TELKOMNIKA, Vol.12, No.4, December 2014, pp. 942~949
ISSN: 1693-6930, accredited A by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v12i4.537

Wireless Sensor Based Hybrid Architecture for Vehicular Ad hoc Networks

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Abstract

A vehicular Ad hoc network is an emerging and widely adopted technology because of their potentiality for innovative applications in transportation sector. Recently, the technology has been faced various challenges and rely on expensive architecture. The implementation of Wireless Sensor Network (WSN) in vehicular networks reduces the required investment and improves intelligent applications performance for driving safety and traffic efficiency. In this paper, we propose a wireless sensor based hybrid architecture for navigation systems for vehicular Ad hoc networks. The architecture is suitable for mountain range roads, where vehicles cannot communication properly. The propose architecture is used to exchange and perceive roadside information and helpful in navigation decision process and for alert messages.

Keywords*: WSN, VANET, applications, safety, GPS*

1. Introduction

The vehicular Ad hoc network aim at enhancing the traffic safety and efficiency through the use of communication and electronic technologies and one of the important part of intelligent transportation system [1],[2]. The applications of VANET provide secure efficient and well-organized communication systems to deal with traffic problems. The traditional vehicular communication systems face various challenges such as high mobility, large amount of data transmitted, exclusiveinfrastructure and navigation devices, costly-wired communication etc. The many applications only supports collection a few types of data such as global traffic information get from cameras and microwave sensors, but they cannot provide accurate information.It is difficult for centralized traffic management system (TMS) to disseminate messages to vehicles nodes and recognize the neighbor.

Wireless Sensor Networks (WSNs) is one of the boosting, cost effective, unobtrusive and unsupervised technology and widely adopted for data monitoring. The WSN based systems consist to large and medium networks of inexpensive nodes, which are capable for processing, sensing, and distributing information. A number of projects have been implemented, which are based on Wireless sensor networks (WSNs) in VANET applications. The most popular projects are: Fleetnet [3], Car TALK [4], SAFESPOT [5]. To overcome the challenges of VANET various types of solutions have been proposed such as wireless sensor package to instrument roadways system [6], WSN based roadside architecture [7], Wireless sensor for ITS (intelligent transportation system)[8]etc. These solutions are better and more flexible in efficiency and performance. But these systems are not using for navigation decision process, the navigation system usually use digital map and geographical positioning system (GPS) to navigate.

2. WSN based Applications

Wireless sensor based applications for intelligent transportation systems and for VANET provides significant advantages in cost and in distributed intelligence. The cost of installation and maintenance are reduced, but the WSN cannot use as a standalone system, it need some additional components and work as a heterogeneous system and collaborate with other technologies. On the other hand, WSN systems have some limitations such as in processing and withlight energy resources etc. The VANET environment is highly mobile, dynamic, and partitions occur very often. The predictable mobility of vehicles needs additional resources and effects on detection and estimation of data. Additional resources in roads provide

Received August 11 2014; Revised September 26, 2014; Accepted October 20, 2014

traffic flow, traffic lights, and power source and roadside unit (RSU) and receivers in vehicles etc. The wireless sensor based applications mainly divided into four types: traffic control, traffic safety, parking and traffic law enforcement applications. WSN based applications are interesting and best alternate because of low installation and maintenance cost. Some of the most relevant applications and their functions show in table 1 below.

Table 1. Wireless sensor based vehicular applications

S/No	Application	Purpose	Main Function
1	iRoad[9]	Overtaking assistance	The iRoad application is roadside WSN based and used for warn upstream vehicle nodes about presence of other vehicle nodes.
2	Qin et al [10]	Animal detection for traffic safety	In this application the vehicle are equipped to warn driver about presence of animals around the roads, the messages are in the form of warning alerts.
3	Weingärtner et al [11]	Monitoring road conditions	In this application the road condition is store in WSN nodes and deliver the information to incoming vehicles to slow the car or turn etc.
4	Sung et al [12]	Collision Warning	In this application sensor nodes measure the speed and route the data to base station and through base station warn vehicles about collision.
5	DGS [13]	Weather and speed monitoring	In this application the sensor nodes warn the driver about weather and speed through camera and report via WAN.

The traffic safety applications used for prevention from accidents [14]. In these applications sensor devices used to warn driver about any dangerous situation like adverse road condition, presence of obstacles, driving in wrong direction etc. Thestatic sensor node is use for detection of arrival of a vehicle and then activates the subsequent static nodes for attain the condition of road stretches. This method used in many applications to support animal detection [8] and overtaking assistance [7]. There is another approach where the traffic and road information is available in advance and when some data acquired, it broadcast within a certain area and vehicles gathered that data. This approach is efficient for non-ephemeral events like occurrence of dangerous road conditions. The traffic law enforcement applications offers permanent monitoring automates the process and report infractions. In traffic control applications the sensor nodes are deployed on road segments and measure the traffic flow, density and speed. The sensor nodes also deployed on intersections and making a decision to direct traffic. The smart parking applications concerns with illegal parking, space. The sensor nodes used for detecting the vacant parking slots.

Some applications are use for traveler navigation to reducethe travel time, cost, and efficient in fuel consumption. Xia et al. [15] proposed a system for path planning and navigation, where vehicles equipped with sensors and these sensors communicate with road sensors and disseminate road condition to sink node such as speed, direction etc. Route changing andtraffic jam detection applications are mostly used navigation. The Figure 1 illustrates the architecture of WSN based VANET applications.

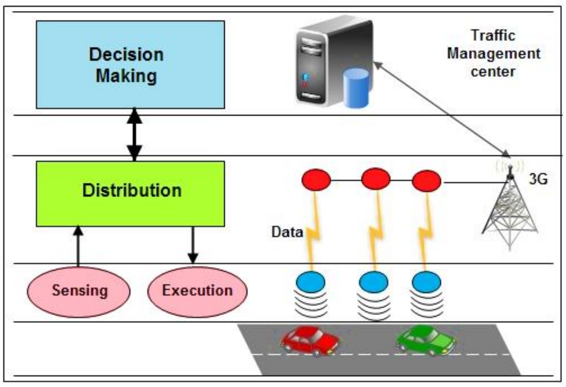

Figure 1. Architecture of WSN based VANET applications

3. System Architecture
3.1 Usage
Our proposed architecture is best for sparse highway environment, where the base station coverage is limited because of mountains ranges and long turns. The wireless sensor nodes work efficiently there and cover the obstacles and ranges. The architecture also covers the long turn on mountains where always traffic jam because of heavy vehicles, where the vehicle nodes cannot communicate properly with base station and with other vehicles, and sensor nodes sense the density information and disseminate the information to server via base station to stop behind vehicles in time with alert messages. Another feature of proposed system is handle traffic jam and disseminates traffic information in real time mode. In proposed system vehicle can detect the traffic jam information from GPS and from other sensors in vehicles such as speed is lower than a threshold certain time period. Then vehicle send the information to near WSN sensors and then pass to sink node. Another usage of our system is preventing from accidents, because vehicles are interchange sensor data continuously over a period of time. By incorporate the information into digital map the neighbor vehicles position is appear on a digital map. Easily calculate the distance, positions, and direction of neighboring vehicles. This information is further used for preventing accidents. The Figure 2 shows the flow diagram of our proposed architecture.

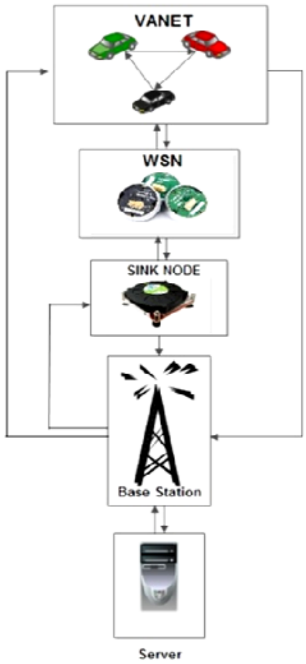

Figure 2. Flow Diagram of proposed Architecture

3.2 System Components
The wireless sensor based proposed system is an intelligent navigation decision system for VANET. The system consists of four main parts: vehicle nodes, wireless sensors, Base station and Sever illustrated in Figure 3.

The vehicle nodes can communicate with each other through wireless network and this side of communication is based on VANET. The vehicles are equipped with onboard unit with navigation and path planning applications. The vehicles exchange different kind of messages with each other like text, video, audio and GPS. The second main component is wireless sensors belong to WSN domain. The sensors are divided into two categories: sink and source nodes. The function of source nodes is to measure roadside traffic conditions such as velocity, direction, and send this information to sink node for further process. The multi-hop routing is used for this communication and sink node work as a gateway. The sink nodes and source nodes also communicate with vehicle nodes and with base station. The sink nodes are powerful compare with source nodes and have more processing power and capacity. The third part is base station, where the base station is use to gather the data from sensors and from vehicles.

The server or data center is used for gather and stored all the traffic and environmental information through base station. These information and data can be used for traffic management and for forecasting. The all components of proposed system are illustrates in below Figure 3.

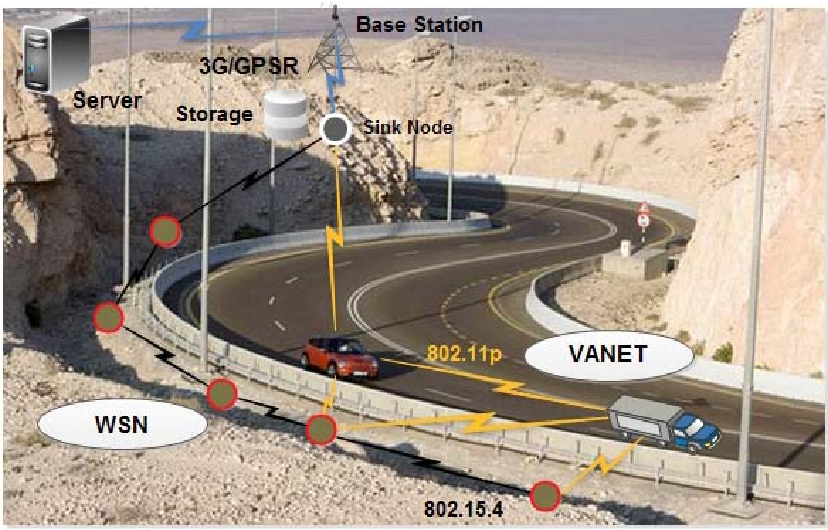

Figure 3. Proposed System Components

3.3 Routing

The two Ad hoc technologies WSN and VANET are implemented with their Divergentcharchterstics. The energy is not a challenge in VANET due to car batteries but WSN nodes have this problem. The VANET topology is dynamic and WSN topology is static. The architecture of proposed system based on network communication, routing techniques, middleware, and applications.

The IEEE 802.11p as arevision of IEEE 802.11 standard is implemented for Communication because of its cost efficiency and widely usage. The standard make possible to communicate between vehicle to vehicle and with roadside via 5.9 GHz band. In WSN we acquire IEEE 802.15.4 standard because of its low data rate, low cost and energy-optimized wireless technology. We adopt multicast Geocast [16] routing protocols for deliver information to a group of destination. In this types of protocols the information broadcasting to a specific geographic region and best for location-based announcements and region-specific resource discovery and queries. In WSN side we adopt ZigBee [17] for communication, because this technology is best for short-range, low power. The middleware collects and store the data, which is come from sensors such as radars, cameras, GPS, which are installed in vehicles. The data is further used for navigation and digital map. The WSN data come from source sensor nodes and collect in sink nodes. The proposed model covers both things navigational data and messages alerts in mountain range roads. The last component is applications in VANET, the application layer support voice control navigation, route planning, simulation navigationetc. WSN nodes are used for sensing, decision making and as a supporting module fordetection and dynamic path planning. The complete protocol architecture shows in Figure 4.

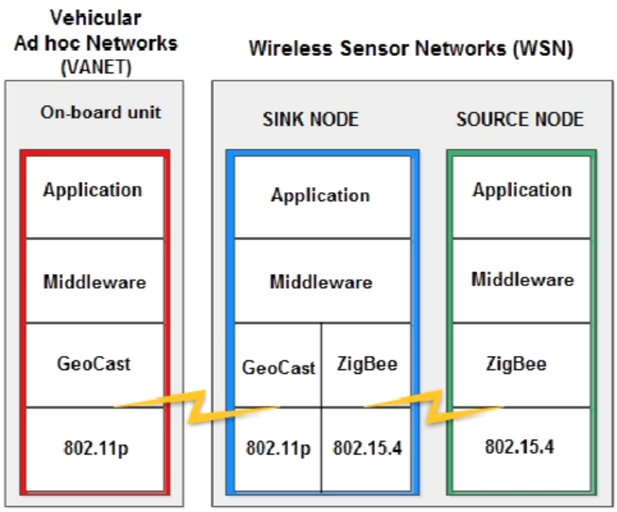

Figure 4. Protocol Architecture

3.4 System Hardware and Software

We use the HP ProLiant DL580 Gen8 Server [18] as a core of the VANET node. This is a new gen 3 technology HP server with more memory capacity and 2X faster internal storage. Other components attach with this server like LCD (touch screen), Bluetooth,camera,microphone, GPS, 802.11 wireless card as shows in Figure 5. The wireless sensor side we use TI's CC2430 chipset work as a source nodes. This tiny node contains low power 8051 micro controller, ZigBee, memory etc. The sink node is upgraded PXA270 processor SD card, GPS,LCD, USB port and touch screen etc.

Figure 5. System Hardware

In software side, the three layers are there data link, service, and presentation layer. The data link layer gather different types of data from GPS and from other sensors. The second service layer analyses the collected data and make available intelligent navigation, path planning, and messaging like text, voice and video.

4. Performance Evaluation

In this section we present simulation results of simple VANET architecture and our proposed WSN based VANET architecture and compare proposed architecture with some previous architictures. The routing task is performed using the GeoCast routing protocols and with different vehicles speed and network sizes. The simulation results are based on data success rate, delay, packet delivery ratio, and time.

4.1 Simulation Scenario

The simulation is based on highway scenario and execute a straight highway model for vehicle mobility. We use NS-3 [19] for testing the highway environments with or without WSN, with the help of VANET mobility generator and NS-3 simulation. NS-3 is a discrete-event network simulator written in C++, and more accurate and efficient simulator. For highway scenario we implement Intelligent Driver Model (IDM) and MOBIL lane change model [20] in NS-3.

Table 2. Simulation Setup

Parameters	Value
Length of Highway	10,000 meters
Number of lanes	1,5
Number of vehicles	20-40
Vehicle speed	50km/h-120km/h
Transmission range	200m
MAC Protocol	IEEE802.11p

4.2 Data success rate

In first scenario the simulation test is based on vehicles nodes to the base station without sensors and below graph shows the average data packets received on server side. Then in second scenario, same test with implementation of wireless sensors in between vehicles nodes and base station. In our experiments, we will use real-time audio communication via VANET. In experiment the vehicles nodes are equipped with 802.11g Wi-Fi adaptor cards with omnidirectional external antenna. The below graphs shows the better average rate of proposed WSN based architecture compare to without WSN system.

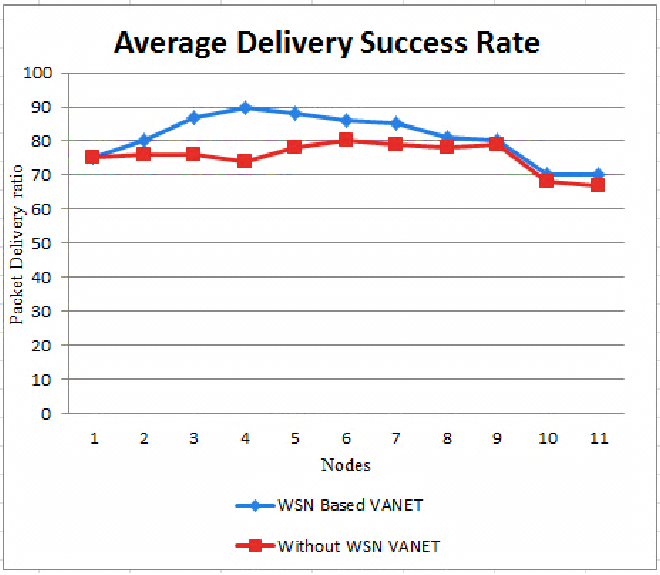

Figure 6. Average delivery success rate with and without WSN

4.3 Average End-to-end time delay

The average end-to-end delay is a calculation of time cost of packet covering its journey from source vehicle to destination vehicle. The average end-to-end time delay contains complete delays like transmission delay, process delay, prorogation and queuing delay. From the results we found that WSN based VANET architecture is better to compare without WSN. The below graphs shows the data, which is evaluated with many simulation results. The graph shows the better performance of WSN based VANET.

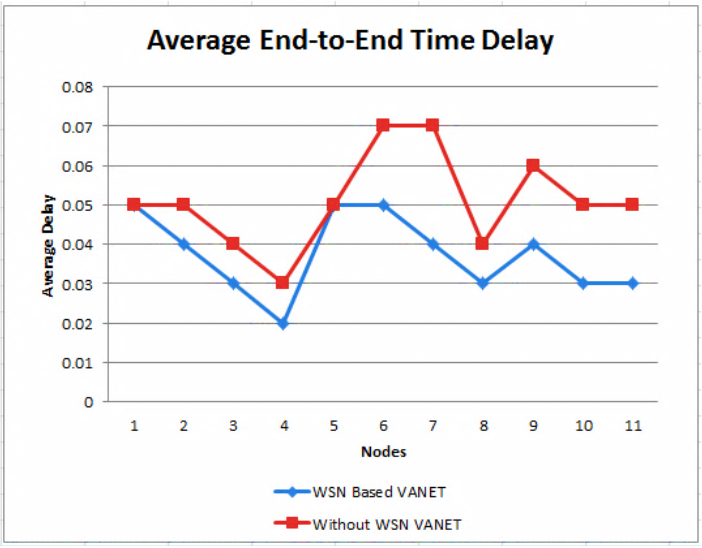

Figure 7. Average end-to-end time delay

4.4 Discussion

The above section illustrated the proposed architecture results and performance in complicated roadsenvironments.The proposed architecture is better in data delivery, end-to-end time delay. In recent years any author proposed different architectures for vehicular enlivenment especially for urban or metropolitan areas. We discuss here some of them and compare with our proposed architecture.

The one of the main problem in previous systems are obstacle handling especially in hill areas where the short curves and long turns present.Through WSN based proposed architecture the exchange of information between vehicles or infrastructure will improve the driving security and efficiency as well. The much architecture have been proposed but they focused on highways plain road environments and ignored the hill areas [21],[22].

5. Conclusion

In this paper, more efficient and hybrid sensor architecture for vehicular Ad hoc network is proposed. The proposed architecture is efficient in mountain roads, where the base station not cover the long range. We discussed the system architecture its hardware and software components and implementation as well. The results proved that WSN based architecture is most efficient and better in performance compare to without WSN system. The proposed architecture can meet the requirement of data transmission and real time audio data transmission.

Acknowledgment

This research is supported by the Ministry ofEducation Malaysia (MOE) and in collaboration with Research Management Centre (RMC) Universiti Teknologi Malaysia (UTM). This paper is funded by the GUP Grant (vote Q.J130000.2528.06H00).

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