Energy Efficient Fog Computing Based Smart Traffic Lights System for Hurricane Evacuation

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Abstract This paper describes an energy efficient fog computing based smart traffic lights system which facilitates hurricane evacuation.

1. Introduction

During a Hurricanes evacuation, people need to move as quickly as possible out of harm's way. However, as residents of large communities hit the road all at the same time, traditional traffic light systems can significantly slow down the evacuation. In this paper, a smart traffic lights system (STLS) based on fog computing is proposed. The proposed system can adapt to real-time traffic conditions during Hurricane evacuation and accelerate the evacuation process. The energy efficiency of the fog-based STLS is evaluated.

1. Intelligent Transportation System (ITS)

The proposed smart traffic lights system operates under the Intelligent Transportations Systems (ITS) framework. Dedicated Short Range Communications (DSRC) is a communications technology specifically designed to support ITS applications. One potential competing technology for DSRC is 5G cellular networks whose success will depend on nationwide carrier deployment. As of now, DSRC technology is the only viable and practical solution to deploy ITS. It also has a short time delay of a few milliseconds. The Federal Communications Commission (FCC) has allocated 75 MHz of the DSRC spectrum at 5.9 GHz to be exclusively used for Infrastructure-to-Vehicle (I2V) and Vehicle-to-Vehicle (V2V) communications. The overall bandwidth is divided into seven channels.

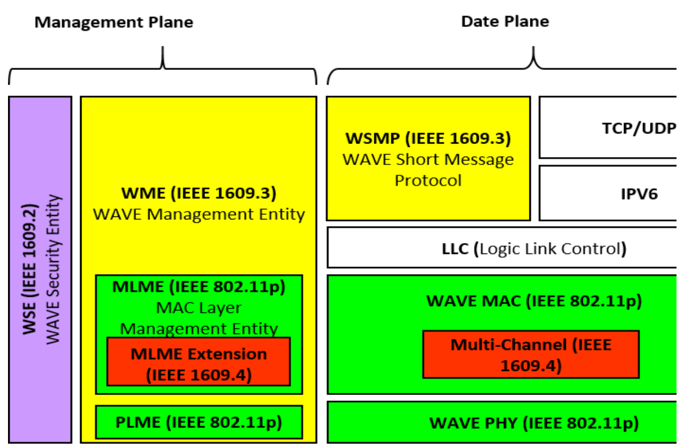
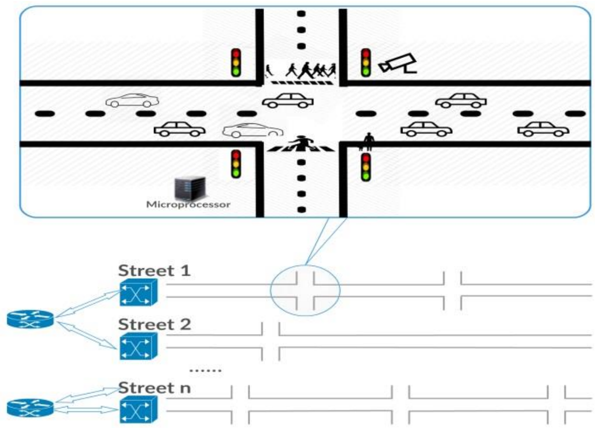


Figure 1: WAVE protocol stack

To deploy transportation-related applications, the communication protocol needs to accommodate vehicles potentially traveling at high speeds. The IEEE 802.11p, namely Wireless Access in Vehicular Environments (WAVE) protocol stack, is used for DSRC. Figure 1 shows the block diagram of the WAVE protocol stack. The Physical (PHY) Layer operates in a 5.850-5.925 GHz DSRC frequency band based on IEEE 802.11p PHY which is an extension to IEEE 802.11a PHY and specifies necessary changes that are required for operations at the DSRC frequency. The WAVE architecture supports a Control Channel (CCH) and multiple Service Channels (SCH). The CCH is used to transmit WAVE Short Messages and announce WAVE services, and the SCHs are used for application interactions. In the MAC Layer, IEEE 1609.4 takes care of the multichannel operation and prioritization of different messages, and IEEE 1609.3 supports a low overhead WAVE Short Message Protocol (WSMP). The higher protocol stack layers' employ IPv6 and other common protocol stacks such as TCP/UDP. WAVE standards on DSRC is the only wireless technology that can potentially meet the extremely short latency requirement for road safety messaging and control [1].

1. Fog Computing Based Smart Traffic Light System

Under the ITS framework, a fog-based Smart Traffic Lights System (STLS) is proposed to reduce the traffic congestion at crossroads as shown Figure 2. This system is collectively clustered around several streets with 4-way intersections, where fog-based computing helps to control traffic lights intelligently to reduce the traffic jams. Every crossroad is deployed with cameras and Road Side Units (RSUs) worked as intelligent fog nodes. Adjacent RSUs can communicate with each other either through DSRC or through wired connections.



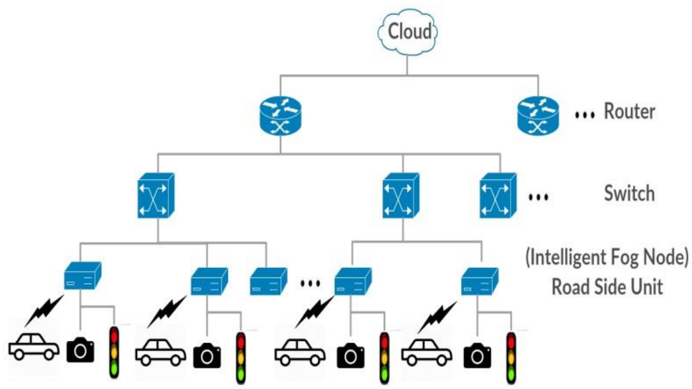


Figure 2: Smart Traffic Light System (STLS) Based

Figure 3: Architecture of Fog Computing STLS

The architecture of the proposed STLS consists of three layers: fog-based RSU nodes, switches and routers as depicted in Figure 3. In the proposed system, all fog
Processing nodes, switches and routers) have been embedded with proper hardware and software drivers as needed. The application model shown in Figure 4 is described as follows:

- *Car Identifier*: This module is performed by a video image processor to get the car information from the raw video streams before transferring to the Traffic Analyzer module for further processing.
- *Traffic Analyzer*: It analyzes the car information as well as the adjacent intersections using the last cycle decision, then obtains the solution of the green light phase distribution of four directions. The control decision is forwarded to the Traffic Lights Controller.
- *Traffic Lights Controller*: It produces traffic lights control signals to adjust the traffic lights.

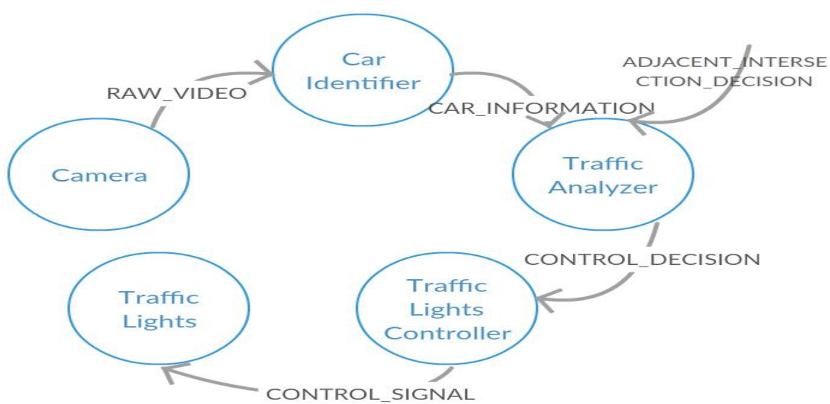


Figure 3: Application Model of STLS

4. Results

The energy efficiency of the proposed STLS is evaluated. The results demonstrated that fog computing, by fully utilizing the computing ability of the local devices, is always more energy efficient than cloud computing. The proposed STLS can preserve power while facilitating Hurricane evacuation.

5. References

[1] Y. Li, “An Overview of the DSRC/WAVE Technology, In: Zhang X., Qiao D. (eds) Quality, Reliability, Security and Robustness in Heterogeneous Networks, 2012.