Application of DSRC/WAVE for More Efficient Streetlamp Control
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Abstract: In the paper, the DSRC/WAVE (Dedicated Short Range Communication/Wireless Access in Vehicular Environments) systems are applied to control the lamps along a street or highway so that the safety of driving and efficiency of power consumption can be addressed at the same time. It would consume a lot of energy if there are few mobile vehicles passing through the streetlamps in the late night and apply the minimum light needs for the safety of the vehicles. According to the standards of the DSRC/WAVE, the demonstration system uses WAVE short message protocol (WSMP) to send message from V2V or V2I. The system uses the information from GPS on OBU to measure and predict the current position and speed of the mobile vehicles and then controls the process of the streetlamps. In the paper, DSRC/WAVE devices are explored to achieve energy conservation and safety with the extensive covered range, high speed rate link and mobility. The system demonstrates an example to show the inherent advantages of combining communication techniques and control techniques in realizing a safer and more energy-efficient transportation environment.

Keywords: DSRC, WAVE, Efficient System.

1. INTRODUCTION

In recent years, due to global warming and energy crisis, there are demands for more efficient energy management. Normally, the streetlamps in the suburban area or along the highway usually light the whole night to provide the illumination. This would consume a lot of energy if there are few mobile vehicles passing through in late night. In contrast, the minimum light needs to be maintained for the safety of the mobile vehicles or pedestrians.

The DSRC/WAVE system is an enabling technology in realizing vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications for the realization of more intelligent transportation. DSRC/WAVE is a 75 MHz communication medium between 5.85 GHz and 5.925 GHz. The DSRC/WAVE system provides high speed radio link and mobility between Road Side Unit (RSU) and On-Board Unit (OBU) within the narrow communication area. Moreover, compared with other methods like as microwave, infrared rays or Wi-Fi, the effective distance of the DSRC/WAVE system is 300~1000(m) more than others [1].

In the paper, a GPS (Global Positioning Systems) receiver is added with the DSRC/WAVE device to get the current position of the mobile vehicle. The usage of the GPS receiver allows the system to more completely characterize the V2I channel by collecting channel statistics over a wide range of mobile vehicle speeds, separations and locations.

The organization of the paper is as follows. Section 2 represents the background of the research work. It talks about the standards of the DSRC/WAVE communications. In Section 3, the hardware implementations of the system are delineated. The operating principle is then described in Section 4. The discussion and future work are performed in Section 5. Finally, the conclusion remarks are given in Section 6.

2. BACKGROUND

The development of DSRC/WAVE system is based on the specifications including IEEE 802.11p, IEEE 1609.1/2/3/4 [2-5]. In Fig. 1, it shows about relation between IEEE 802.11p and IEEE 1609. IEEE 802.11p is to define one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for stations (STAs) within a local area. IEEE 1609.1 is to delineate the services and interfaces of WAVE resource management, including protective mechanisms for security and privacy. The all applications and availableness for the operations of the DSRC/WAVE mode are authorized by the Federal Communication Commission (FCC) for intelligent transportation systems (ITS). IEEE 1609.2 is to define...
secure message formats, and the processing of those secure messages, within the DSRC/WAVE system. IEEE 1609.3 is the specification of the network and transport layer protocols and services which support multi-channel wireless connectivity between IEEE 802.11 WAVE devices. IEEE 1609.4 is the specification of MAC sub-layer functions and services which support multi-channel wireless connectivity between IEEE 802.11 WAVE devices. The above standards describe the DSRC/WAVE architecture and services necessary for multi-channel DSRC/WAVE devices to communicate in a mobile vehicular environment. Refer to the series of the IEEE 1609, the demonstration system uses WAVE short message protocol (WSMP) to send messages from V2V or V2I.

3. HARDWARE IMPLEMENTATIONS

3.1 Block Diagram

In the paper, the block diagram is illustrated in Fig. 2. The major blocks include several parts: OBU with a GPS receiver, RSU, Controller Board and three streetlamps. These parts would be described as follow.

![Block Diagram](attachment:image.png)

Fig. 2 Block diagram for the system.

3.2 RSU and OBU with GPS

The RSU and OBU are primarily consisted of micro-controller system (INTEL IXP435) and wireless communication system (ATHEROS AR5414A). The micro-controller system with IXP435 supports a wide range of communication applications. In the system, the RSU and OBU are communicated with the DSRC/WAVE system which is realized in the AHEROS AR5414A chipsets. Otherwise, the GPS receiver is a common cost-effective integration to apply the position and speed of the mobile vehicle.

3.3 Controller board and streetlamps

The Controller Board includes the current driver and the micro-controller system. The current driver is normally op-amplifier circuit to control the amplifier of the current through the three streetlamps. The micro-controller system is used to process the data of position and speed of the mobile vehicle from GPS. After judge the data, it sends the switch control to current driver for the operation of the streetlamps.

4. OPERATING PRINCIPLE

The demonstration system is primarily composed of one OBU, one RSU, three streetlamps, one controller board and a vehicle. The OBU which would be travel by a mobile vehicle includes the Global Positioning System (GPS) module and the DSRC/WAVE transmitter module.

The GPS receiver has two purposes. One is to obtain the current position of the mobile vehicle from the satellites. The other is to send the reference clock to the DSRC/WAVE transmitter module. It would establish the synchronous communication to the DSRC/WAVE receiver of the RSU for multi-channel access.

The RSU not only includes the GPS module and the DSRC/WAVE receiver module but also connects to the controller board. The controller board includes the microprocessor and current driver for the light control of the streetlamps. It connects with RSU and the streetlamps through the current driver, and provides the calculation the estimation of the distance between OBU and RSU from the GPS incoming data.

The overall controlled process of the system is depicted as Fig. 3 and described as follow. The mobile vehicle which the OBU is travel by is drove through the road which the streetlamps are averaged distributed to 30(m). During the vehicle is moving forward along the road, the GPS module of the OBU would be received the position data continuously. The position data from the GPS module would be sent from the DSRC/WAVE transmitter module to the DSRC/WAVE receiver module of RSU by WSMP when the mobile vehicle enters to the effective area. Then RSU would send the location data of the GPS modules in the OBU and in the RSU continuously to the controller board. When the controller board receives the position data of the OBU and RSU, an algorithm will be used instantaneously to calculate and estimate the speed of the vehicle and the distance between the OBU and the RSU. According to the speed and the distance, there are several setting values of the threshold level for judge the switching state of the current driver to control the streetlamps from the microprocessor of the control board. Following the switching state of the current driver, the light of the streetlamps would be controlled by the action of the mobile vehicle. The original operation state of these
streetlamps along the load is lightless. When the mobile vehicle is drove close to the fist streetlamp, the current driver would be increased the current for the first streetlamp according to the speed of the vehicle and the distance between the OBU and the RSU. When the vehicle is away from the streetlamp, the current driver would be decreased the current for it until lightless. For other streetlamps, the controlled process is the same.

![Diagram](image.png)

Fig. 3 The overall control process of the system.

From the operation of the system with the DSRC/WAVE devices, the power efficiency would be realized. In addition, the safety for the vehicle also would be achieved by the control with the switching state of the current driver to provide if the light of the streetlamps is enough.

5. DISCUSSION AND FUTURE WORK

The OBU and RSU of the experiment system is setup as Fig. 4. The DSRC/WAVE structure following the latest standards is realized in the demonstration system. The following results will be measured in the future:

A. The effect of the accuracy of the position and speed provided by GPS to switch control of current driver.

B. The effect of the time of the DSRC/WAVE communication to switch control of current driver.

C. The power performance of the efficient streetlamp control.

![Image](image.jpg)

Fig. 4 The RSU and OBU.

6. CONCLUSION

In the paper, DSRC/WAVE devices are explored to achieve energy conservation and safety with the extensive covered range, high speed rate link and mobility. The demonstrated system perform an example to show the inherent advantages of combining communication techniques and control techniques in realizing a safer and more efficient transportation environment. The paper will highlight some perspective applications by fusing DSRC/WAVE into existing vehicular control systems.

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REFERENCES