Chapter 23
Vehicular Delay Tolerant Networks

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ABSTRACT

Traditional networks suppose the existence of some path between endpoints, small end to end round-trip Delay time, and loss ratio. Today, however, new applications, environments and types of devices are challenging these assumptions. In Delay Tolerant Networks (DTNs), an end-to-end path from source to destination may not exist. Nodes may connect and exchange information in an opportunistic way. This book chapter presents a broad overview of DTNs, particularly focusing on Vehicular DTNs, their main characteristics, challenges, and research projects on this field. In the near future, cars are expected to be equipped with devices that will allow them to communicate wirelessly. However, there will be strict restrictions to the duration of their connections with other vehicles, whereas the conditions of their links will greatly vary; DTNs present an attractive solution. Therefore, VDTNs constitute an attractive research field.

INTRODUCTION

Delay Tolerant Networking, sometime referred to as Disruption Tolerant (*DTN*), has been developed as an approach to building architecture models tolerant to long *delays* and/or disconnected network partitions in the delivery of data to destinations. In this chapter, we will study the characteristics of these architectures, and many of the protocols developed to ensure packet delivery in these networks. We henceforth use *DTN* to refer

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to both Delay Tolerant Networking and Disruption Tolerant Networks. For *Vehicular DTN*, the acronym *VDTN* is used.

The vehicular network research field, and in extent the *VDTN* research field, have attracted great attention in the last few years. Initiatives such as i2010 Intelligent Car Initiative Intelligent Car (2009) aim to decrease the accidents and CO2 emissions in Europe utilizing sensors and vehicle-to-vehicle (V2V) communication to increase road safety. According to these projects, cars equipped with wireless devices will exchange traffic and road safety information with nearby cars and/or roadside units.

According to the ETSI 102 638 technical report (ETSI TR102_638, 2009, June), the 20% of the running vehicles will have wireless communication capabilities by 2017. The same report estimates that by 2027 almost 100% of the vehicles will be equipped with communication devices.

The design of the core Internet protocols is based on a number of assumptions, including the existence of some path between endpoints, small end to end round-trip delay time, and the perception of packet switching as the right abstraction for end-to-end communications. Furthermore, the efficiency of these protocols is based on assumptions about the resources available to the nodes and the properties of the links between them. Traditionally nodes are considered to be fixed, energy unconstraint, connected by low loss rate links, and communication occurs due to the exchange of data between two or more nodes.

Today, however, new applications, environments and types of devices are challenging these assumptions and call for new architectures and modes of node operation. Some of these challenges are intermittent and/or scheduled links, very large *delays*, high link error rates, diverse and/or energy constrained devices, with heterogeneous underlying network architectures and protocols in the protocol stack, and most importantly, the absence of an end-to-end path from a source to a destination. Applications that may pose such challenges include spacecrafts, planetary/interplanetary, military/tactical, disaster response, mobile sensors, vehicular environments, satellite and various forms of large scale ad hoc networks. The variety of these applications, the impossibility of having a fixed wired Internet infrastructure everywhere, and the inclusion of mobility in most of these applications, make these challenges more difficult to surmount. This often leads us to a new approach of designing networks, taking into account several constraints and characteristics, using *DTN*.

This book chapter provides a broad view of what is *DTNs*, their main advantages and disadvantages as well as some of the main research subjects that involve *DTNs*.

BACKGROUND

VDTNs have evolved from *DTNs* and are formed by cars and any supporting fixed nodes. Fall (2003) is one of the first authors to define *DTN* and discuss its potential. According to his definition, a *DTN* consists of a sequence of time-dependent *opportunistic contacts*. During these *contacts*, messages are forwarded from their source towards their destination. This is illustrated in Figure 1, in the first contact the origin sends the message to A in time t_1, then A holds the message until it delivers to the destination in the contact at time t_2. *Contacts* are characterized by their start and end times, capacity, latency, end points and direction. The *routing* algorithm can use these pieces of information to decide the most appropriate route(s) to deliver a message from its source to its destination. However, *routing* in a network where the edges among the mobile nodes depend on time signifies is not a straightforward task. One needs to find an effective route, both in time and space. All nodes along the path should consider the nodes movement pattern and the possible communication opportunities for message *for-*

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