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# A Visible Light Communications Framework for Intelligent Transportation Systems

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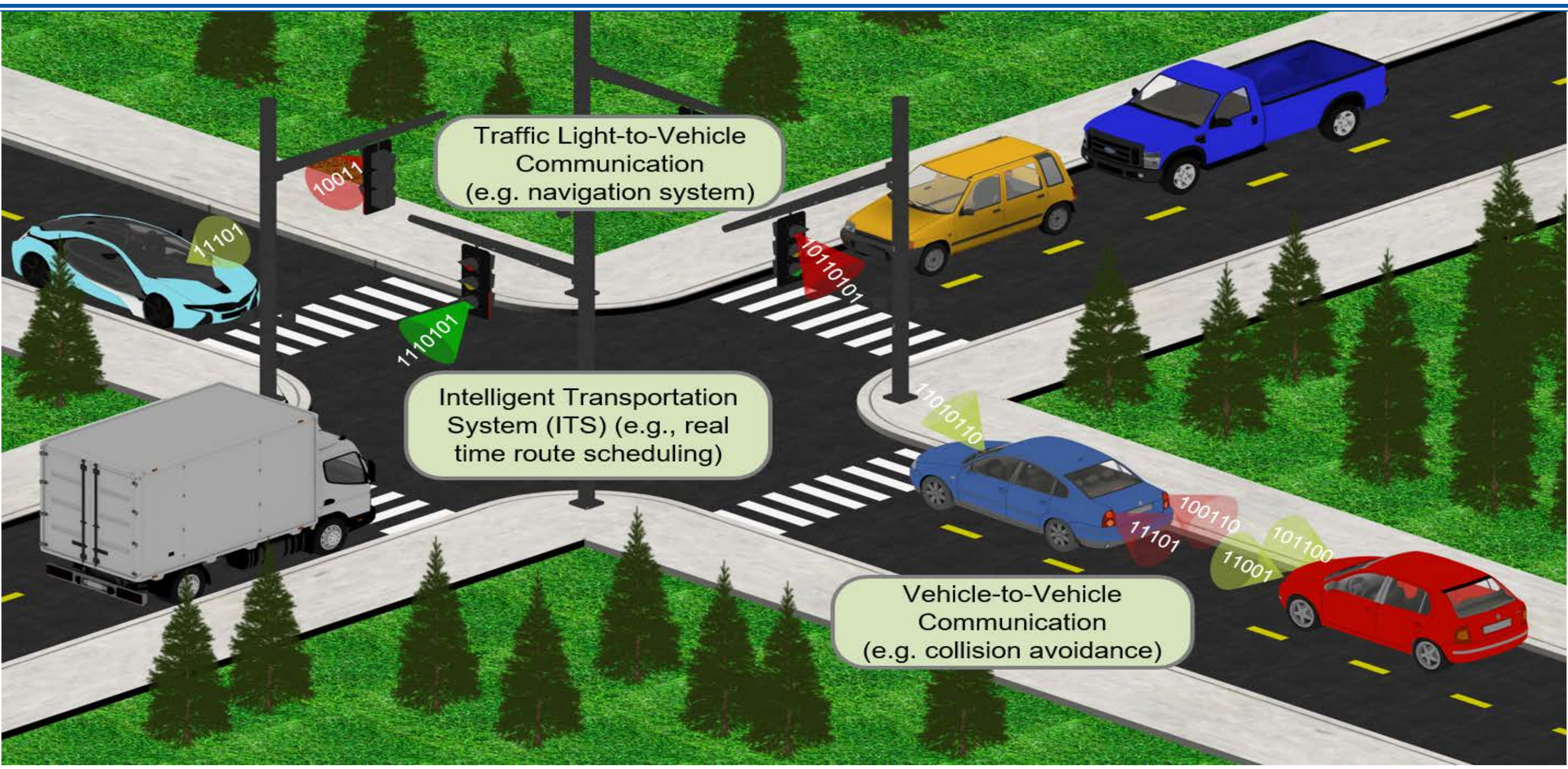


**Figure 1. Intelligent Transportation System using VLC Framework**

In this research, we developed a visible light communication (VLC) framework that can be used for intelligent transportation system (ITS). ITS has been motivated by the need to reducing traffic congestion and offering better user experience in navigation and location-specific services. Recently, within the field of ITS, VLC has drawn attention in the research community in the areas of high data rate transmission, secure communications, and indoor localization systems. The use of VLC in ITS could lead to potential new useful applications. For example, as traffic lights used to control traffic flow are fixated in a particular location, VLC would be of great use to enable the traffic lights to be able to talk to the vehicles in their proximity and convey important information about the traffic condition. In this project we developed a framework to potentially support infrastructure-to-vehicle (I2V) and vehicle-to-infrastructure (V2I) communication. (In our context the infrastructure refers to traffic lights using VLC.) Specifically, transportation systems rely on traffic lights not only to order traffic flow, but they can also be used to share important information to the cars. The developed smart traffic light can provide information about the traffic conditions several blocks down the road and, in case of accidents, this information would be useful for the driver to detour their original driving route to help reduce congestion and save time. The infrastructure of the ITS is primarily composed of a central station that controls the traffic flow. When new information is provided to the traffic lights, they are routed to the central station to do analysis and provide smarter traffic control. Our focus is on the development of VLC infrastructure to establish communication between the traffic lights and vehicles for better traffic management.

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## Study Methods

To begin with, we established a visible light communication link between a traffic light and a vehicle, which can receive the information. To do that, we first developed transmitter circuitry composed of an embedded system and optical electronics fast-switching network. The traffic light not only will be performing its functionalities (i.e., providing traffic light signals to pedestrians and drivers), but also sending out pertinent coded information to the vehicles through light pulses. After presenting the transmitter side circuitry, we then presented the receiver circuitry  composed of optical electronics circuitry in which the photodiode along with other circuitry is used for detecting and decoding the VLC signal coming from the traffic lights. The received signal passes through an analog-to-digital (ADC) before passing to the embedded system to receive and decode the transmitted signals. We have also developed and experimented with a novel optical code-division multiple-access (CDMA) scheme for overloaded optical CDMA transmission in which the optical codes will be uniquely decoded. This new coding system could potentially provide higher data rate and can support a larger number of users in the visible light communication protocol establishment. After developing the system, we conducted actual experimentation using a traffic light model/ prototype and experimented the VLC framework to test its functionality and have been working on improving its performance.

## Findings

After developing the system, we conducted actual experimentation using a traffic light model/ prototype and experimented the VLC framework to test its functionality. We were able to successfully transmit and receive the information sent by the traffic lights.

## Policy Recommendations

In future smart traffic light systems, implementation of the proposed system could provide information about the traffic conditions several blocks down the road, and, in case of accidents, this information would be useful for drivers to detour their original route to help reduce congestion and save time.

## About the Authors

Dr. Hovannes Kulhandjian is an Assistant Professor in the Department of Electrical and Computer Engineering at California State University, Fresno (Fresno State). His current research interests are in digital signal processing, wireless communications and networking, with applications to underwater and visible light communications and networking geared towards Intelligent Transpiration Systems (ITS).

## To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/1911

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