International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 3 Issue 4, April 2014

The Concept of Delay Tolerant Network Approaches and Issues

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Abstract— **Delay Tolerant Networks (DTNs) are a class of networks that enable communication where connectivity issues like sparse connectivity, intermittent connectivity; high latency, long delay, high error rates, asymmetric data rate, and even no end-to-end connectivity exist. The DTN architecture was introduced to deal with this connectivity. In these networks vehicles use a message relaying service by their mobility in the network and collect messages from source nodes. In this paper, we will review the architecture of DTN is introduced at first; including the characteristics of Delay Tolerant Mobile Network routing protocol in delay tolerant networks issues.**

I. INTRODUCTION.

Delay-tolerant networks (DTN) have been designed to operate in environments where Internet Protocol Suite does not seem to work well. Delay-tolerant networks use a message-oriented overlay that supp orts intermittent connectivity, overcomes communication disruptions and delays. Transmission of data between source and destination nonexistent for the time of a communication is also allowed. All aforementioned features are achieved by using store-and-forward message method. Services the method provides are very similar to electronic mail, but with improved naming, routing and security capabilities [1].

II. CONCEPT

A delay-tolerant network is an overlay on top of existing regional networks. The overlay is called the bundle layer and is intended to operate above the existing protocol stacks in various network architectures and provide a gateway function between them when a node physically touches two or more dissimilar networks [2]. Flexibility and scalability are advantages of using the introduced approach. One may easily link already existing TCP/IP networks with networks that will app ear in the future for deep space communication purposes and will probably use their own transport, network and physical layers. A bundle-layer protocol is used overall across the network.

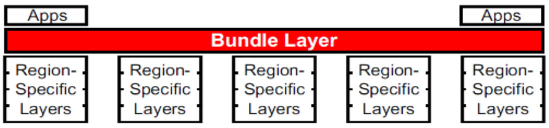

Figure 1 Bundle-layer in a stack of layers [3]

III. THE BASIC FEATURES OF DELAY-TOLERANT NETWORK

Compared to traditional Internet, mobile ad hoc networks, WLAN,
DTN network have the following basic features [9].

A. *Intermittent Connection*

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

B. *High delay, 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 [9]. Each hop delay might be very high due to the fact that DTN intermittent connection keeps unreachable in a very long time 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.

C. *Limited resource*

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.

D. *Limited Life time of node*

In some special circumstances of the restricted network, the node is common to use the battery power on the state of hostile environment or in harsh conditions, which will cut the life time of node. When the power is off, then the node cannot guarantee

ISSN: 2278 – 1323

normal work. That is to say, it is very possible the power is off when the message is being transmitted.

E. Dynamic topology

Note that the DTN topology is dynamic changing for some reasons such as environmental changes, energy depletion or other failures, which results in dropping out of network. Or, the requirements of entering DTN also make topology change.

F. Poor Security

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

G. Heterogeneous interconnection

DTN is a overlay network for transmission of asynchronous message. Introducing the bundle layer, the DTN can run on different heterogeneous network protocol stacks and DTN gateway ensures the reliable transmission of interconnection message.

IV. DTN ARCHITECTURE

Working with DTNs requires reconsidering the way in which application protocols operate since delays and disruptions have to be considered the default. This means that highly interactive application protocols do not operate well in DTN environments, nor does security or reliability mechanisms that require multiple end-to-end handshakes. And the otherwise ubiquitously available Internet infrastructure services (DHCP-based auto configuration, DNS lookups, certification validations, etc.) are likely out of reach or at least not directly accessible. At the same time, *store-carry-and-forward* operation of DTNs offers unique properties for enabling communication in challenged environments and for efficient cooperation between mobile nodes.

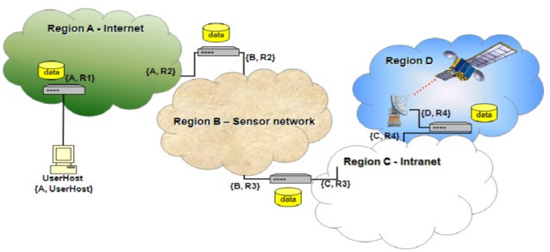

Figure 2 DTN Architecture

V. DTN CHARACTERISTICS

- Very large delays.
- Intermittent and scheduled links.
- Different network architectures.
- Conversational protocols fail.
- No ARQ.

VI. DTN APPLICATIONS

The Delay – Disruption Tolerant Networks is an active research area and has been initially developed for Deep Space Communication (Inter – Planetary Internet), however the Delay Tolerant Networks has wide spectrum of advantages and applications across terrestrial scenarios ranging from providing connectivity across all environments, Underwater/Acoustic networking, Tactical Military applications and the like.

A. Deep space networking

The DINET I, known as Deep Impact Network is an experimental validation of Inter – Planetary Networks, which is the NASA's implementation of Delay – Tolerant Networks. NASA (National Aeronautics & Space Administration) has successfully tested the first deep space communication network model using the DTN by transmitting around 200 space images (approx 14 MB) to and from a space craft known as EPOXI – uploaded with DTN software (functioned as a DTN router,) located more than 32 million kilometers from earth. The DTN prioritization has ensured that all high priority images were successfully delivered and no data loss or corruption found anywhere in the network. DINET II is designed to develop and validate additional DTN functionality like extended priority system, contact graph routing management and so on [4]. Along with the European Space Agency, NASA has successfully used DTN protocols to control and drive a small LEGO robot (car) at European Space Operation Centre located at Darmstadt, Germany from the International Space Station (ISS). The Multi – Purpose End – to – End Robotic Operation Network (METERON) is an application of DTN which aims at simulating selected future human exploration scenarios including immersive remote control of a robot by an astronaut in orbit around a target object (such as Mars or Moon) [5].

B. Tactical military applications

With gradual deepening and development of modern military warfare towards Network Centric Warfare (NCW), the performance of Networks and Protocols will play a significant role. The custom network protocols based on end – to – end connectivity is not suited for military communication networks, which is a long/variable delay with high error rates and greatly heterogeneous. Realization of a robust, intelligent and integrated communication and careful consideration of types of assets that have to be connected will form a solid foundation for Network Centric Warfare. The vast repertoire of military assets

ISSN: 2278 – 1323

include Ground Troops, Armored–Non armored vehicles, Naval Platforms, Airborne units, along with Command & Control and Intelligence , Surveillance, Reconnaissance assets that may be fixed or mobile. Moreover the tactical environment is extremely harsh and with marching troops to supersonic tactical aircraft, the huge extent of mobility gap and heterogeneous nature introduces more challenges in traditional protocol design. These conditions results in Intermittent Connectivity with wide ranging communication delays.

C. Underwater/acoustic networking

The underwater acoustic networks are generally formed by acoustically connected ocean – bottom Sensors, autonomous underwater vehicles & surface stations which provide links to on shore control centre. Underwater Acoustic network is growing rapidly due to its advantages in disaster Prevention, Harbor Portal, Underwater Robotics, Tactical under sea Surveillance, oil gas pipelines monitoring, Offshore explorations, Pollution monitoring & oceanographic data collection, Salinity Monitoring. But the challenges include slow propagation of acoustic waves, limited bandwidth and very high delays. Multiple unmanned or autonomous underwater vehicles (UUVs, AUVs), equipped with underwater sensors, will also find its application in exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions. To make these applications viable, there is a need to enable underwater communications among underwater devices [6]. Approaches like Delay Tolerant Network may be a better match to many underwater networks by avoiding end – to – end retransmission & supporting very sparse & often disconnected networks [7].

D. Smartphone application

The Delay Tolerant Network Approach can be implemented in the Android platform to provide connectivity in environments that lack Efficient Network Infrastructures. The implementation of DTN services and protocol stack on the Android platform is known as "Bytewalla" which allows the use of android phones for the physical transport of data between network nodes in areas where there are no other links available or when the existing links are highly intermittent [8].

VII. ISSUES IN DELAY TOLERANT NETWORKS.

In this section we discusses some of the issues which are still very open, either due to a lack of consensus in the DTNRG, or due to there being areas (like DTN key management) where much basic research remains to be done.

A. Key Management

The major open issue in DTN security is the lack of a delay-tolerant method for key management. We are at the stage where we only really know how to use existing schemes, which ultimately require an on-line status checking service or key distribution service which is not practical in a high delay or highly disrupted environment.

B. Handling Replays

In most networking scenarios, we either wish to eliminate or else dramatically reduce the probability of messages being replayed. In some DTN contexts this will also be the case particularly as replaying a (e.g., authenticated, authorized) message can be a fairly straight forward way to consume scarce network resources.

C. Traffic Analysis

A general traffic analysis protection scheme is probably not, in any case, a realistic goal for DTNs, given their tendency to be resource-scarce and there have been no calls for a generic approach to this problem. However, for some disruption tolerant networks, hiding traffic (e.g., the existence of a signal from a sensor net) may be a very important security requirement.

D. Routing Protocol Security

DTN routing protocol security must clearly be in our list of open issues. However, if a putative DTN routing protocol was to use either the Bundle protocol or LTP, it could clearly make use of their existing security features. The security mechanism proposed for metadata blocks has been generalized for other non-payload blocks and may provide a solution to some of these issues.

E. Multicast Security

Within DTN, there is currently no mechanism defined for restricting which nodes may register in a "multicast" or "any cast" endpoint. The security architecture currently does not address the security aspects of enabling a node to register with a particular multicast or any cast EID. Without a capability to

ISSN: 2278 – 1323

restrict the registration of nodes in multicast or any cast endpoints, any node may register in such an endpoint and thereby receive traffic sent to that endpoint.

F. Performance Issues

Provision of security within a DTN imposes both band-width utilization costs on the DTN links and computational costs on the DTN nodes.

VIII. CONCLUSION

The DTN architecture was designed to provide communications between networks that are characterized by long delays and discontinuous end-to-end connectivity. It supports different types of connectivity, including scheduled, predicted and opportunistically connected networks. The store-and-forward approach introduced in DTN is not novel and is widely used in the protocol send mail. Asynchronous messaging, enhanced security against unauthorized access and reactive fragmentation - these are the features that make DTN an interesting subject to further research.

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ISSN: 2278 – 1323