DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Vehicle-to-Vehicle Communications in Mixed Passenger - Freight Convoys

Extensive measurements of the propagation channel (path loss and dispersion) between cars and trucks, and between cars whose connection is blocked by trucks

Advanced Research

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Project Title:
PATH Technical Support for Automated Vehicles

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WHAT WAS THE NEED?

Vehicle convoys (platoons) hold a promise for significant efficiency improvements of freight and passenger transportation through better system integration. Through the use of advanced driver assistance, vehicles in a convoy can keep shorter distances from each other, thus decreasing energy consumption and traffic jams.

However, reliable and low-latency communications are a vital prerequisite for such systems. The standard for vehicle-to-vehicle (V2V) wireless communications is IEEE 802.11p, and its performance for communication between passenger cars has been widely explored. There are hardly any results about the performance of such systems when both trucks and passenger cars are present.

WHAT WAS OUR GOAL?

The overall purpose of this project is to investigate the performance of 802.11p based wireless communication systems for interactions of convoys with mixed truck/car situations, and assess the impact on convoy formation.

WHAT DID WE DO?

1. Obtained measurement data for the propagation channels between trucks and cars in various convoying situations, affecting mixed-passenger-freight traffic. These scenarios were clearly of great importance for mixed-traffic convoys, yet have not yet been explored or measured.

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2. Created a simulation platform (MATLAB) for the physical layer of the IEEE 802.11p standard, and used this platform to evaluate the performance of802.11p conforming radios (with "standard" receivers) in such propagation channels.
3. Provided an evaluation framework that can assess (in a reproducible way) the performance of communications systems for convoys (latency, packet arrival rate), based on measured data.

WHAT WAS THE OUTCOME?

Based on these measured data, it was shown that the propagation channel can be accurately modeled using a GSCM approach, whose benefits include that:

i. It can easily handle nonstationary (e.g. fast time-varying) channels,
ii. It provides not only delay and Doppler spectra, but inherently models the MIMO properties of the channel,
iii. It is possible to easily change the antenna influence, by simply including a different antenna pattern,
iv. The environment can be easily changed. The simulation results were found to compare well with the ones obtained from the measured data, and show that the GSCM approach can reliably be used in future system evaluation tools instead of "raw" measurement data.

The team also implemented a simulation platform for the PHY and MAC layers of the IEEE 802.11 p standard. This platform was used to evaluate the performance of IEEE 802.11 p conforming radios (with "standard" receivers) in such propagation channels. The intrinsic geometry of the trucks (i.e. a large metallic trailer behind the driver's cabin) is shown to have a significant impact on the evaluation results, when the antennas are mounted on top of the truck driver's cabin, by

i. Obstructing the LOS between the Tx and Rx vehicles, with important attenuation, when they are traveling in convoy in the same direction, or
ii. Acting as a reflector with contribution sometimes stronger than the LOS component located in the near-field of the antennas when both the Tx and Rx vehicles are traveling in opposite directions.

WHAT IS THE BENEFIT?

Prime benefit from the outcome of the project is that it helps in the understanding of how the 802.11p behaves in mixed traffic environment particularly when large body vehicles are present that can block the radio path ways.

IMAGES

Image 1: Receiver Module

Image 2: Photos of the server racks holding the equipment

Image 3: Receiver Array on top of the Vehicle

Image 4: Transmitter antenna on top of the vehicle