Vehicular Networking Using Optical Transceivers

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***Abstract*—**In this work we describe and demonstrate a system for exchanging vehicle state information using short-range directional optical transceivers. The system design is intended to mitigate contention associated with periodic safety message broadcasts in a near-neighbor configuration; that which has been demonstrated to be severe enough to jeopardize latency constraints required for collision avoidance. Our demonstration system consists of an onboard vehicle computer, four optical transceivers, I/O hardware, and vehicle state messaging, management, and distribution software.

I. Introduction

Much effort has been directed towards increasing the safety of vehicles. Two themes emerge: (1) increasing the safety of individual vehicles through on-board safety improvements and sensing, and (2) increasing the safety of vehicles as system of interacting units. The latter is, of course, achieved by enabling vehicles to be interconnected using networking technology. The use of collaborative sensing is also a means by which vehicles can share sensed data about a vehicle's surroundings, or about its current operating state (position, velocity, acceleration and other vehicular operating characterizations). Such technology would allow for communication between vehicles and has the potential to introduce profound opportunities for the advancement of transformative applications regarding safety, traffic, and convenience [2].

Vehicular networking is being pursued at many levels; of interest to us are proposals for DSRC, or Dedicated Short Range Communications [1]. If based on an RF model such as existing 802.11 (WiFi) techniques, there is the possibility of severe contention in the presence of multiple vehicles that attempt to share state [3]. This is particularly problematic for a system that attempts to share vehicular dynamics and any reasonable rate (e.g., a rate of 10 Hz achieves only a minimum latency of 100ms).

In order to alleviate the problems associated with RF broadcast storms among vehicles, we implement a scheme using directional optical transceivers performing messaging with datagrams (Fig. 1). Messages including vehicular state are periodically broadcasted from each transceiver and are received by adjacent transceivers in the field of view of the transmitter. Each vehicle supports multiple transceivers that simultaneously broadcast messages and receive data from adjacent vehicles. This "dual-simplex" optical communication conveniently avoids spectral crowding issues found in conventional wireless ad hoc networks. Localization is also readily achieved by the labeling of transmissions and the identification of sector of data origin and is useful to corroborate conveyed GPS positions of neighboring vehicles.

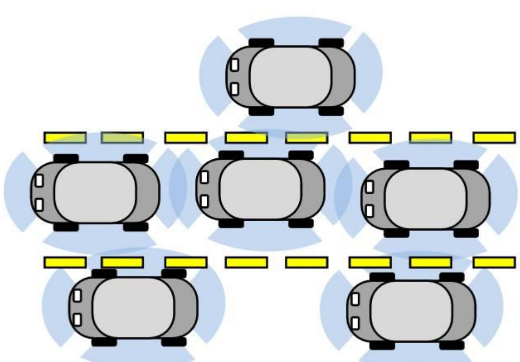

Figure 1: Optical Communication Medium

II. Hardware and Software Components

Each "node" in our system contains an onboard computer, four optical transceivers (front/back/left/right), interfacing hardware, and data management software. The transceivers are comprised of two isolated transmitter and receiver circuits. The transceivers interface with the processor via multiple USB connections. The management software suite disseminates local vehicular state data and receives external state data storing it in a message queue. The content and queue priority of the transmitted and received data is application-specific allowing for application flexibility.

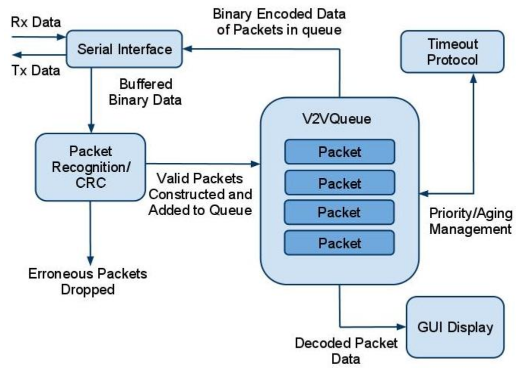

Figure 2: Software Module Diagram

III. Description of Demonstration

Our demo consists of a fully-functional four-transceiver node and two separate external single-transceiver nodes. The 'full' node emits periodic messages containing its state while the remaining nodes communicate simulated state information associated with neighboring vehicles. The GUI (not shown) displays the location and speed of neighboring vehicles based on the received messaging.

Figure 3: In-Car Computer with GPS and Single Optical Transceiver

References:

[1] "Dedicated Short Range Communications," www.standards.its.dot.gov.

[2] C.-L. Huang et al., "Adaptive Intervehicle Communication Control for Cooperative Safety Systems," *IEEE Network*, Jan./Feb. 2010.

[3] A. Agarwal, and T.D.C. Little, "Role of Directional Wireless Communication in Vehicular Networks," submitted to Intelligent Vehicles 2010, June 2010.