Chapter 5
Robust Broadcasting of Media Content in Urban Environments

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ABSTRACT

In this work, the authors apply raptor codes to obtain a reliable broadcast system of non-time critical contents, such as multimedia advertisement and entertainment files, in urban environments. Vehicles in urban environments are characterized by a variable speed and by the fact that the propagation of the radio signal is constrained by the configuration of the city structure. Through real experiments, the authors demonstrate that raptor codes are the best option among the available Forward Error Correction techniques to achieve their purpose. Moreover, the system proposed uses traffic control techniques for classification and filtering of information. These techniques allow assigning different priorities to contents in order to receive firstly the most important ones from broadcasting antennas. In particular, as vehicle speed and/or distance from the broadcasting antenna increase, performance results highlight that these techniques are the only choice for a reliable data content delivery.

INTRODUCTION

Content-based information dissemination has a potential number of applications in vehicular networking, including advertising, entertainment, traffic and emergency announcements. In this work we focus on the use of a wireless vehicular communication system where corporate business servers push multimedia-based advertisement information (e.g. daily offers) to passing-by vehicles in urban environments (Fiore, Cassetti & Chiasserini 2005; Härri, Filali & Bonnet 2007).

Wireless vehicular communication systems include Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications schemes. In terms of technologies, a single standard is

DOI: 10.4018/978-1-4666-1794-0.ch005

being developed specifically targeting vehicular environments, and supporting both V2I and V2V communication modes. This standard, known as IEEE 802.11p (Martinez, Cano & Manzoni 2009) is an enhancement of the original IEEE 802.11 standard that basically combines the IEEE 802.11a (operation in the 5 GHz band) and the IEEE 802.11e (MAC-level QoS support) annexes. In particular, the band of frequencies reserved for the operation of IEEE 802.11p is defined at 5.9 GHz, although there is still not a worldwide consensus on the use of this band.

Cars in urban environments are characterized by a variable speed and by the fact that the propagation of the signal is constrained by the configuration of the city structure (Giannoulis, Fiore & Knightly 2008). If a road side unit (RSU) wants to propagate a block of information to a passing by vehicle, the most basic approach would be to periodically rebroadcast the same content. This approach has fundamentally two limitations, namely: data synchronization and car speed. The first issue stands in the fact that, if the car starts receiving the block of information when the cycle has already began, it will have to wait for the next cycle to get the whole of the information. The second issue refers to the fact that, depending on the car speed and on the configuration of the city layout, the car will be reached by the information sent by the specific RSU during a limited interval of time.

In this work we propose an optimized solution for the broadcast-based delivery of small-size multimedia contents such as advertisements and news to moving vehicles using IEEE 802.11p. The objective is to reduce the problems due both to content synchronization and to the limited size of the transmission window. With this purpose we adopt raptor codes, which are an extension of LT-codes with linear time encoding and decoding. LT-codes (Luby Transform) are a new class of codes introduced by Luby for the purpose of scalable and fault-tolerant distribution of data over computer networks (Shokrollahi 2006). Moreover, we use also flow control techniques based on filtering and classification of information in order to privilege the most important information for the user.

The rest of this paper is organized as follows. The *Background* section briefly describes the FEC schemes and the flow control techniques used in this work. In the section *A Robust Broadcast-based Content Delivery System*, we present the developed system for robust broadcasting of content to mobile users/vehicles. The performance evaluation of our system is discussed in the *Performance Evaluation* section. Finally, after delineating future research directions, conclusions are drawn.

BACKGROUND

In this section we introduce some background concepts about FEC and control flow techniques that are exploited in the broadcasting multimedia system proposed in this chapter.

Forward Error Correction Techniques

Forward Error Correction (FEC) is a transmission control system where the transmitter adds redundant data, called Error Correction Code (Luby & Vicisano 2004), to identify and possibly correct an error in the transmission without requiring the transmitter's intervention.

XOR is one of the simplest FEC schemes for error handling, being designed to ensure protection against the loss of a single packet in the presence of low error rates (Peltotalo, Peltotalo & Roca 2004). Its aim is to partition each source block using a fixed source symbol length, and then to add redundant symbols built as the XOR sum of all Source Symbols. This process is called Encoding (k+1, k), where k is the number of Source Symbols.

Reed-Solomon (R-S) (Lacan & others 2009) is a much more sophisticated FEC scheme that assumes an RS(N, K) code, which results in N codewords of length N symbols, each storing K