Chapter 20

Delay Tolerant Networks: Architecture, Routing, Congestion, and Security Issues

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ABSTRACT

Opportunistic networks are one of the emerging evolutions of the network system. In opportunistic networks, nodes are able to communicate with each other even if the route between source to destination does not already exist. Opportunistic networks have to be delay tolerant in nature (i.e., able to tolerate larger delays). Delay tolerant network (DTNs) uses the concept of “store-carry-forward” of data packets. DTNs are able to transfer data or establish communication in remote area or crisis environment where there is no network established. DTNs have many applications like to provide low-cost internet provision in remote areas, in vehicular networks, noise monitoring, extreme terrestrial environments, etc. It is therefore very promising to identify aspects for integration and inculcation of opportunistic network methodologies and technologies into delay tolerant networking. In this chapter, the authors emphasize delay tolerant networks by considering its architectural, routing, congestion, and security issues.

INTRODUCTION

Delay Tolerant Networking (DTNs) is a new way of communication that facilitates the data transfer between source and destination even if a fully connected path may not exist between two end nodes. The Delay Tolerant Network (DTN) (Cerf et al., 2007) is an emerging area that has attracted keen research efforts from both academia and industry. DTNs consider an extreme network condition that is different from the traditional communication networks. There may not exist a complete end-to-end path between the data source and destination, and thus network is subject to dynamic node connections and unstable topologies. The communication in DTN is done by exploiting the characteristic of nodes i.e. mobility,
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available connections, and provided buffer space etc. DTNs find broad applications in the situations where legacy networks cannot work effectively, such as data communications in rural areas where stable communications infrastructure is not available or is costly. DTN is useful for extreme environments like battlefields, volcanic regions, deep oceans, deep space, developing regions etc., where they suffer challenging conditions as military wars and conflicts, terrorist attacks, earthquakes, volcanic eruptions, floods, storms, hurricanes, severe electromagnetic interferences, congested usage, etc. These challenging conditions result in excessive delays, severe bandwidth restrictions, remarkable node mobility, frequent power outages and recurring communication obstructions (Khabbaz et al., 2011). Vehicular networking is a wide and growing field of DTNs, where many applications are being explored (Benamar et al., 2014). One of these applications is to provide Internet access to vehicles by connecting to roadside wireless base stations (Ott and Kutscher, 2004). Non-commercial applications include monitoring and tracking wildlife animals (Juang et al., 2002), and environmental monitoring, such as lake water quality monitoring and roadside noise monitoring. DTNs can be applied in a variety of other fields ranging from healthcare to education to economic efficiency (Abdelkader et al., 2016).

The idea of Delay Tolerant Network (DTN) (Warthman, 2012) was taken from Inter Planetary Networks (IPN) (Burleigh et al., 2003), this was started in 1970s. The IPN was invented to communicate between earth and mars. The DTN is a type of wireless ad-hoc network which tolerates the intermittent connectivity. The intermittent connectivity can be defined as the sudden change of state (up/down) of any communication link between the nodes. The DTN can also be defined as intermittently connected wireless ad-hoc network (“Mobile Ad-Hoc and”, n. d.) that can tolerate longer delays, intermittent connectivity and prevent data from being lost by using store-carry-forward approach. The Store-carry-forward approach enables the nodes to take the message, store it in the buffer provided at each node and forward the same whenever new node comes in its communication range. DTN technology has become a new research focus in many fields including deep space communications, military tactical communications, and disaster rescue and internet access in remote areas. Internet Research Task Force (IRTF) has organized Delay-Tolerant Research Group (DTNRG) to research OTN technology, and as an important research theme, DTN technology has been accepted by the guidelines in MobiCom 2008 and Milcom 2009(Lu et al., 2010).

With the advent of the Internet of Things (IoT) a number of new devices will become part of our day today life. Constrained Application Protocol (CoAP), and its extensions, are specially designed to address the integration of these constrained devices in IoT environment. However, due to their limited resources, they are often unable to be fully connected and instead form intermittently connected and sparse networks in which Delay Tolerant Networking (DTN) is more appropriate, in particular through the Bundle Protocol (BP).

The chapter is organized as follows. In next section, the characteristics of DTNs, types of DTNs and applications of DTNs are mentioned in different sub-sections. The architectural structure of DTNs is described in further section. Then Routing and buffer management of DTNs are explained. Security aspects of DTNs are mentioned further. Some case studies of DTNs are given in last section.

Characteristics of Delay Tolerant Networks

A DTN have the following basic characteristics (Fall et al., 2008):