Chapter 15
DTN Technologies for Vehicular Networks

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ABSTRACT

A Delay Tolerant Network (DTN) is one type of challenged network where network contacts are intermittent or link performance is highly variable or extreme. In such a network, a complete path does not exist from source to destination for most of the time. In addition, the path can be highly unstable and may change or break unexpectedly. To make communication possible in a delay tolerant network, the intermediate nodes need to take custody of data during the blackout and forward it toward the destination when the connectivity resumes. A vehicular network nicely falls into the context of DTN since the mobility of vehicles constantly causes the disruption of link connectivity's between vehicles. In this chapter, the authors discuss some research challenges and issues which might occur in a Delay Tolerant Network and how they are related to vehicular networks.

INTRODUCTION

Delay/disruption tolerant networks (DTN) can be used to increase the robustness of the network where the network protocols must be explicitly designed to perform despite frequent disruptions. A typical DTN consists of a set of wireless nodes, some or all of which are mobile. The nodes can range from small sensor nodes, to mid-sized devices carried by people, robots or vehicles, to larger semi-permanent installations. Due to node mobility or limited radio range, end-to-end paths do not always exist between some or all the nodes. As a result, data are transferred in a store-carry and forward paradigm. Vehicular ad hoc networks (VANET) have been envisioned to be useful in road safety and many commercial applications. For example, a vehicular network can be used to alert drivers to potential traffic jams, providing increased convenience and efficiency. It can also be used to propagate emergency warning to drivers behind a vehicle (or incident) to avoid multi-car collisions. To realize this vision, the FCC

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has allocated 75 MHz of spectrum for dedicated short range communications (vehicle-vehicle or vehicle-roadside), and the IEEE is working on standard specifications for inter-vehicle communication.

As technology advances make it more feasible and cost-effective to produce vehicles that are equipped with communication capabilities that allow for inter-vehicle communication, large scale vehicular ad hoc networks are expected to be available in the near future. There are various kinds of VANETs based on the entities involved, such as vehicle to vehicle communication (V2V), vehicle to roadside communication (V2R) or vehicle infrastructure integration (VII), and roadside to roadside communication (R2R).

There are different ways to look at DTN and VANET. At one extreme, DTN is more general, and VANET is a special kind of DTN. At another extreme, DTN techniques are only used in some VANET applications when vehicles are far away from each other, but not in safety related applications which have strict delay requirements. Nevertheless, DTN and VANET have many common characteristics which present challenges and opportunities for the research community.

Many unique characteristics of VANET bring out new research challenges. First, due to fast vehicle movement, network topology and channel conditions change rapidly. As a result, many well-studied structures such as tree, clustering, grid, are extremely hard to set up and maintain. Second, the network density is highly dynamic. The traffic load is low in rural areas and during night, which may result in frequent disconnections and network partitions.

On the other hand, during rush hours or traffic congestion, the network density is very high, which may generate data collisions and result in network congestion. Third, the vehicle mobility is partially predictable since it is limited by the traffic pattern and the road layout.

These unique characteristics bring out research issues at different layers of the network stack. At the physical layer, directional antenna/MIMO techniques may be applied to increase the network capacity. At the data link layer, new MAC protocols should be designed to meet latency and reliability requirements, especially for safety related applications. Because vehicles move along roads, directional-antenna-based MAC mechanisms might be especially useful for VANET. At the network layer, protocols should be designed to exploit the mobility to maintain the route. At the transport layer, new protocols should be designed to tolerate routing layer disruptions. From the network perspective, security and scalability are two significant challenges. Although power efficiency in VANET is less of a concern, scalability may still be critical. Due to the nature of the vehicular applications, there might be more flooding/broadcasting in VANET than in traditional ad hoc networks.

This could easily create network congestion if the communication protocols are not well-designed.

There are many challenges and opportunities in DTNs. Many VANET applications can be built on DTNs, and hence most of the challenges and opportunities presented in VANET are also valid in DTNs. As social networking becomes popular, more applications can be built over DTNs. Also, a number of non-interactive applications related to sensor networks can be adapted to DTNs. Unlike Internet applications, DTNs provide an opportunity for aggregation, replication, and in-network processing as data traverses the network. Traditionally, DTN is treated as an edge solution for the future Internet paradigm. It is a challenge to re-think the Internet as a DTN. Further, DTNs may rely on some level of infrastructure support to improve their performance, and hence hybrid DTN/infrastructure networks are another area to explore.

There are many technical issues to explore in DTNs. First, how to achieve service discovery, context awareness and group communication, which are standard modules in distributed sys-