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Wireless Sensor Network and its Applications in Automobile Industry

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Abstract - *Wireless sensor network have gained much attention in recent years and now a days it is used in applications of various domain which leads to development of smart sensors. These sensors are small, having limited processing and computing resources, and they are inexpensive as compared to traditional sensors. These sensor nodes can sense, measure, and collect information from the environment and, based on some control decision process and transmit the sensed data to the user. Hence wireless sensor network also leads to research of smart sensors that are used in emerging applications. By using its applicability, automobile industry is advancing rapidly. In this paper, three automobile applications of wireless sensor network such as Car theft control, Automobile pollution control, Headlight Intensity Control are explained in detail.*

Key Words: **Automobile pollution control, Car theft control, Headlight Intensity Control, Wireless sensor network.**

1. INTRODUCTION

In recent years, wireless sensor networks (WSNs) have gained worldwide attention, mainly in the area of Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These sensors are small in size and have limited processing and computing resources, as well as they are inexpensive compared to traditional sensors.

Smart sensor nodes are low power devices equipped with one or more sensors, a processor, memory, a power supply, a radio, and an actuator. A variety of mechanical, thermal, biological, chemical, optical, and magnetic sensors may be attached to the sensor node to measure properties of the environment. Since the sensor nodes have limited memory and are typically deployed in difficult-to-access locations, a radio is implemented for wireless communication to transfer the data to a base station (e.g., a laptop, a personal handheld device etc). Battery is the main power source in a sensor node. Secondary power supply that harvests power from the environment such as solar panels may be added to the node depending on the appropriateness of the environment where the sensor will be deployed. Depending on the application and the type of sensors used.

1.1 Definition

WSN (wireless sensor network) are spatially distributed autonomous sensors used to monitor physical and environmental conditions such as temperature, pressure, etc. and to pass their data through the network to the main location. Number of heterogeneous sensor node devices spread over a large field as shown in fig 1 Gateway provides wireless connectivity. Wireless connectivity is provided by IEEE 802.15.4 (Zigbee) or Xbee protocol.

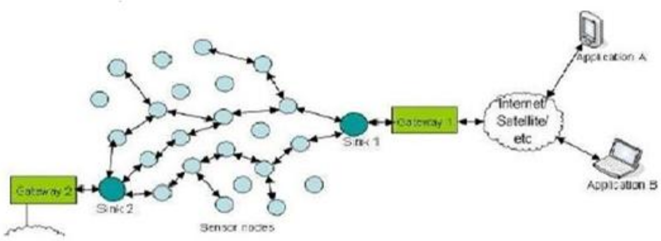

Fig- 1: Wireless Sensor Network Overview

1.2 Features of Wireless Protocol

- Low cost wireless link for industrial/commercial sensor and actuator devices.
- Data rates of 250kb/s, 40kb/s and 20kb/s.
- Star or peer to peer operation.
- Support low latency devices.
- Consumes less power.

1.3 Smart Sensor Node Characteristics

- Consist of one or more sensor, a memory, processor, a power supply, a radio.
- Consumes less power.
- Easy to implement.
- Low cost.

1.4 Network Topologies

There are various topologies through which wireless sensor network is implemented. These topologies are as follows,

- Star Network
- Cluster Tree Network
- Mesh Network

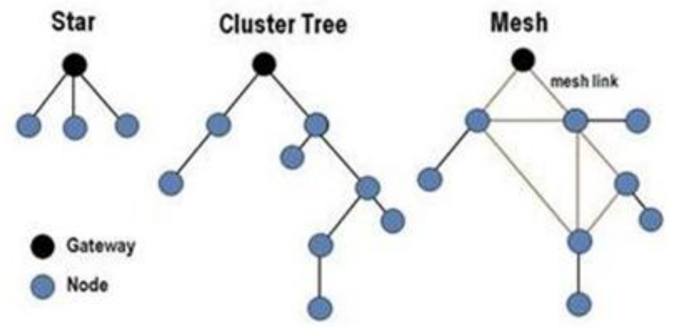

Fig- 2: WSN Network Topologies

WSN nodes can typically organized in above three types of network topologies as shown in fig 2. In a star topology, each nodes are connected directly to a gateway. In a cluster tree network, each node connects to the higher node in the tree and then to the gateway, and data is routed from the lowest node on the tree to the gateway. To offer increased reliability, mesh networks feature nodes that can connect to multiple nodes in the system and pass data through the most reliable path available. This mesh link is often referred to as a router as shown in above fig 2.

1.5 Sensor Network Architecture

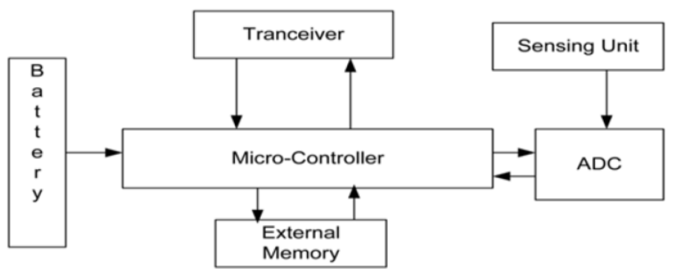

Fig- 3: Sensor Node Architecture [1]

WSN architecture consists of various components such as sensing unit, Processing Unit, Power Unit, Transceiver Unit, memory unit. Sensing unit senses analog signal and give it to ADC which then convert analog signals to digital and supplied digital signal to microcontroller. Microcontroller performs operations according to set conditions and give output signal to transceiver unit. Power unit is used to provide power supply to microcontroller.

1.6 WSN Applications

Wireless sensor network has applications in various domains for example military, environmental, health, home and office, automobile and other commercial applications.

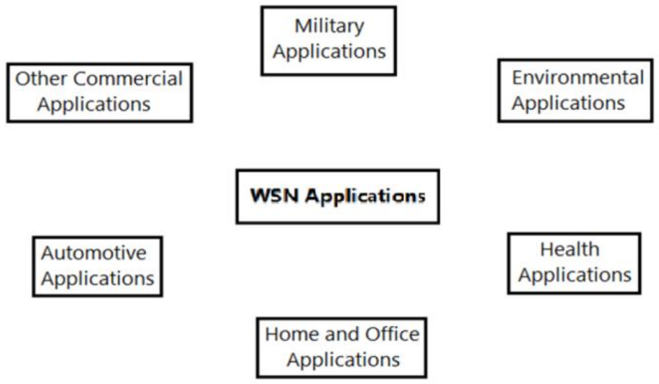

Fig- 4: Wireless Sensor Network Applications

This paper focuses on automobile applications of wireless sensor network. Automobile applications are as follows:

- Detecting and monitoring car thefts.
- Automobile pollution control.
- Headlight intensity control.

2. CAR THEFT CONTROL

Today, vehicles have been an essential part of our daily life. Unfortunately, we are also facing the high possibility of vehicle theft. Because of the high theft rate, vehicle tracking/alarming systems become more and more popular. Generally, these systems can be classified into three types: lock devices, alarm systems, and vehicle tracking/recovery systems. The commonly used lock device is the steering wheel lock. Although it is relatively cheap, it is inconvenient to use and may be easily disarmed by skilled thieves. Car alarm systems (prices range $100 to $500) are very popular these days. However, the vast majority of blaring sirens are false alarms. However, there are several disadvantages. First, these systems have high cost of $500 to $1300.

Although the upfront purchase price keeps decreasing, the maintenance cost remains high. For example, these systems often come with a monthly monitoring fee. Second, GPS-based systems do not work indoors and terrain interference may occur in dense urban areas. Third, GPS-based tracking systems are easy to defeat since the thief knows where device is located. The thief can simply break off the antenna or cover it with metal, and then the GPS tracking system will become useless.

To address the limitations of existing vehicle tracking/ alarming systems, a Sensor-network- based Vehicle Anti-Theft System (SVATS) is developed. In SVATS, each vehicle is equipped with some sensors. All sensors in vehicles parked in the same parking area form a sensor network. For each parking area, one separate sensor network is formed and one base station (BS) is installed.

SVATS relies on the sensors to detect vehicle theft and notifies the police through the BS. [3]

2.1 System Overview

In SVATS, each vehicle has a wireless sensor node which can be connected to the power source of the vehicle. All sensors in vehicles parked in the same parking area such as shopping centres, schools, hospitals, airports, residential areas, form a sensor network. For each parking area, one separate sensor network is formed and one base station (BS) is installed.

Within a sensor network, each node is monitored by its neighbours, which identify possible vehicle thefts by detecting unauthorized vehicle movement. For example, suppose Emily comes back home and wants to park her car in the residential parking lot. Before she leaves the car, she powers on the sensor node in her car by a remote controller. The sensor node broadcasts an authenticated join message to sensors in the neighbouring cars. After joining the network, it periodically broadcasts an authenticated alive message to its neighbours. Commanded by the remote controller, it sends an authenticated leave message to neighbours when the car leaves; the sensor is then turned off. [3]

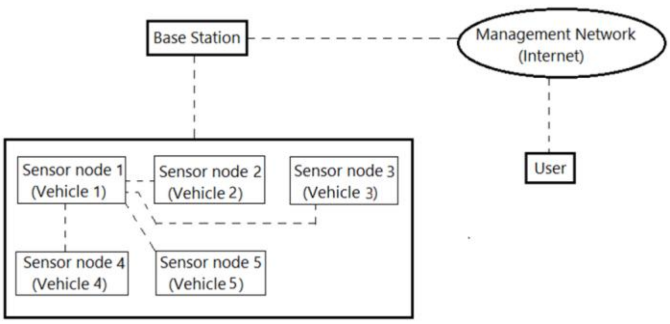

Fig- 5: Block diagram of Vehicle Theft Control

If a thief moves the car, without sending an authenticated leave message, the neighbouring sensors can detect the car movement. If the thief destroys the sensor in the car, the neighbours will not receive authenticated alive messages from the sensor, thus detecting the abnormal phenomenon. They will report the problem to the BS, which in turn automatically sends a warning message to the security officer. The vehicle owner can also be notified at their choice.

The basic SVATS system is enough to detect stolen vehicle. To track the stolen vehicle, we enhance SVATS by using the wireless nodes or access points deployed along major streets and around the intersections. This roadside wireless access points can be used to communicate with the sensors within the passing-by vehicles. In case a car is stolen, the sensor node within the car can detect its own unauthorized movement by using movement sensors or by measuring neighbouring cars sensor signal, and hence report problems to the roadside wireless devices. In this way, the vehicle can be tracked city-wide as long as it is within the area where SVATS system has been deployed.

Since the sensor is attached to the vehicle power, its position is known and may be destroyed by the thief, and then cannot report problems for tracking. To address this problem, there is deployment of more sensor nodes, referred to as the slave sensors, inside each vehicle. The slave sensors should be put at several hidden places inside the vehicle so that the thief cannot locate them in a short time. Slave sensors are used to monitor the original sensor node, referred to as the master sensor, and to report vehicle theft when master sensor is destroyed. [3]

2.2 Advantages

- Wireless Sensor Network based system prevents car theft.
- Real time measurement monitoring.
- Reduces cabling cost.
- Reduces false alarming rate.
- Can accommodate new devices at any time.
- It can be accessed through a centralized monitor.

3. AUTOMOBILE POLLUTION CONTROL

Vehicles are a major source of pollution in urban areas. The drastic increase in number of vehicles has also resulted in a significant increase in the emission load of various pollutants. As shown in the fig 6 sourced from Central Pollution Control Board, Govt. of India, and vehicular pollution contributes 72% to total pollution produced by various sectors. The various measures taken presently by the government are: Fitness certification is a main requirement for commercial vehicles and public transport vehicles. For non-commercial passenger cars, fitness certification is required for renewal of registration, only after 15 years from the date of first registration. PUC (Pollution Under Control) certificates are required to be obtained every three months for all categories of vehicles. In case of two wheelers no such requirement exists. [4]

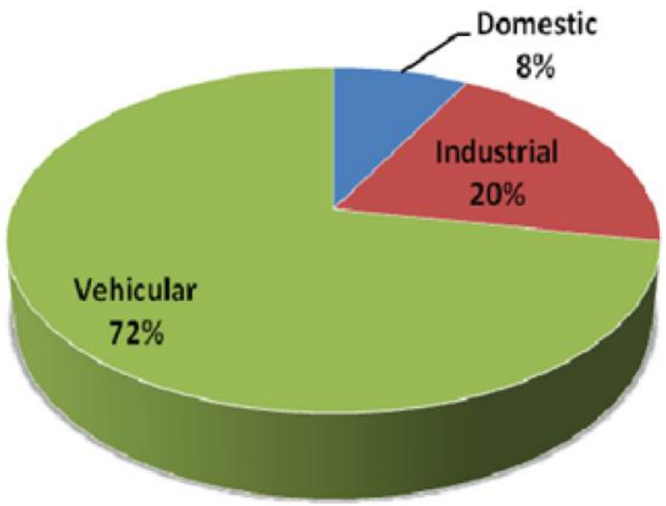

Fig- 6: Contribution of pollution by various sectors [4]

Recent advances in sensing technology, particularly in the area of wireless sensor networks (WSNs), now enable environmental monitoring in real time, and at unprecedented spatial and temporal scales. This is a sensor network in which all vehicles at the time of registration will be attached with a device (Sensor Node), which is able to provide aggregated information about the pollutant concentration released by the vehicle all time.

3.1 System Overview

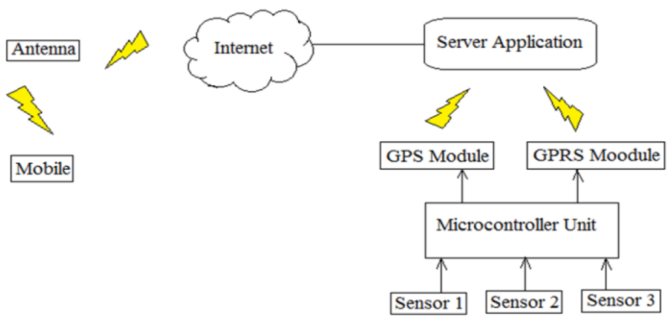

Fig- 7: General architecture of automobile pollution control

The design of the can be viewed from the general architecture shown in Fig 7 In its bottom layer the microcontroller has been programmed to retrieve the raw sensor observations from gas sensors and the location and time information from the GPS module. The program then translates the raw sensor data observations along with GPS information to descriptive observations by applying the specialized processing steps. The processed data are then packed to a specialized message format and forwarded to GPRS module. GPRS module is responsible to transmit the data messages (possibly in the form of SMS in this use case) to the server application. Server application consists of a Data acquisition module, a Specialized Alert system and a database. Data acquisition module acts as a gateway for the data transmitted by the sensor node to the server application. Alert subsystem is used to send the alerts to the desired users (vehicle owner, concerned traffic personal), when the vehicle starts to cross the specified threshold of pollution. Alerts enable the users to know the particular vehicle is not meeting Pollution Under Control (PUC) conditions, so that certain actions can be taken. Once received the message from the node the database handler receives the event and stores the observation in the database.

The VehNode prototype is designed based on a microcontroller board with Atmega 328P-P microcontroller, gas sensors, SM5100B-D GPRS module and GTPA010 GPS module to track the present location and time awareness. The web connectivity is established by the GPRS module so that all collected and processed data is available on the web in real time. The web accessible data within our prototype setup is mostly derived from the output of gas sensors and GPS module. Gas sensors used are MQ-135 gas sensor used to measure NOx, Benzene, CO2 concentration and MQ-7 sensor used to measure Carbon monoxide (CO). The microcontroller board hardware and the firmware programming language, is utilized to integrate the sensor components with the web enabled computing component. [4]

3.2 Advantages

- With the help of this system we can reduce automobile pollution.
- Real time measurement monitoring.
- It can be accessed through a centralized monitor.

4. HEADLIGHT INTENSITY CONTROL

The increase in number of road vehicles has outpaced the improvements and developments on the road resulting into unsafe road travel. Around 33 during night time travel in spite of the fact that during night time the number of vehicles fleeting through the roads is comparatively very much lower as compared to the number of vehicles during the daytime [6]. Also, the accident taking place during the night time also shows a trend of having higher proportion of fatalities.

The current headlights which are present in the market do have a setting to manually reduce the intensity of their own headlights. Any type of a particular headlight in the vehicle whether it is a headlight or tail light has its own intensity level setting which changes with the different variety of headlight being used in the system. The different type of headlight which may include the halogen headlights, LED headlights, tungsten _lament headlights, etc. consists of different levels of headlight intensity. Either of these variety of lights being used in the headlight or tail light their maximum intensity of light obviously affects the drivers. The current headlights being used in the vehicles only have a setting by which the user can manually set the intensity level.

The problem which is expected to be tackled by the system is the problem of temporary blindness which is caused due to the elevated headlight intensity of the vehicles. This in turn would eventually lead to reduced number of accidents due to temporary blindness especially due to night time travel.

This scenario could be effectively tackled by reducing the intensity of the headlights simultaneously which would completely avoid the problem of temporary blindness. This could be implemented by developing a system which would sense the headlight intensity of the oncoming vehicle and sensing the headlight intensity it should be capable of reducing the intensity. [5]

4.1 System Overview

As shown in Fig 8, the architecture consist of LDR (light dependent resistor which senses the intensity of headlight of the oncoming vehicle. This intensity is received in analog form. This is converted into digital form with the help of ADC (analog to digital convertor). This value is passed to IC8051 microcontroller which compares the received value with the predefined threshold intensity.

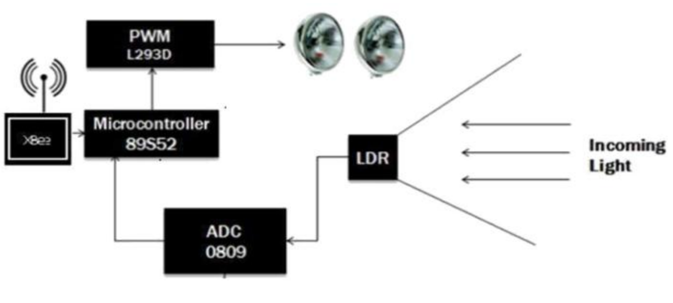

Fig- 8: Architecture of Headlight Intensity Control [5]

If the intensity is greater than the threshold then the signal is passed to the oncoming vehicles system with the help of X -Bee transmitter and receiver system. If the received intensity is less than the threshold value then the event does not occur. In the oncoming vehicles side the signal is received. If the intensity is more than the threshold then the oncoming vehicles microcontroller gives a signal to lower its own intensity. This is done with the help of PWM (Pulse width modulator) which modulates the light to the intensity specified by the microcontroller. [5]

4.2 System Design

System consists of following components,

4.2.1 Microcontroller

The microcontroller to be used in the system is IC89S52 which belongs to the 8051 family. The function of the microcontroller in the system is to compare the intensity value of the oncoming headlight with the threshold headlight intensity which would be set into the system. The working of the microcontroller is shown in Fig 11. Microcontroller take signals from light intensity sensor. It will perform control operations and give

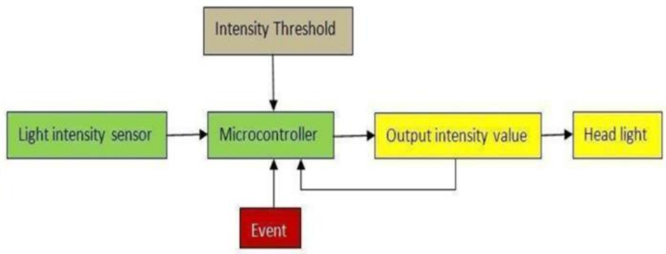

Fig- 9: Block diagram of working of the microcontroller [5]

4.2.2 Analog to Digital Converter

An analog-to-digital converter (ADC) is a component that converts an analog signal to a digital number or a digital signal that represents a certain amplitude of the signal. The function of the ADC is to convert the analog signal sensed by the LDR to digital which is given as input to the microcontroller. An ADC is defined by its bandwidth which is the difference between the highest frequency and the lowest frequency. [5]

4.2.3 X-bee transmitter and receiver

The X-Bee transmitter and receiver is used in the module of Wireless Sensor Network. The X-Bee is utilized in transferring the normalized intensity level to the other vehicle. The X-Bee is used for faster transfer of data or signal to the other receiver incorporated in the system of the other vehicle. X-Bee transmitter receiver pair consists of Atmel microcontroller 1281. It is comparatively much faster and efficient as compared to the ZigBee. In terms of, range and line of sight the ZigBee is inferior to the X-Bee. Due to all these factors, for wireless transmission of signal transmission between the systems the X-Bee was considered to be a better option as compared to the ZigBee transmitter and receiver. [5]

The X-bee can send or transfer signal or data within the range of 100 m or 300 ft and has a line of sight of 1.6 kms. The System needs to be incorporated in both the systems. The XBee transmitter and receiver has to be incorporated in both the vehicle system for proper functioning of the system.

4.2.4 Pulse Width Modulator

The pulse width modulator performs the main function of regulating the headlight intensity with respect to the threshold headlight specified to the microcontroller. Pulse-width modulation (PWM), as it applies to motor control, is a way of delivering energy through a succession of pulses rather than a continuously varying (analog) signal. By increasing or decreasing pulse width, the controller regulates energy flow to the motor shaft. [5]

4.2.5 Threshold Intensity

A variety of headlights are used in different vehicles, which means the threshold intensity also varies accordingly. The threshold intensity is denoted by (i^{th}). The threshold intensity is the maximum value which is perceivable to human eyes. It is an elemental component of the proposed system which tackles the problem of temporary blindness. [5]

4.3 Flowchart

Following flowchart is used to carried out functioning of microcontroller. Intensity controlling operation is performed by using operations explained in flowchart.

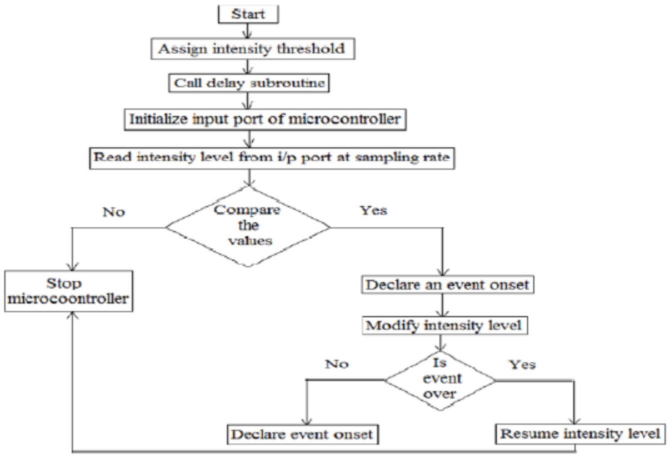

Figure 12: Working of a Microcontroller [5]

4.4 Advantages

- Accidents due to temporary blindness are avoided.
- Real time measurement monitoring.
- Reduces cabling cost.
- Can accommodate new devices at any time.

5. CONCLUSION

Wireless sensor network concept is very useful for automobile applications. Three applications are studied. First application was about car theft control, with the help of this system we can avoid car theft and also reduce the disadvantages of existing system which is used for car theft control. Second application discussed is related to automobile pollution control which will automate the existing pollution control system. Third application was Headlight Intensity Control with the help of wireless sensor network. By using this system, accidents that occurs due to temporary blindness gets reduced.

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