported by all stations of the network.
d) End-to-end loss is relatively small.
e) For repairing the errors, retransmission based on effective feedback from the receiver.

Such networks fail in remote areas or country-side areas due to lack of infrastructure support to internet. So such networks frequently temporally partitions known as intermittently connected networks. In such scenarios internet protocol demonstrate inefficient performance.

II. FEATURES OF DTN

A. Intermittent connection

In most of the cases of DTN lacks end-to-end connection between source and destination which is one of the most important characteristics of DTN. During the transmission period network partition and unexpected error occur due to the mobility and energy of nodes.
So that network keeps intermittent connection and partial connection because of no guarantee of end-to-end connection.

B. Low data rates

Due to the long latency and disconnectivity of data delivery the transmission rate may be low and the data rate reduced if two nodes do not meet with each other for a longer period of time.

C. Delivery rate

The amount of time difference between messages entered into the network and its successful reception at the destination known as delivery latency.

D. Limited longitivity

Some hostile environment networks like sensor networks, military applications, personnel emergency used network etc. end nodes may be deploys. Source to destination path may not exist for longer period of time. So the end system should not be responsible for data delivery using classical TCP/IP protocol.

E. Larger delay

The time consumed by a bit of data to travel across from source to destination network. Due to the queuing delays which may takes extreme of time as hours or days, so that it is calculated.

III. CHALLENGES

A. Buffer space

DTN networks need to store all the pending messages till it reaches destination due to the intermittent connection. These messages are stored in the buffer space for a long period of time which causes disconnection frequently.

B. Contact

DTN suffers from disconnectivity problem sender and receiver tries to communicate when opportunistic contacts are available.

C. Limited power

Due to the nodes mobility and disconnectivity among the nodes more utilization of energy resources due to sending, receiving, storing and computing messages. So energy efficient routing protocol should be developed.

D. Security

Security is always a significant issue for any network. As user may required to receive an acknowledge for ensure a

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secure guarantees about the message authentication, because the random movement of messages through intermediate nodes to reach at its destination. So there are various cryptographic techniques are used for successful secure end-to-end routing.

IV. ARCHITECTURE OF DELAY TOLERANCE NETWORK

Delay network architecture is designed as an overlay of existing networks which divided into regions that are homogeneous. It provides an end-to-end path based on the following principles:

a) Enhancement of the ability for good path selection to use for transfer of long stream data packets.
b) Store-carry-forward fashion support to store data within the network until reached at destination.
c) The infrastructure is protected from unauthorized access by different security mechanisms.

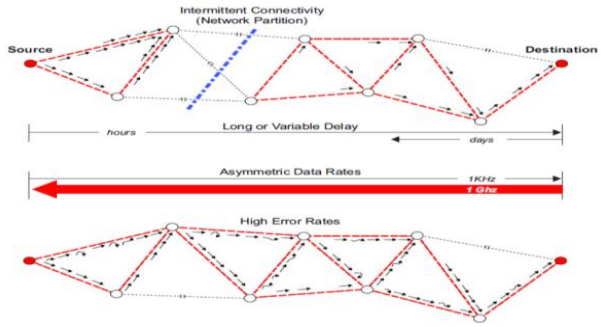

Fig.1. Architecture of DTN

A. *Concept of bundle layer*

DTN architecture introduce an overlay just above the transport layer is called bundle layer. Bundles are also called messages. By storing and forwarding entire bundles between the nodes, data transfer takes place. The bundle comprises with source nodes' user-data, control information, a bundle header. This layer is already easily linked with TCP/IP to provide a gateway when two nodes come to contact with each other. Flexibility is the major advantages[4].

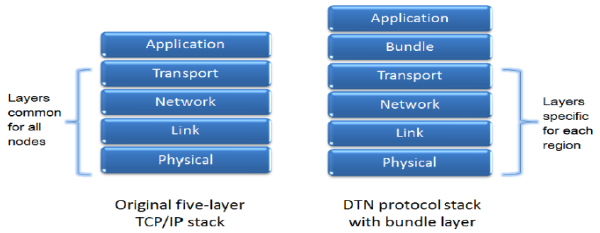

Fig.2. Bundle layer

B. *Store-carry-forward technique*

The concept of store-carry-forward overcomes the problem associated with traditional protocols that may be bidirectional data rates, lack of connectivity, irregular delays etc. This method is very similar as like the real life postal service. Before reaching at the destination a letter has to processed and forwarded through a set of post officers. Like in this technique a complete message or some portion of the message is transferred and successively stored in the nodes until it reaches at the destination through in a network.

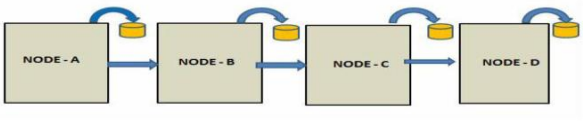

Fig.3. Store-carry-forward technique

C. *Types of contacts in DTN*

In DTN, whether or how the nodes make contacts with each other broadly classified as opportunistic and scheduled. The opportunistic contacts are an unscheduled contact which can occur instantly. The node do not have any idea regarding a contact may be direct or indirect in the future. Moving people, automobiles, airplanes etc. make this type of contact and transfer of message as they have sufficient energy for communication. On the other hand in scheduled contact the information is directly or indirectly known to the node for establishment a contact path at a particular time, for a particular duration. Synchonization of time in every node is the major drawback. Example of schedule contact is a inter-planetary communication [3].

D. *Custody transfer*

Bundle layer offered retransmission of message in case-of corrupted or lost data through the concept of bundle layer. The custodian node stores the message until successfully transferred to the next node and takes the custody of next node and takes the custody of that message until TTL expires.

V. ROUTING PROTOCOLS IN DTN

According to the information gathered to the nodes for taking a perfect routing decision the routing protocols in DTN are classified. There are two strategies broadly explains the basic methodology of DTN protocols.

A. *Flooding strategy*

The strategy undergoes flooding family, a set of nodes, called relay nodes contains the multiple copies of each messages. These relay nodes having the capability to sore the messages until, they cannot contact with final destination at which the message is delivered [14]. Having no knowledge/information about the networks of this family protocols and performance is improved due to the use of some advanced scheme. Replication increases the probability of receiving messages at destination nodes.

B. *Forwarding strategy*

Uses the knowledge's about the network to select the best path (shortest one) to the destination without replicating the data packets. Then the message is forwarded along this path to find its destination. There is no message duplication in this strategy family [13].

Goals of DTN routing protocols
1. Maximization of message delivery rate.
2. Minimization of message latency.
3. Minimization of total resource consumed in message delivery.

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1) Epidemic protocol:
According to FIFO policy messages are forwarded. Replica of a message will spread like of a disease in a some epidemic network, ultimately reaching to its destination. When two mobile hosts come into contact, they decide which messages are exchanged between them by looking one another's summery vector. Summary vector is the list of each message along with its identifier which saved in nodes buffer. It is especially very useful protocol where lack of knowledge about topology management and nodes mobility pattern[15]. This protocol was modified by Vahdat et al. (2000) which is based on flooding based strategy.

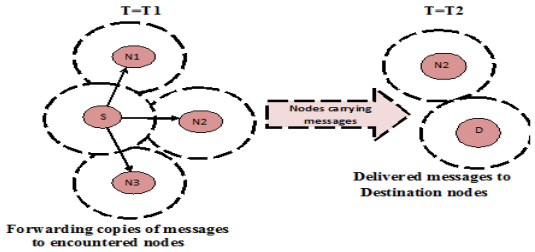

Fig.4. Epidemic routing

2) Prophet:
This protocol is based on delivery predictability and history based, which was first proposed by Lindgren et al.(2003).Replication technique is same as epidemic which is flooding based. For the prediction of probability to ensure more no of messages delivery at the destination, it stores the encountered history and node movements. A message will transferred from one node to other if the second node has higher delivery predictability value than the first node for the destination of the message [17].

3) Maxprop:
In Maxprop protocol, node contains a n routing tables for an effective routing in DTN. This table is updated according to the packet transmitted to the neighbouring nodes and also dropped packets. On the basis of information obtained from routing table, messages are forwarded according their ordered with to their cost to reach at destination.

4) Spray and Wait:
To control the message spreading throughout the network, Spyropoulos et al. (2005) was proposed the Spray and Wait mechanism. This protocol consists of two phases. In spray phase 'L'no of replicas of message initially forwarded to the first 'L' encountered nodes of a source node. In wait phase destination nodes contain a copy of message for direct transmission. Using the same principle conformation message is received from destination node[5].

5) Mobyspace:
This effective routing protocol was suggested by Leguay et al. (2005) with a mobility pattern space routing method. According to this method, similar mobility pattern with destination node received message is forwarded by each node to the encountered nodes. Nodes with similar mobility pattern demonstrate a better routing using mobyspace protocol.

6) Rapid:
It is simple approaches which can neglect other routing metrics such as delay, energy consumption etc. for the measurement of fraction of packets delivered to the destination within a specified amount of time. RAPID uses more bandwidth at the start of the opportunity transfer of metadata as it is replicates whenever the availability of bandwidth.

7) Bubble Rap:
This protocol belongs to the forwarding strategy family with social based protocol based on the knowledge of centrality of nodes and the community it belongs. Forwarding of a message is done, if both the destination node and the relay nodes belong to the same community, otherwise transmission of the message takes place to the node having highest centrality value independent of its community. Each node does not delete the forwarding message copy till it is not delivery to the destination[9].

VI. APPLICATIONS OF DTN

Some examples of DTNS application are discussed below:-

Space agencies:- interplanetary communication, international space communication (currently under research).

Commercial:- agricultural crop monitoring, data transaction, vehicle tracking, communication in underground mines.

Public service and safety:- smart-city event response, global airport-traffic control, remote learning, security and disaster communication, smart transportation network.

Military and Intelligence:- search and rescue communication, cargo tracking, UAV (unmanned aerial vehicle) communication and control.

Personal use:- personal monitoring in wildlife and remote areas.

VII. CONCLUSION

In this article, we survey about the introduction of Delay tolerance network architecture with their supporting features for successful packet delivery. We further define the challenges arise for efficient routing and different strategies with different types of routing protocols for making forwarding decision of message delivery.

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BIOGRAPHIES

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