Performance Evaluation of Parking Guidance and Management System using Wireless Sensor Network

Vivekanand P. Thakare, N. A. Chavan

Abstract*— To deal with the parking guidance system issue related to the parking lots, this paper proposes a vision of improvements in parking guidance and information system based on wireless sensor network. This system consists of parking space monitoring nodes (senor nodes), parking status display unit (PSDU), Micro Control Unit (MCU) and Central Co-ordinator. The guiding nodes transmit the information of vehicle entrance through wireless sensor network. Micro Control Unit sends information to sensor nodes as well as PSDU which shows the parking status and also display the nearest parking lot. All the process can be monitored by the central co-ordinator. The preliminary test results show that the performance of this WSN based system can effectively satisfy the needs and requirements of the existing parking systems. Also it minimizes the time consumed for finding the free parking lot as well as nearest parking lot.

Keywords -Wireless Sensor Network (WSN), Parking Status Display Unit (PSDU), Micro Control unit (MCU), Advanced Virtual RISC (AVR).

I. INTRODUCTION

Nowadays, the parking issue is becoming more and more serious for the owner of the cars in most metro cities. The limited availability of parking results in traffic congestion, air pollution, gasoline and time wastage as well as driver frustration. Smart parking is a parking garage that utilizes various technologies to efficiently manage the garage. Lot of research and development is being done all over the world to implement better and smarter parking management mechanisms. Widespread use of wireless technologies along with the recent advances in wireless applications for parking, are very useful to solve emerging parking problems. Wireless Sensor Network (WSN) technologies has attracted & increased attention of the user and are rapidly growing due to their extensive application potential in various fields. This field is expected to provide an efficient and cost-effective solution to the efficient car parking problems and guide drivers to park the vehicle at the appropriate parking lot within a minimum time.

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We present smart parking assist system based on wireless sensor network. It is the parking technology that guides and provides information about availability of parking spaces located in parking lots and the nearest parking lot for the incoming vehicle. Therefore it becomes possible for parking guidance systems to track parking space occupancy and guide drivers to find empty parking spaces in large parking lots through wireless communication.

In this paper, we develop a smart parking assist system based on wireless sensor network to provide convenient parking services to drivers in large parking lots. The proposed scheme is characterized by employing MCU to manage the whole parking lot through wireless communication. The main contributions of this paper are as follows.

- First, the proposed scheme can support real time parking service to drivers in large parking lots. With real time parking service, drivers can quickly know the parking status at the entrance itself whether the parking space is available in the parking garage or not.
- Second, the proposed scheme provide friendly parking information services to the moving vehicles. With this friendly parking information, the MCU can provide information to the drivers regarding the parking lot nearest to the incoming vehicle just after the display of vacant parking spaces. Therefore gasoline and the time wasted in searching for the vacant parking space nearest to the vehicle can be effectively reduced.

The remainder of this paper is organized as follows. In Section II, we explain related work. In Section III, we introduce System Architecture. In Section IV, we present the System Model. Section V includes experimental setup, followed by Performance Evaluation through comparison of different sensors for parking requirement and different parking methods with test cases in Section VI. Finally we draw conclusion in Section VII.

II. RELATED WORK

Many approaches were proposed in the past to improve the parking guidance mechanism in order to save most of the time of the driver for seeing the parking space and also headache of drive the car inside the parking lot and see the parking space.

PGI is a parking technology [10] that guides and provides

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information about the availability of parking spaces located in major cities. Vehicle detectors are installed at entrances, exits and/or individual parking space to collect and calculate the number of occupied and available spaces. Common detectors include loop detectors, machine vision, ultrasonic, infrared, microwave and lasers. Information, ranged from ”empty” or ”full” lot, to the number of availability, or to the exact location of available spaces, are displayed at various spots so that drivers can make better decision.

Vehicle detection sub-system (VDS) and management sub-system (VMS) [5] is based on wireless sensor network (WSN). The VDS sub-system is used to detect the occupancy of a parking lot and report the result to the management sub-system. The management subsystem processes the gathered information and provides the information to the drivers. To evaluate the system, the WSN based VDS is implemented and experimented on the system with various kinds of cars.

A smart car parking management system [9] is proposed to compare sensor data gathered from different varieties of Acoustic, light and Magnetic sensors to detect whether a car park bay is vacant or occupied in a given time. The main focus of the work is to utilize WSN to monitor a large area of wireless network. A WSN distributed over a large area is expected to gather information by different types of sensor nodes. This system is designed to gather parameters from all active sensors of different types. A central server then compares and analyzes these parameters recorded in different environment conditions to detect whether a car park bay is vacant or occupied in a given time.

A WSN based Visual Display Systems is implemented [11] to inform drivers about the available parking space. The authors have evaluated the performance of this Parking Guidance System (PGS) with several kinds of cars and demonstrated the feasibility of battery-powered T-Sensor node with simulation analysis using real measured current profile. This PGS architecture supports self-healing when a routing problem occurs.

The PGIS discussed in [1], there are three kinds of nodes, which are monitoring nodes, routing nodes and sink node. The monitoring nodes would detect the status of every parking space, and transmit the information through routing nodes hop by hop to the sink node. The sink node connects to the information and management center through RS-232 interface. After processing the data, the information and management center will send the message to all the nodes and update the information in LED screen at the entrance of the parking lot. So this PGIS can help the drivers to park their cars quickly and safely.

Based on the above classification of smart parking systems, a parking garage may employ one or a combination of above systems to best serve their customers. The system determines the occupancy of a given area and display space-availability information to customers via dynamic message signs located throughout the garage.

III. System Architecture

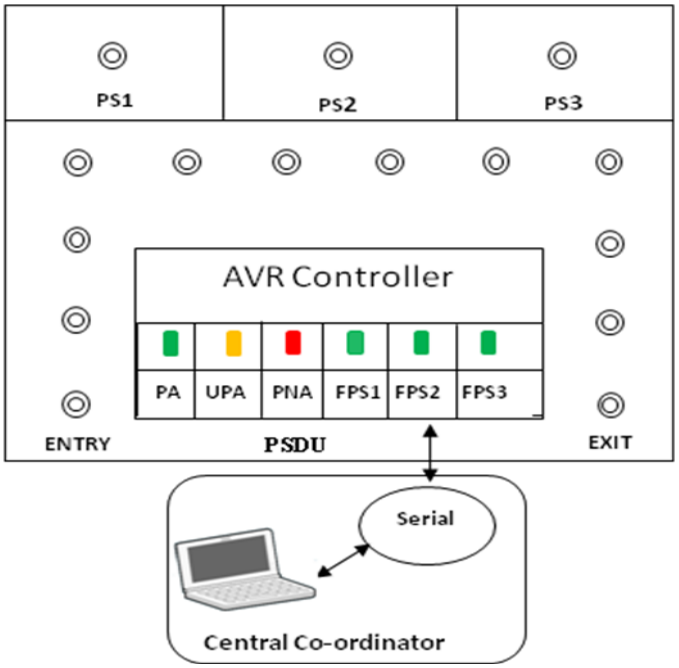

Fig. 1 System Architecture

The proposed system architecture is as shown in figure 1. It consists of IR Sensor Nodes, Micro Control Unit (MCU), and Parking Status Display Unit (PSDU). This system architecture is connected to the Central Co-ordinator using serial interface.

A. IR Sensor Nodes

IR Sensor Nodes forms a Wireless Sensor Network and communicate with each other using IR transmitter and Receiver. IR sensors are the motion detectors which detects the motion of the vehicle and also the presence of the vehicle at the parking slot. Whenever any vehicle comes at the entrance of the parking area that vehicle is detected by the IR Sensor and sends the information to the AVR Controller.

- *Design of IR Sensor Module:-*

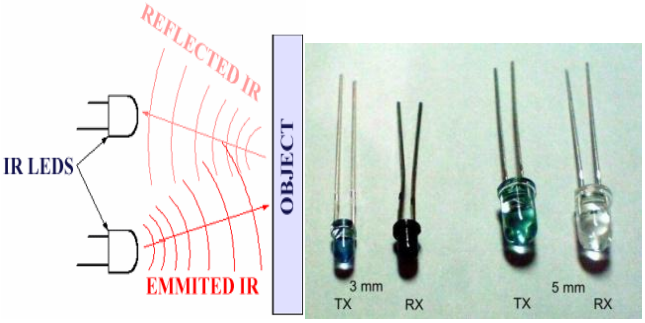

Fig.2(a) Fig.2(b)
Fig.2(a) Object Detection by IR Sensor
Fig.2(b) Actual Photograph of IR Sensors

To know the status of the parking lots properly, every parking space must be detected effectively by the IR sensors located in every parking lot as well as in the parking area. In order to achieve this, a right sensor is used for wireless communication. The detail comparison of various sensors used for parking systems, are discussed in section IV. Through this detail comparison, we decide to use IR Sensor. The schematic design of detection of object using IR Sensor

is shows in the Figure 2(a). The actual photograph of IR Sensor is also shown in figure 2(b).

B. Parking Status Display Unit (PSDU)

Parking Status Display Unit consists of six different LEDs which shows the different status of the Parking by glowing the respective LED. These LEDs are as shown in figure 3.

- *PA (Parking Allowed):* – This LED shows the parking availability in the Parking area. If any of the Parking lot is empty, this LED glows and Parking is allowed to the vehicle.

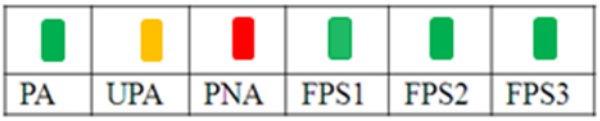

Fig. 3 Parking Status Display Unit

- *UPA (UnParking Allowed):* - Whenever unparking is possible, this LED glows. It means that any vehicle can be unparked if no new vehicle is parking or entering into the parking area. If vehicle is entering into the Parking area then the signal is send by IR Sensor to the AVR Controller. AVR Controller sends information to the IR Sensors located at the parking slots so that no vehicle can be unparked during the parking of other vehicle and hence collision is avoided between two vehicles.
- *PNA (Parking Not Allowed):* - Whenever all the parking slots are full with the vehicles then this LED glows which shows that Parking is not allowed.
- *FPS1(Free Parking Slot 1):* - If Parking lot No. 1 is free, then this LED glows to show that Parking lot No. 1 is free and Parking can be possible at lot No. 1.
- *FPS2 (Free Parking Slot 2):* - If Parking lot No. 2 is free, then this LED glows to show that Parking lot No. 2 is free and Parking can be possible at lot No. 2.
- *FPS3 (Free Parking Slot 3):* - If Parking lot No. 3 is free, then this LED glows to show that Parking lot No. 3 is free and Parking can be possible at lot No. 3.

C. AVR Controller (MCU)

Advanced Virtual RISC Controller is the main control unit of the Smart Parking Assist System. It Controls all the IR Sensor Nodes, Parking Status Display Unit (PSDU) and the whole system. It receives the signal from the IR Sensors and also sends the information to them in order to manage the parking System.

Fig. 4 AVR Controller kit

The Microcontroller we selected is ATmega32 as shown in figure 4. It is 8 bit MCU working with low power supply voltage range 2.7V to 5.5V. It consists of advanced RISC architecture with 32 KB self-programming flash program memory, 2KB SRAM, 1KB EEPROM, 32 bit programmable I/O lines, with 16MHz max. operating frequency. The power consumption at 1MHz, is 3V. Active mode: 1.1mA, Idle mode: 0.35mA, and Power down mode: <1µA.

Whenever any vehicle arrives at the entrance of the Parking, MCU receives the signal from the IR Sensor nodes and shows the status of Parking at the PSDU. Also it communicates with the IR Sensors located at the Parking lots so that no vehicle can be unpark during the arrival of the new vehicle at the Parking area and collision of two vehicles can be avoided.

Unparking status can also be displayed by MCU so that if any vehicle is interested to unpark from the bay, can be easily unpark. It also shows Parking availability status by communicating with the IR Sensors so that if no space is available in the Parking slots then no entry should be given to the new coming vehicle.

D. Central Co-ordinator

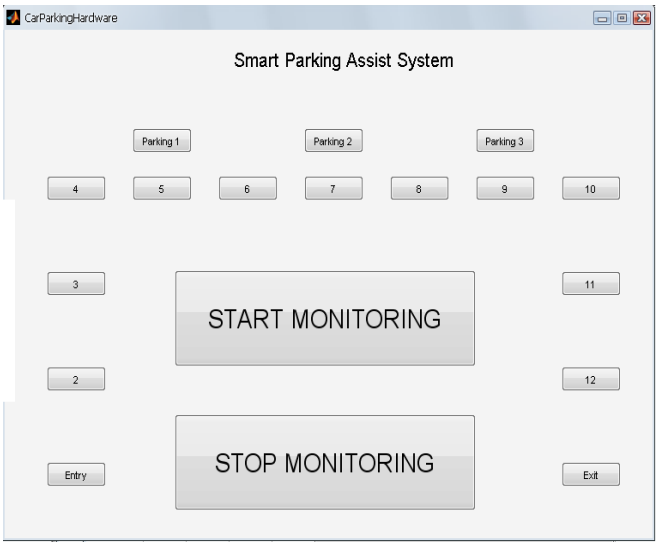

Fig. 5 Central Co-ordinator

The GUI as shown in figure 5 will be used by the System Administrator to control and manage the Smart Parking Assist System. A MATLAB 7.10 code is acts as a central co-ordinator and coordinates the whole parking System model. The Administrator can easily manage and control over the whole Parking System and also monitor the Parking Status of the system.

IV. SYSTEM MODEL

In order to implement the Smart Parking Assist System using wireless sensor network efficiently, we have to setup a System model to take some experimental test. This system model provide the parking guidance mechanism in order to reduce the time of the driver for searching the parking space and also headache to drive the car inside the parking area and search the nearest parking lot.

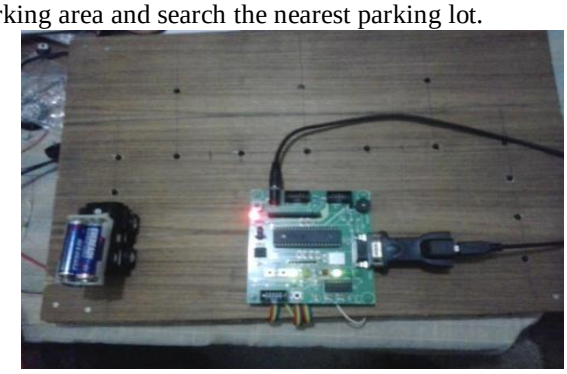

Fig. 6 System Model

The initial Smart Parking Assist System (SPAS) model includes 16 sensor nodes, 4 guiding nodes, 3 parking lots, Parking Status Display unit (PSDU), and MCU (AVR Controller) as shown in figure 6.

Initially, when the system starts functioning, all the sensor nodes form a network. These sensor nodes check the status of parking spaces and send the report to the MCU (AVR Controller). MCU transmits the status information to Parking Status Display Unit (PSDU). Simultaneously, the same report should also send by MCU to the central co-ordinator by the serial interface.

When a vehicle parks in a parking lot, the sensor node detects that the parking space is occupied and it sends a report message to the MCU. MCU turn off the respective LED to indicate that the respective lot is not free. It only glows those LEDs whose respective parking lots are free. Side by side it also shows the nearest parking lot for incoming vehicle by continuously glowing the LED of that respective lot.

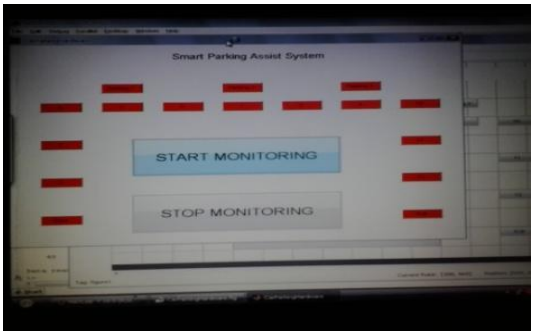

Fig. 7 Central Co-ordinator

The Central Co-ordinator, is running on the laptop or desktop whose GUI is shown in figure 7, is connected to the system model by serial interface and act as a system administrator. It continuously monitors the parking area and shows the status of occupancy by displaying the green colour of the slot. Also Central co-ordinator shows real time approach of the vehicle inside the parking area, due to which the system administrator can also monitor the status of the parking at the same time.

V. EXPERIMENTAL SETUP

The SPAS model is developed as a proof of concept to meet the real time requirement of the parking guidance and management systems. We have carried out some preliminary experiments to evaluate the functionalities and features provided by our model. In our initial experiment we have modeled for 3 parking lots.

A. Parking Guidance:

- *Experiment 1:*

  Total Parking lots are free: When all the parking lots are free, the sensor nodes placed in the parking lots detect that there is no event generated and the message signal is send to the MCU. The MCU send this message to the Parking Status Display Unit (PSDU) which glows all the three LEDs as shown in figure 8.

Fig. 8 Total Parking lots are free

- *Experiment 2:*

  Two vehicles are parked: In this scenario we experimented by parking two vehicles in the parking lots. The sensor nodes detected the event and transmitted the report to the MCU. MCU can forward the same message to the Central Co-ordinator as well as to the PSDU. PSDU can show the status of available free parking lots as shown in figure 9. Consequently the central co-ordinator also shows the status of the parking.

Fig. 9 Two Vehicles are parked

- *Experiment 3:*

Total Parking lots are Full: When all the parking lots are full, the sensor nodes placed in the parking lots detect that there is no space available in the parking area for parking the vehicle. The Parking Status Display Unit (PSDU) shows that all the parking lots are full by glowing the PNA LEDs in RED colour as shown in figure 10. Similarly the same status can be seen at the central co-ordinator also.

Fig. 10 Total Parking lots are full

B. *Parking Management:*

- *Reduces Parking Time:*

During all the above mentioned Experiments, our SPAS model guides the driver to find the nearest parking lot to the incoming vehicle, so that in a minimum time the respective vehicle can be parked in the nearest parking lot. Due to this, it reduces most of the time of the drivers for searching the parking lot as well as the gasoline wastage.

- *Avoid Collision:*

Unparking possibilities are shown by the MCU on PSDU by glowing yellow LED. Whenever such situation occurs so that unparking can give rise to collision, the yellow LED can be OFF by the MCU and no vehicles are allowed to unpark. This can considerably avoid the collision.

VI. PERFORMANCE EVALUATION

A Smart Parking Assist system is designed for real time application to provide efficient parking guidance and management to save most of the time of the driver to search the parking spaces. The performance of Smart Parking Assist System can be identified by comparing various parameters related with various sensors used in parking system as well as various parking methods implemented up till now for parking guidance and management. The experiments taken above can also useful to map the performance of our system. The performance evaluation is given in the test case shown in table III.

A. Comparison of Different Sensors used for Car Parking System:

Table I: different sensors used for car Parking system.

Sensor used	Detection of parking spaces	Circuit	cost	Disad vantages	Advantage
IR Sensor	Accurate	Simple	Very low	Reflection can be affected by colour of the car.	Range can be changed depending on ambient light intensity. 2. Easy to design low range as well as high range sensor.
Magnetic Sensor	False Detection may occur	Highly Sensitive	Low	Continuous operation would drain more than 1.5 mA at 3V.	Sensors based on magneto-resistors are suitable for vehicle detection.
Light Sensor	Accurate	Simple	Expensive	1.Two nearby sensors can cause interfern ce. 2. more light to operate.	Able to distinguish modulated light from ambient light.
Optical Sensor	Accurate	Complex	Expensive	It cannot detect pedestrians or object from vehicles of interest, therefore acknowledge false detection	Easy installation & maintenance.
Image Sensors	More Accurate	Complex	More Expensive	1.More Expensive 2. complex circuit	More accurate to detect the object.

C. Comparison of Different Methods used for Car Parking System:

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Table II: different methods of car Parking system

Parking Methods	Possibility to detect different types of object	Type of sensor used	Use of central Server
Vehicle counting System[8]	Yes	Optical Sensors	Yes
Car parking management System[9]	Yes	Light Sensors, Acoustic Sensors & Magnetic Sensors	Yes
VDS[11]	No	Magnetic Sensor	No
PGI[10]	Yes	Loop Detectors	No
PGS[5]	Yes	T-Sensor, T-sink, T-BS	Yes
PGIS[1]	Yes	Ultrasonic Sensors	Yes
SPAS	Yes	IR Sensors	No

D.*Test case:*

Table III: Test cases of the system model

SN	Test items in scenario	Test Result
1	Can MCU get sensor signals properly from Sensor nodes?	Yes
2	Can every parking spaces are detected by IR sensors effectively?	Yes
3	Can IR Sensors properly detect the vehicle?	Yes
4	Does PSDU provide proper parking status according to the availability of parking lots?	Yes
5	Can No. of available parking spaces are updated on real time by MCU on PSDU?	Yes
6	Did MCU transmit real time information to the Central Co-ordinator?	Yes
7	Can Central Co-ordinator monitors and updates the position of vehicle according to actual parking?	Yes
8	Did the system calculate the nearest distance correctly from the location of the vehicle?	Yes
9	Did the system trace the moving vehicle if it parked on the lot which is not nearest to it?	Yes
10	Is the system feasible to avoid collision between two vehicles?	Yes
11	Does this system provide parking status within minimum time?	Yes
12	Can we implement this system on current parking systems without more changes?	Yes

From the Experimental Preliminary Tests, comparisons and test cases shown above, it is clear that SPAS model using IR Sensors are reliable, low cost, and easy to detect any type of vehicle and having simple circuit. Also it satisfies the requirement of the current parking systems. Smart Parking Assist System (SPAS) provides efficient solution for searching the free space in the parking area as well as it also provides the parking lot of nearest distance for the incoming vehicle. This can considerably reduces the searching time for free space and also reduces the fuel consumption. Therefore it is suitable for the current parking monitoring, guidance and management systems.

Conclusion

This paper introduces Smart Parking Assist System (SPAS) based on wireless sensor network. We developed SPAS system Architecture with Sensor nodes for car parking system and MCU to guide and management of the parking area. Smart parking assist systems employ advanced technologies to permit efficient use of parking lots. Smart parking ranges from simple systems that show the number of available spaces to complex ones that can guide drivers to a free parking lot nearest to the incoming vehicle. The Central co-ordinator can monitors the step by step approach of parking scenario.

The evaluation results shows that the SPAS system we developed can satisfy the application, also there is no need to make changes in the existing parking system during implementation. Therefore it achieves greater significance.

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AUTHOR PROFILE

Mr. Vivekanand P. Thakare, has received his BE degree from KITS Ramtek in 2001. Currently he is pursuing his ME degree in Wirelss Communication and Computing from GHRCE, Nagpur. This research paper is related with the project work of ME. He has total teaching experience of 7 Yrs. He is a member of CSI. He has following publications.

Journal Publications:

Presented a technical paper on "**A Comparative Study of different Smart parking Assist Systems using wireless sensor networks**", in International Journal of Smart Sensors and Adhoc networks (IJSSAN) ISSN No. 2248-9738 Volume-1, issue-4, 2012

International Conference Publications:

1. Presented a technical paper on "**A Comparative Study of different Smart parking Assist Systems using wireless sensor networks**", in International Conference of Computer Science and Engineering (ICCSE-2012), organised by IRNet at Nagpur on 3rd Feb, 2012.

2. Presented a technical paper on "**Pervasive Computing (A Security issue For Sensitive Adaptive and Responsive Digital Environment)**", in The International Conference on Advances in Communication, Embedded system and Computing (ICACEC2011) was sponsored and organized by Sagar Institute of research and Technology, Bhopal and held at Bhopal, Madhya Pradesh, India during January 14-15, 2011.

Attended International Conference:

Attended 2nd International Conference on Emerging Trends in Engineering and Technology (ICETET-09) held at G. H. Raisoni College of engg. Nagpur, India, on 16-18 Dec, 2009.

National Conference:

1. Presented a technical paper on "Bluetooth Technology" in Annual technical paper meet held at Institute of Engineers, Nagpur on 27th Oct, 2007.
2.Presented a technical paper on "Performance Analysis of flooding Attack prevention Algorithm in MANET", in ARTCON-2010 held at Annasaheb Dange College of Engineering & Technology ASHTA on 15th -16th Jan, 2010.
3. Presented a technical paper on "Prevention of unauthorized updation in web database", in emerging trends in electronics engineering and computing (E^3C-2010) held at J. D. College of Engineering, Nagpur on 9th -10th Feb, 2010.
4.Presented a technical paper on "Pervaisve Computing", in national Conference on Recent Trends in Engineering & Technology (SAPNDAN - 2010) held at Yashwantrao Chavhan College of Engineering, Nagpur held on 25th – 26th Feb, 2010.
5. Presented a technical paper on "Computer Networking using IPV6 – made easy", in a national level tecfest Wheelspin – 11 organized by Bapurao Deshmukh College of Engg. Sevagam, Wardha, held on 25th Jan, 2011.
6.Presented a technical paper on "An efficient Power Saving protocol for internet traffic in wireless LAN", in ASCENT-2011 held at BCYR's Umrer College of Engineering, umrer held on 25th Feb, 2011.

Attended STTP:-

2. Attended a one week STTP on "Emerging Trends in wireless communication & Networks", organized by BCYRC's Umrer College of Engineering, Umrer on 23rd – 28th March, 2009.

Attended Workshop:-

1. Attended a two days workshop on "Recent trends of MATLAB software in engg. & Technology" held at Gurunanak Institute of Engg. & Tech. Nagpur on 26th-27th Nov, 2009.
2. Attended a 5 Days workshop on "Highly intellectual teaching skills (mission 10X)", organized by Wipro Technology at KDK College of Engineering, Nagpur during 27th Sep. to 1st Oct, 2010.

Asst. Prof. Ms Nekita A Chavhan, has received BE degree from KDK College of engineering in 2005,And ME Degree in Wireless Communication and computing From GHRCE, Nagpur in 2008. Her Total Teaching experience is 5 years and Research is 3 years in the field of wireless Communication, Adhoc and sensor Network, Mobile Computing. She is a member of IEEE And CSI. She has following publications.

Journal Publications:

1) Presented technical paper on **"Everything Connected To Everything** in International Journal on Computer Engg and Information Technology**.(IJCEIT) ISSN-0974-2034,**SERC ,Durg in 2009.

International Conference Publications

1) Presented technical paper on **"Security Patterns for VoIP** in International Conference,**WECON** held at Chitkara Institute of Engg., Rajpura ,Punjab on 18th & 19th October 2008.
2) Presented technical paper on **"Multiple Design Pattern For VoIP Security"** in ***International Conference, ICAC3-2009*** held on 23-24 January-2009 in FCR College of Engg. and Technology , Mumbai.

National Conference

1)Presented technical paper on **"Mobile Computing** in ASCENT-2007, National Level Technical Paper Contest & Seminar organized by Umred College of Engg. and Technology, Umred on 23-24th Feb 2007.

Worked as Reviewer:

1. Reviewed papers for ICETET 10 , GHRCE, Nagpur
2. Reviewed papers for NCIPET 12 , SB Jain College of Engg., Nagpur

Attended FD:

- Attended and successfully completed Training program on Wireless Networks under CEP-CDEEP , conducted by IIT Bombay and attended at DEP-VNIT, Nagpur form 11th to 12th December 2006.
- Attended and successfully completed DTE sponsored Short Term Training Program (STTP) on **"Pedagogical Training in Engg Education"** organized by GP, Nagpur from 5th March to 7th March 2009.
- Attended and successfully completed Short Term Training Program (STTP) on **"Certificate course on VoIP Technology"** organized by VNIT, Nagpur from 15th January to 29th January 2008.
- Attended and successfully completed Short Term Training Program (STTP) on **"Seminar On RF IC Design and Testing"** organized by VNIT, Nagpur from 12th January to 13th January 2008.
- Attended and successfully completed ISTE & AICTE sponsored Short Term Training Program (STTP) on **"Wireless And Mobile Communications"** organized by Priyadarshini College of Engg. and Arch. Nagpur from 7th September to 17th September 2009.
- Workshop on "foss adoption in education "C-DAC kharghar ,Mumbai 27th july2011
- Workshop on CIII Mission Innovation Pune 15 - 20 august 2011.
- Workshop "cyber security"maximess april 2011
- Attended program "Workshop on soft computing" from 13-14 Jan 2009 and "Workshop on Data Mining" from 16-17 Jan 2009 at GHRCE, Nagpur.