Wireless Sensor Network for Vehicle Speed Monitoring and Traffic Routing System

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Abstract: **A smart Vehicle Speed Monitoring and Traffic Routing System (VSMTRS) is proposed using Wireless Sensor Networks to monitor and report about the speeding vehicles and also to regulate the traffic. The system is built up of wireless modules including Crossbow MicaZ mote MPR2400, a 2.4 GHz IEEE 802.15.4, Tiny Wireless Measurement System (TWMS), a data acquisition card MDA320CA and a base station MIB510. The other modules include a microcontroller and a motor. The software used includes Tiny OS-1.11, Crossbow Moteworks (Xsniffer, Moteview, Moteconfig), MATLAB 7.30 for Data Processing PIC 16F877A is used for generating required data. MPLAB Assembler is used for microcontroller programming. This paper explains about the hardware prototype setup for part of VSMTRS, the algorithms used for the purpose, the advantages and the limitations of the entire system. Also the configuration of the setup, the OS and the application software are elaborated.**

Keywords: Wireless Sensor Networks; motes; Intelligent Traffic System; traffic routing; Central Monitoring Station

I. INTRODUCTION

The advancement in Wireless Sensor Networks (WSN) and embedded systems has led to extensive research in various fields. One of the major applications with a lot of potential impact on social well-being is identified as the implementation of WSN in designing Intelligent Transportation Systems (ITS). The concept is even more significant in developing countries like India, as the on road vehicle population is increasing more than ever.

II. MOTIVATION

The road accidents are also touching all time high rates. In a dubious distinction for the country, World Health Organization (WHO) has revealed in its first ever global status report on road safety [3] that more people die in road accidents in India than anywhere else in the world, including the most populous China. WHO, in its report, states that road fatalities will become the biggest killer by 2030. The statistics for India are chilling. At least 13 people die every hour to road accidents in the country. Technology can play a very significant role in bringing the chaos under control. A little intuitive yet contextual analysis and large scale adoption of innovative technology to tame this "epidemic" should be one of the first priorities of a responsible scientist.

III. RELATED WORK

There has been a lot of research in designing and implementing ITS (Intelligent Traffic System) but using WSN in ITS is still in its infancy. A few technologies that have been used in earlier attempts include inductive loop detectors, micro-loop probes, and pneumatic road tubes, all of which use underground intrusive sensors. However, these sensors disrupt traffic during installation and repair, which leads to a high installation and maintenance cost. Video and ultrasonic sensors which are fitted underground are less intrusive and easier to install. But these systems are also very costly and maintenance is complex. Their accuracy depends on environment condition. Tubaishat et al. [5] use sensor nodes that are environmentally robust and has very high life-time and low maintenance costs. The nodes are placed alongside the roads on the pavements. The vehicles are detected using the magnetometer sensor attached to the node which detects the distortions of the Earth's magnetic field caused by a large ferrous object like a vehicle. This is quite effective but the introduction of ultra light cars like a TATA Nano and other hybrid cars with heavy electronics setup inside them that can interfere with the magnetometer is quite questionable.

Wireless Sensor Network for Intelligent Transportation System (WITS) [6] proposed by Chen et al. is another attempt at data gathering and traffic management which is based on very complex intersection signal control algorithm and needs a mote to be installed in every vehicle and a separate detector node is used to count the number of vehicles at the intersection. The detection mechanism is not explained in detail.

Our design description focuses more on practical deployment of the system in Indian conditions by using real motes in a simple scenario simulation. The ITS proposed also looks into other major traffic related problems like Accident Reporting and Over speed Detection, making full use of the capabilities of a WSN.

IV. PROBLEM DEFINITION

A wireless sensor network is a sophisticated system which finds its use in applications like ocean and wildlife monitoring, military surveillance etc. The same concept of large scale monitoring and surveillance through wireless sensor network (WSN) can be implemented to ensure

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enhanced safety measures and innovative traffic controlling techniques. The proposed Vehicle Speed Monitoring and Traffic Routing System (VSMTRS) utilizes WSN wherein a sensor node is installed in all automobiles which can communicate among themselves and with a Central Monitoring Station (CMS), along with the sensor nodes placed at appropriate points on the roads.

V. VEHICLE SPEED MONITORING AND TRAFFIC ROUTING SYSTEM (VSMTRS)

The Fig. 1 below shows the various applications of wireless sensor network that our proposed system intends. The motes installed in vehicles will act as nodes in the network and help in sending/receiving data to/from the Central Monitoring Station. This can be used to control traffic effectively, report cases of over speeding directly to police, immediately inform medical departments in case of accidents and reduce the risks of road accidents.

At Position A in Fig. 1, there is a chance of traffic jam as there are more number of vehicles at that position. The CMS can identify this situation by knowing the increase in the mote density at that position. Thus the CMS can inform the other vehicles about the situation at Position A with the required details like the street at which thing situation prevails, so that they can choose a different path and hence reduce chances of traffic jam. Suppose the vehicles are going to petrol pump via Route A, the other vehicles can choose Route B with the information from the CMS.

Over speeding of vehicles can be easily detected at the CMS and the driver can be alerted and the same can be reported to the Police Station. By this way the drivers can be aware that they are being watched by police and over speeding can be prevented to a large extent. The motes can warn the nearby vehicles about the speeding vehicle and the distance of the speeding vehicle from the other vehicle. Again the risk of road accidents is greatly reduced. Even in cases of accidents, alarming system can be implemented and medical facilities can be made available at the earliest by informing Hospital as well as Police Station for necessary actions.

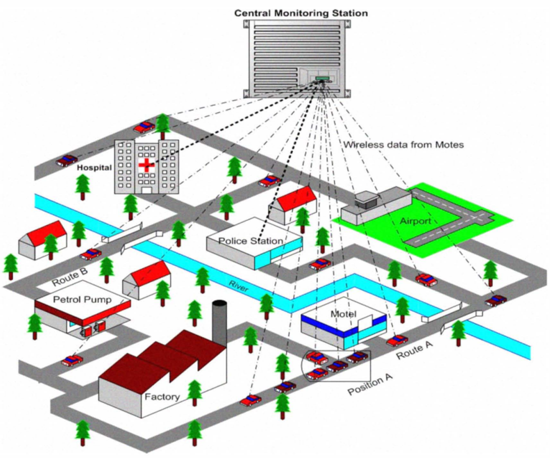

Fig.1

Illustration of a typical VSMTRS

VI. INTENDED APPLICATIONS

We use the WSN for the following purposes related to road traffic.

A. *Traffic Routing*

Let A and B are 2 routes to a common destination C, but A is the preferred one as shown in fig. 2. External Check Points (ECP) are planted at critical areas where there is a large probability of a traffic jam. If the traffic at route A surpasses a preset amount (which are monitored by the check-point and is determined by comparing the mote-density in that area), the central monitoring station is informed by these check-points which in turn can redirect the next batch of traffic through route B, thus solving the traffic jam to a large extend. This might help in avoiding many accidents.

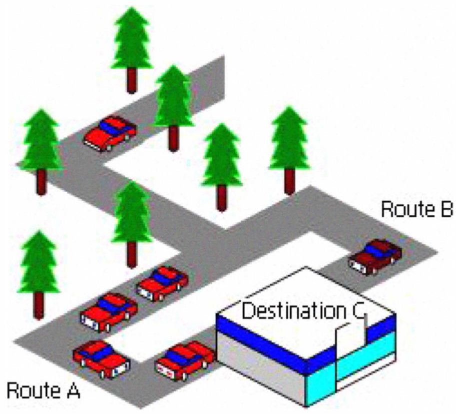

Fig.2 Illustration of traffic routing mechanism

B. *Over speeding*

Over speeding is one of the main causes of accidents in India. VSMTRS tackles this issue in the following way. Special motes called External Check Points (ECP) are installed along the road at critical areas and Internal Check Points (ICP) are installed within the car. The reason why we need check points is because it is not always desirable to check over speeding (e.g. on speedways) and the speed limit varies from place to place. The sensor node in a car can act as ICP, is also connected to the speedometer and the speed of the car is always transmitted along the block of data to the ECP. If the speed reaches a critical limit which is still below the speed limit, the ICP warns the driver by an alarm. The ECP has a preset speed limit and if the speed of the car exceeds this limit, the ECP reports to the CMS by sending the unique address corresponding to the ICP. The CMS informs to the concerned authorities.

VII. ALGORITHMS

A. *Traffic Routing Algorithm (TRA)*

ECPs continuously monitor the mote density in those areas where there is a large probability of traffic jam. If there is heavy traffic beyond predetermined critical limit, the message is passed onto the CMS. The CMS displays this information in the signboards installed in those areas where the driver can take an alternative path. This information is also displayed within the car. Fig.3 shows the flow chart of TRA.

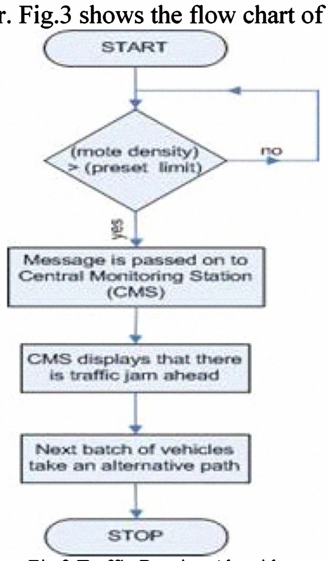

Fig.3 Traffic Routing Algorithm

B. *Overspeed Detection Algorithm (ODA)*

As soon as the car is started, the speed of the car is monitored by the microcontroller using polling mechanism.

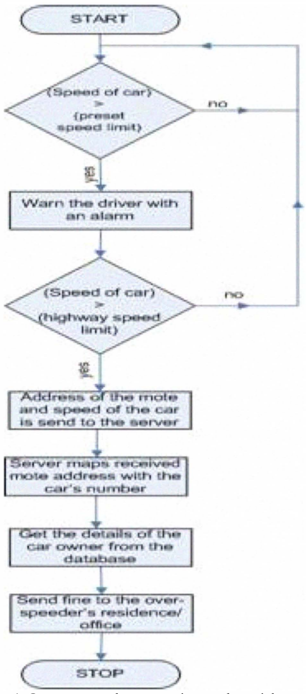

Fig.4 Over speed Detection Algorithm

If by any chance the car has crossed the preset speed internal limit, the microcontroller generates an interrupt signal which triggers two things. Firstly, the driver is alerted that the car speed has reached critical value either by using a beep sound or by flashing an LED .Secondly; it checks the external speed limit, if that is also surpassed then the mote ID is passed onto the server through the wireless network. The server maps the received mote address with the car's number in the database using Matlab. Using the car's number, the details of the owner of the car like his residential address, phone number, etc can be obtained. Fig.4 shows the flow chart of ODA

VIII. HARWARE IMPLEMENTATION

Fig.5 shows an overview of our implementation of the VSMTRS. Due to limitation in lab facilities, we are using a motor whose speed is controlled by a microcontroller (PIC16F877A) using the Pulse Width Modulation (PWM) peripheral available in it. When motor speed has breached the speed limit, an interrupt signal is generated by the microcontroller which is fed into the Data Acquisition Card (MDA320CA). The Data Acquisition Card communicates the received information to the MICAz mote (MPR2400) attached to it through a 51-pin connector. The mote transmits the data to a router which is part of the WSN. The router again transmits this data to another mote which is connected to a sensor board (MIB510). The sensor board with the mote attached to it through a 51-pin connector is called the Gateway. The Gateway sends the received information to the server through a USB interface. The server processes the data and takes the necessary action. The server can store the speed of the vehicle which has crossed the speed limit. It is possible to map the mote address to the vehicle's number and get the information of the owner so that the owner can be fined for the offense. The servers can be located in police stations, provided those areas have proper network coverage.

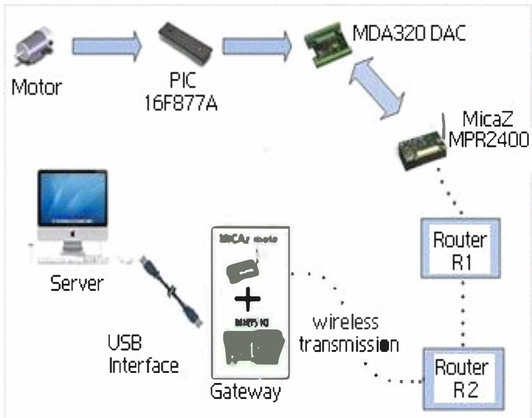

Fig. 5 Vehicle Speed Monitoring and Traffic Routing System(VSMTRS)

IX. SOFTWARE IMPLEMENTATION

A. Ccnfiguring Mote

We use the Cygwin (Unix-like environment and command-line interface for Windows) necessary for compiling and burning *.nc (nesC) files on to the motes. nesC is network embedded systems C, a component-based, event-driven programming language used to build applications for the TinyOS platform. One mote is configured as a sender and another one is configured as a receiver. A third mote is attached to the gateway (MIB510) and configured as a base station. The base station can now capture any radio packets sent over the air in its range.

B. Using Xsniffer to view the radio Transmission in the network

Xsniffer is software used to monitor data transmission in a network. Xsniffer has different options as in the fig.6 and 7. There are 2 options in Xsniffer under packet type: one is XMesh {Display incoming packets as XMesh multihop}and the other is General{Display incoming packets as general TOS packets } [8]) For test purposes we take packet types as 'general'. The columns of the display show the contents of the various parts of each data packet.

The most important columns to note in the display are:

- *Addr*: The intended destination address of the data packet (Bcast means 'broadcast', i.e. any receiver is the intended destination).
- *RF*: The received radio power at the sniffer Mote.
- *Type*: The type of data packet (0 is a normal data-carrying packet; we look at other packet types in the mesh experiments).
- *Grp*: The group (radio channel) which the mote belongs to.
- *Src*: The source of the data packet - i.e. the ID of the Mote which has actually transmitted this packet.
- *Orgn*: The origin of the data packet - i.e. the ID of the Mote which first sent this packet (it may have been forwarded by another Mote, in which case *Src* and *Orgn* are different).

The output is stored as an Excel sheet file. All the received data will be displayed in the log with different types. The data stored in Excel file in '*.csv' format can be used for debugging purpose. The options window allows us to set the packet type, the control port (serial port or TCP socket), Log filter, Log file options etc.

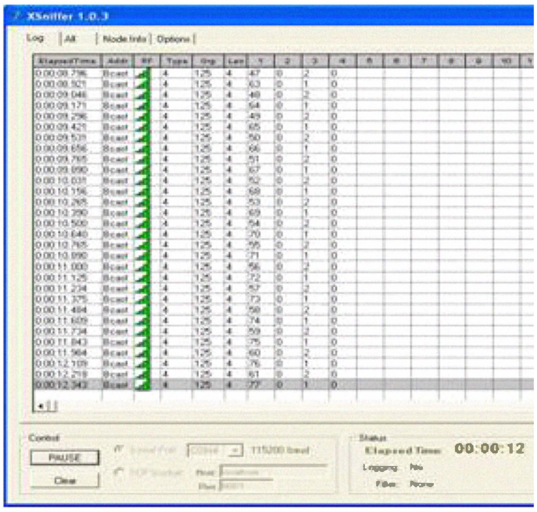

Fig.6 Xsniffer 'Log' window

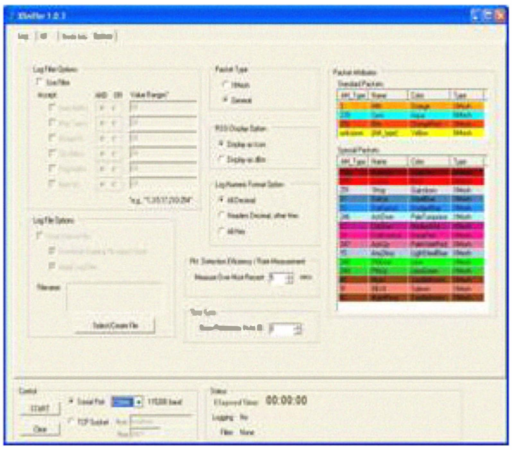

Fig.7 Xsniffer 'Option' window

C. Using MatLab for data processing

For experimental purpose, we use MatLab for VSMTRS message reporting. As stated above in section IX, the data packets read by Xsniffer are stored on to the excel file 'datalog.csv' which is processed by MatLab for over speed detection and reporting.

X. FUTURE WORK

A. Accident reporting

In the event of a road accident, reporting it to the proper authorities is an important factor. This feature is yet to be implemented. The mote installed in a car can detect a high impact collision and send an alert signal to the central monitoring station. The CMS in turn tracks the location where the accident has occurred using Global Positioning System (GPS) and directs casualty alert to the authorities concerned

XI. CONCLUSION

A comprehensive and thorough analysis of implementing WSN in ITS has been presented. Two practical applications of WSN in this context has been identified and implemented with extensive description of the software and hardware implementation process. The proposed system is highly flexible and adaptive to Indian conditions. It is comparatively more economical when compared to the conventional advanced techniques involved in modern ITS due to lower deployment and maintenance costs. The proposed VSMTRS is capable of routing the traffic on heavily crowded roads with minimal human supervision and higher efficiency. Large scale deployment of the same will ensure better traffic management on Indian turf.

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