Wireless Reprogramming of Vehicle Electronic Control Units

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Abstract—The new generation vehicles will have many sophisticated systems such as drive-by-wire, navigation, traffic congestion control, road guidance, and advance crash warning. Already, dozens of onboard computers control complex vehicle functions. From time to time, an onboard computer needs reprogramming. Currently, dealers manually reprogram software in onboard computers via a wire based electrical connection. Updating software wirelessly is a preferred alternative to the manual method because the vehicle need not be physically present at a repair facility to perform the update. Wireless software reprogramming will save customers’ and technicians’ time and money. In this paper, we present a wireless download algorithm for reprogramming of vehicles’ electronic control units, using current wireless technologies. Our algorithm proposes a hybrid infrastructure that combines wireless unicasting and multicasting data delivery.

I. INTRODUCTION

In recent years, the multicast communication has become necessary in a variety of mobile services, such as video and audio sharing, software update distribution and news. This paper gives a short overview of basic wireless multicast routing concepts and describes a solution for providing multicast content distribution for software updates.

Recent studies show interest in hybrid wireless systems combining different radio access networks (RANs) to provide efficient data services to mobile users [1-3]. Keller, Lohmar, Tönjes, and Thielecke [1] discussed synergy of different RANs. The overall communication infrastructure consists of many RANs. The type of needed service will influence the decision on which RAN to use for that particular wireless transmission. Multicasting intuitively best fits a digital radio broadcasting carrier, digital audio broadcasting (DAB), digital video broadcasting (DVB) or a multicast capable cellular channel. Unicasting intuitively belongs to cellular networks such as GSM, IS-95, or IS-136 (D-AMPS) [4].

Munaka, Yamamoto, and Watanabe [2] presented the Advanced-Joint System for data multicasting in intelligent transportation system (ITS). This multicast methodology is based on disseminating data that are location dependent. If a vehicle is in the tower's coverage area, then that vehicle is a part of the tower’s multicast group. When the vehicle moves to a different tower, the vehicle will join the next multicast group. The base station that keeps track of multicast groups will predict, based on the history of the vehicle movement, which multicast group the moving vehicle is likely to join. The current multicast group will send a preparation message via the wired network to the next multicast group in the vehicle's path. This redundant information is to reduce packet loss due to coverage handoff and the lack of group membership.

Synergy of cellular and broadcasting infrastructures into one system is intuitively justified by two reasons. First, unicasting is an inefficient and very costly method to deliver common content to many users by point-to-point connections, as in a traditional cellular system. Second, it is also inefficient to engage multicasting over a large area for the communication to only a few users. Multicasting is justified when the number of recipients is very large. Following the same logic, according to Bria [5], cellular unicasting is a better alternative when number of users is small.

II. SYSTEM DESCRIPTION

A. Infrastructure

The infrastructure consists of a central server (CS), regional managers (RMs), multicasting towers (MTs), and unicasting towers (UTs), as shown in Fig. 1. The automotive company (AC) or the electronic control unit (ECU) supplier decides that a certain ECU needs reprogramming. In other words, for example, only the ECUs of a certain vehicle type, having a certain vehicle configuration, and produced during a certain time period will be updated. The vehicles in need for the particular software update form a multicast audience. The CS keeps the list of all vehicle identification numbers (VINs) of the multicast audience. Wire or optical cable connects the CS to the all RMs. The CS distributes the software update and the multicast audience information to all RMs. An RM connects by wire to unicasting towers (UTs) and a multicasting tower (MT) for a particular geographic region. The RM instructs MT to multicast packets of the software update to the targeted vehicles. The targeted vehicles, in the region, periodically unicast information about missed packets. The RM collects the information from the UT and prepares a missing packet list for the region. The order of the packets in the list is based on the OR method [2]. In other words, the resulting list is prioritized by the number of times a particular packet failed to reach the targeted vehicles. Higher number means higher priority for that packet in the list. The RM frequently updates the list, for the duration of the downloading process, with the current missing packet information. In the consequent multicasting round, the MT multicasts only the packets from the missing
packet list. The MT sends the packet with the highest priority first.

B. Vehicle

A vehicle is equipped with a wireless capable device. Duri et al. [6] defined automotive telematics as the information-intensive applications that are being enabled for vehicles by a combination of telecommunications and computing technology. The telematics control unit (TCU) is a vehicle’s wireless transceiver and the gateway to the intra-vehicle network, e.g., Controller Area Network (CAN) [7]. The TCU performs the following functions: (1) receives multicast packets from the multicast carrier, (2) accumulates packets creating the software image in the internal buffer, (3) analyzes created image and composes the vehicle's missing packet list, (4) sends and receives unicast messages on unicast carrier, (5) periodically reports missed packets via unicast, (6) runs algorithm that reprograms targeted ECU from the complete software image, and (7) performs diagnostic and functional tests after the ECU is reprogrammed. The TCU has logic to determine if it is safe to reprogram the targeted ECU. The TCU checks the battery and other target-specific conditions. The TCU reprograms the targeted ECU from the buffer when it becomes convenient (i.e., safety critical ECU is updated when the vehicle and engine stops, and the ignition is off).

We define process of collecting the wireless software packets in the vehicle’s internal buffer as downloading and process of updating the targeted ECU from the internal buffer as reprogramming. The TCU reprograms the targeted ECU from the buffer when it becomes convenient (i.e., safety critical ECU is updated when the vehicle and engine stops, and the ignition is off).

We created a simulation to explore parameters of the proposed reprogramming algorithm. The program simulates the infrastructure and vehicle communication on the roads of greater Michigan. We are in the process of examining the impact of vehicle movement, speed, region changes; communication errors; synchronization of the towers; size of the software; and others; to the performance of the proposed algorithm. Our future publications will show detailed performance analysis of the proposed architecture and algorithm.

III. WORK IN PROGRESS

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REFERENCES


