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Zigbee Based Pothole Detection System for Vehicular Safety

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***Abstract* - There has been increasing load on the Road infrastructure with increase in world's population, because Roads are flooded with vehicular traffic. It has become difficult for the driver to manage in this scenario. This is the prime motivation behind making a vehicle intelligent enough to aid driver in various aspects. In this paper, we present a ZigBee based pothole detection system to warn the driver about the road conditions while driving, thus avoid possible accidents. Road conditions has worsened due to many reasons like rains, oil spills, road accidents or wear and tear; which make the road difficult to drive upon. During driving in the night, just the headlights might not be a sufficient assistance for driver. Unexpected hurdles on road may cause more accidents. Also because of bad road conditions, fuel consumption of the vehicle increases; causing wastage of precious fuel. All these reasons urge that it is important to get information of such bad road conditions, collect this information and distribute it to vehicles, which in turn can warn the driver.**

***Keywords* - Pothole, WPAN, ZigBee.**

I. INTRODUCTION

The existing road networks vary in age, condition and performance. In order to monitor the ongoing performance several maintenance programs have been established. These programs help to predict future pavement conditions and assess long term need, to support investment planning and decision making, to assess the road safety and to identify rehabilitation and maintenance treatment. As part of these programs, pavement surface condition assessment is identified as a key component that includes reliable measurements on distresses like cracks, potholes, rutting, etc [1]. The Road surface damages like potholes, bumps, gaps etc. are serious issues causing distractions for safe and comfortable transportation. Hence to fix these problems, centralized road inspection is required. Jakob Eriksson et al [2] described a system and associated algorithms to monitor the potholes using a collection of sensor-equipped vehicles, which used the inherent mobility of the participating vehicles, collecting data from vibration and GPS sensors and processing the data to assess the road surface conditions. Girts Strazdins et al [3] have developed a pothole detection system based on participatory sensing using Android smart phones in driving vehicles. Accelerometers and Global Positioning System (GPS) are used to detect and geo tag potholes encountered during the ride.

Sudarshan S Rode et al [4] proposed a novel Wi-Fi based architecture for pothole detection wand warning system. The system assisted the driver in avoiding potholes by giving prior warnings. There are various challenges involved in this. First there should be a way to get information about road conditions. Then this information must be distributed to all vehicles that might need this information. Lastly the information must be conveyed in a manner which can be understood and used by driver [5]. In the designed system, the wireless access point collects the information about potholes in its vicinity and distributes this information to other vehicles using wireless broadcast. Here 'vicinity' can be defined in many ways. Ideally the vicinity is every route that vehicle can take till it encounters next access point. There are many existing systems working in the area of Pothole Detection and Vehicular Networks. The main problem in those systems is that pothole detection systems concentrate only on collecting the data; whereas vehicular network applications rely on the spontaneous data generated by sensors deployed in vehicles. They are not coordinated enough to collect, maintain and distribute information. Also the current systems are not cost effective; mainly because most of the systems use GPS for localization which has high deployment as well as maintenance cost. Some systems also use cellular network; which can also be the reason for high cost. The paper is organized as follows. Section II deals with the need for ZigBee. Section III deals with the architectural design of the system. Section IV deals with the experimental results and discussions. The paper is concluded in section V.

II. WHY ZIGBEE

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

ZigBee wireless sensor network has great advantages in terms of low power consumption, high fault tolerance, flexibility, and autonomy [6]. Since the ZigBee can go from sleep to active mode in 15 ms or less, latency can be very low and the devices can be very responsive compared to Bluetooth wake-up delays. Because ZigBee can sleep most of the time when not in use, the average power consumption can be very low, resulting in long battery life. It is a typical wireless communication technology, which is widely used in most of the communication applications because of its long battery life, high fault tolerance, flexibility [7]. ZigBee techniques are used as back bones to develop ubiquitous applications while

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current information technology evolution moving from electrification to mobilization though most successful business cases still rely on mobile tools, such as PDA, WIFI, RFID, and GPS, to realize the concept of ubiquitous [8]. Fig.1 shows the ZigBee network.

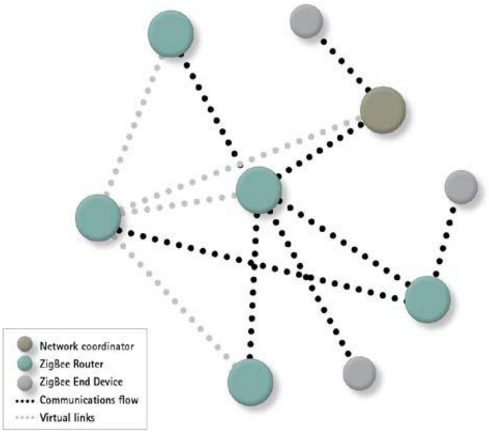

Fig.1. ZigBee Network

Zigbee hardware typically consists of an eight bit microcontroller combined with a miniature transceiver a small amount (example 32 KB) of flash memory and RAM. Most of the Zigbee stack is provided in ASIC. Zigbee operates with ISM 2.4 GHz frequency band and is pin for pin compatible with max stream Zigbee product. There are three radio frequencies used for Zigbee radio frequency communications 2.4 GHz with 16 channels and a data rate of 250 kbps for worldwide coverage, 868 MHz with a single channel and a data rate of 20 kbps in Europe and 915 MHz with 10 channels and a data rate of 40 kbps in America.

For comparison even at 250 kbps the data throughput is only about one tenth that of blue tooth. Another wireless networking solution but more than sufficient for monitoring and controlling usage. Broadcast range for ZigBee is approximately 70 meters. Theoretically Zigbee networks can contain up to 64 k (65,536) network nodes. Current testing has not reached anywhere near that level. The name ZigBee is said to come from the domestic honeybee, which uses a zigzag type of dance to communicate important information to other hive members [9].

III. Architectural Design

The system has two components; one is mobile node and other is the access point. Access points are responsible for storing information about potholes in its vicinity, taking feedback from vehicles, updating information in the repository and broadcasting information to other vehicles. Whereas a mobile node is a small device placed in a vehicle to sense potholes about which it does not have prior information, to locate and warn the driver about potholes; about which it has prior information, and giving data about newly sensed pothole to access point. The system can be divided into two subsystems: Sensing subsystem, Communication subsystem. These two subsystems work independent of each other, but have one center point they revolve around; that is data about the potholes. Sensing system generates the data; Communication collects co-ordinates and distributes the data and generates information for the driver. Fig 2. shows the basic design of the system being used in the setup. It has a sensing subsystem which senses the potholes on the road, a communication subsystem which broadcasts the information from the sensing subsystem to the other vehicles approaching the pothole. There are different ways in which these subsystems can be realized and implemented. All the ways have their own advantages and disadvantages.

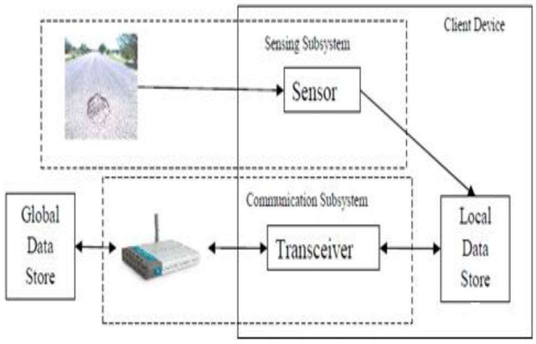

Fig.2. Architectural Design of the System

The communication subsystem takes data from different vehicles and broadcasts it to other vehicles. This system uses ZigBee infrastructure for communication between Access point and Mobile nodes. This is also a popular approach in several proposed systems which are safety oriented. The access points are deployed on the road so frequently that vehicle will never be out of network coverage, or planted at frequent intervals where they are needed in accident prone areas, dangerous turns, in areas where the road conditions are especially bad. Access point keeps on broadcasting the position of the pothole in its range. The vehicles can give immediate feedback of new potholes or nonexistent potholes which are suggested by Access point. Here access point can also help vehicle in finding the location of pothole. Fig.3 shows the implementation of the system.

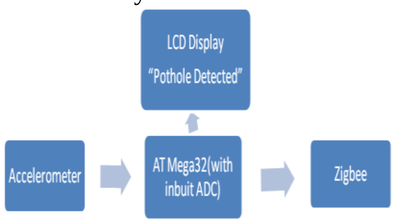

Fig.3a. Test Car Transmission

Fig.3b. Hotspot Reception

Fig.3c. Warning to approaching car

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Accelerometer measures total specific external force on the sensor and sends a signal to microcontroller which detects the pothole after getting the signal from accelerometer and displays the message on the LCD. Microcontroller also sends the signal to ZigBee transmitter unit mounted in a car which sends the signal to Road side equipment to indicate the detection of pothole which in turn broadcasts the warning message to vehicles approaching the pothole. The communication subsystem is the backbone of the entire system. It involves communication between vehicle and Access point deployed as hotspot. Some of the issues involved while designing the system are as follows.

- Data rate between Hotspot and vehicle was assumed to be 1/3rd of the Bandwidth. In reality this might change. Data rate can also be dependent on the vehicle speed, environment
- Throughput of the system depends on number of vehicles in access point range and speed of these vehicles. It has been shown by experimentation that data transferred reduces from average of 58MB at 5mph to 3.8MB at 75mph also because of the protocols that were used for the experimentation in general networking need handshaking which is an extra overhead when wireless network is concerned.
- If too many vehicles approach the hotspot, the hotspot might fail to send the signal to all the vehicles approaching the pothole as a result, some of the vehicles approaching the vehicles might miss the warning signal.
- As the standard communication frequency for Wi-Fi is 2.4GHz there might be interference from many devices in the vicinity such as Bluetooth devices, cordless phones in the range which might corrupt the warning signal.
- End to end reliability is also not provided in broadcast communication, as getting the ACK for data is not possible.

IV. Experimental Results and Discussions

Fig. 4 and Fig. 5 show the working model of the pothole detection system.

Fig.4a.

Fig.4b.

Fig.4a.Vehicle with On Board Equipment
Fig.4b. On Board Equipment

The two figures show the on board equipment prototype of the system. As this system detects a pothole, the output is displayed on the LCD as shown in fig. 4b. Fig. 5 shows Road side equipment. This output is displayed as soon as the test vehicle detects a pothole on the road. This can be used to display the big screens on the road side as a warning for the approaching cars.

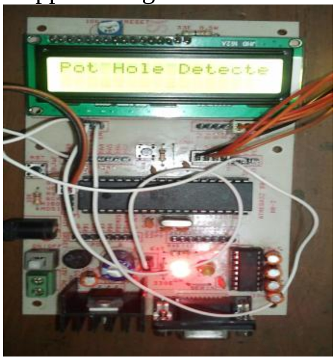

Fig.5. Hotspot Display (Road Side Equipment)

Fig.6. Approaching Car Output

The figure 6 shows the output on the approaching car which gets a warning from the hotspot setup on the roadside. The message “Nearing Pot Hole” is displayed on the screen of the approaching car as warning to the driver to take necessary precautions.

V. Conclusion

In this paper, pothole detection system based on ZigBee network for smooth driving of vehicles has been implemented. The vehicular networks are the future of road transport system. Many on-going projects are working in the direction of providing driver with all the information he needs about roads traffic movements. The pothole detection system is aimed at providing the road condition information to drivers to ensure smooth driving. The most suitable architecture in terms of cost, area coverage, cost of deployment has been proposed and implemented. The emphasis has been to use pothole detection as one application in the larger context of the Intelligent Vehicle Warning System. We can, given the channel capacity identified, conceptualize a more general architecture supporting further such applications leading to an Intelligent Road Information System to contribute to safety on Indian roads.

REFERENCES

[1] Sudarshan S Rode, Shonil Vijay, Prakhar Goyal, Purushottam Kulkarni, Kavi Arya, "Pothole Detection and Warning System: Infrastructure Support and System Design", *IEEE International Conference on Electronic Computer Technology*, 2009, pp 286-290.

[2] Sudarshan Rode "A Pothole Detection System", M.Tech Thesis, IIT Bombay, 2007.

[3] Kulkarni N.S., Bhargava S, Rakesh R, Shantanu Singh Bundela and Rajeshwari hegde," Design Of Low Cost Low Power Motes for Wireless Sensor Networks Using Msp430", *Journal of Information Systems and Communication*, Volume 3, Issue 1, 2012, pp.-182-186

[4] Chia-Ping Huang, "ZigBee wireless network application research case study within Taiwan university campus", *Eighth International Conference on Machine Learning and Cybernetics*, 2009 12-15.

[5] Liu Yanfei, Wang Cheng, Qiao Xiaojun, Zhang Yunhe, Yu chengbo,Liu Yanfei "An improved design of ZigBee Wireless Sensor Network", (2009) *2nd IEEE International Conference on Computer Science and Information Technology*, 515- 518.

[6] C. Koch, I. Brilakis, "Improving Pothole Recognition through Vision Tracking for Automated Pavement Assessment", http://ctwbisql1.ctw.utwente.nl/~hartmannt/Proceedings/Papers%20in%20pdf/38.pdf

[7] Jakob Eriksson, Lewis Girod, Bret Hull, Ryan Newton, Samuel Madden, Hari Balakrishnan, "The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring", *MobiSys'08*, June 17–20, 2008.

[8] Girts Strazdins, Artis Mednis, Reinholds Zviedris, Georgijs Kanonirs, Leo Selavo, "Virtual Ground Truth in Vehicular Sensing Experiments: How to Mark it Accurately", *SENSORCOMM 2011 : The Fifth International Conference on Sensor Technologies and Applications*, pp 295-300.

[9] Shaosheng Li, Wenze Li, Jianxun Zhu, "A Novel Zigbee Based High Speed Ad Hoc Communication Network", *Proceedings of IC-NIDC2009*,pp 903-907,*IEEE 2009*.