

Chapter 44

QoS–Aware Chain–Based Data Aggregation in Cooperating Vehicular Communication Networks and Wireless Sensor Networks

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ABSTRACT

Vehicular Communication Networks (VCNs) and Wireless Sensor Networks (WSNs) are emerging types of networks, which have individually been extensively explored. However, their cooperation and exploring advantages offered by their integration are poorly explored. Such integration helps better investigate impacts of human mobility and transportation behaviors on safety and well-being of cities, their residents, their surrounding environments, and ecology. In this chapter, the authors propose a QoS-Aware Chain-based data Aggregation (QoS-ACA) technique for wireless sensor networks cooperating with vehicular communication networks, which fast, reliably, and energy efficiently aggregates sensor data and sends the aggregated value to the road side units. Ensuring quality of service parameters has been put forward as an essential consideration for wireless sensor networks, which are often deployed in unattended and open environments and are characterized by their limited resources. To this end, in-network data aggregation is an efficient solution to save energy and bandwidth and to provide meaningful information to end-users.

DOI: 10.4018/978-1-4666-8473-7.ch044

INTRODUCTION

Vehicular Communication Networks (VCNs) are an emerging type of networks, in which vehicles and Road Side Units (RSUs) communicate with each other to provide real-time information to drivers and policy makers. Popularity and importance of VCNs have increased in recent years as they can support a wide range of applications. Although VCNs have some similarities with VSNs (Vehicular Sensor Networks), they have important differences. VCNs exploit sensing and communication infrastructure deployed along-side the roads to monitor vehicles (e.g. presence, type, speed) and the environment (e.g. pollution). This information is gathered by the RSUs in order to manage traffic congestion and safety, among others. VSNs, on the other hand, are sensing and communication infrastructures formed by equipping vehicles with onboard sensing and communication devices to enable vehicles to collect sensory information about themselves (e.g. speed, location) or the environment (pollution) and to communicate with each other or RSUs in order to transmit information about vehicular traffic control and accidents, among others. Figure 1 (b) illustrates the difference between VCNs and VSNs.

Similarly to VCNs, Wireless Sensor Networks (WSNs) have also received much attention in recent years. A WSN consists of a large number of spatially distributed autonomous wireless sensor nodes which are usually deployed in an unattended environment to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollution (Akyildiz et al., 2002; Romer & Mattern, 2004; Haenselmann, 2006). VSNs can be considered as a special type of Wireless Sensor Networks (WSNs). Unlike WSNs, however, VSNs are highly mobile and do not have the severe resource constraints (in terms of battery, processing, and memory) of the WSNs.

In this paper, we focus on VCNs and WSNs and their cooperation. This is because while VCNs and WSNs have individually been extensively ex-

plored, their cooperation and exploring advantages offered by their integration are poorly explored. Such integration helps better investigate impacts of human mobility and transportation behaviours on safety and well-being of cities, their residents, their surrounding environments, and ecology. Wild animals living on the border of cities are hit very often by cars passing by. Areas in which people frequently commute are subject to more pollution, which in turn threat asthma, COPD, and heart patients more. Road traffic noise and congestion are to be blamed for increase stress and frustration of citizens of big and crowded cities. Fine grained monitoring and (near) real-time reasoning capability of wireless sensor networks alongside the already available communication infrastructure of vehicular communication networks can facilitate more efficient study and more reliable and accurate investigation of human beings mobility parameters and their effects.

To this end, we consider a scenario in which a WSN with CO₂ and sound sensors are deployed along-side the VCNs as illustrated in Figure 1(a). We aim to detect the highly polluted areas in terms of both sound and CO₂ and provide reliable information to be able to redirect the traffic to the unpolluted and clean areas. By doing so, we aim not only to detect busy areas potentially facing traffic jams but also to inform heart and lung patients about areas to avoid.

The Need for Data Aggregation

To detect highly polluted areas, either every sensor node should send all its raw data to a RSU or it should be able to detect pollution and its density locally. In case of the former, it is very expensive (in terms of communication) for the sensor nodes to send their raw data to the RSU very frequently. The raw data transmission from every sensor node to the RSU will deplete wireless sensor nodes' limited energy, which consequently influences the quality and quantity of sensor nodes' measurements. Ensuring high quality of sensor data

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