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Internet of Things Based Coal Mine Safety Monitoring System

T. Thilagavathi[1], Dr. L. Arockiam[2]

Research Scholar, Department of Computer Science, St. Joseph's College (Autonomous),

Tiruchirappalli, Tamil Nadu, India[1]

Associate Professor, Department of Computer Science, St. Joseph's College (Autonomous),

Tiruchirappalli, Tamil Nadu, India[2]

Abstract: The safety of miners in the mining environment is a major challenge. A miner's health and life are exposed to many critical issues. Underground mining requires continuous monitoring of every parameter like methane gas, high temperature, fire accidents monitored. Disasters in coal mines are due to the complexity of the mining environment and the various tasks carried out in coal mines. So, it is very important to monitor the working environment of coal mines. Coal mine monitoring systems are wired network systems that play an important role in the safe production of coal mines. Due to the continuous expansion and deepening of the exploitation areas of coal mines, many paths are turning into blind areas, which have a lot of hidden dangers. To overcome this problem, advanced mechanisms have been proposed in a coal mine safety monitoring system that can improve the monitoring level of production safety and reduce accidents in coal mines.

Keywords: Gas sensor, MEMS sensor, LDR sensor, Buzzer

I. INTRODUCTION

Coal is India's most important commercial energy resource. And it is the third-largest coal-producing country in the world. Coal contributes over 70% of electricity generation. Every worker is designated to fulfil a certain role in the mine's functioning and is equipped with the appropriate infrastructure. In this sector, several workers are losing their lives during the hazards. This risk factor is occurred due to the usage of existing monitoring system and less safety measures in the environment. Recently, several research works are carried out to improve the monitoring system and the safety measures of the workers in the underground coal mine.

II. PROBLEM DEFINITION

Workers in mining areas face many risk factors. However, accidents are happening in mines due to increasing landslides, gas leakage, low power supply, etc. To protect workers in the mining environment there is a need for developing an automated wireless monitoring system to safeguard the workers from the hazards in the different types of mining environments.

III. SYSTEM REQUIREMENTS

These are the requirements are needed to implement this paper. The following tables shows the needed requirements.

Table 1: Hardware Requirements

Name	Raspberry Pi 3 B+
Processor	BCM2837
RAM	1GB in-Built
System type	64-bit Operating system
Sensors	MEMS, GAS, LDR

Table 2 : Software Requirements

Operating System	Raspbian Stretch
Language	Python
IDE	Python IDEL 3

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IV. LITERATURE REVIEW

Molaei et. al.,[1] Reviewed the adaptability of the mining industry to IoT systems and its current development and investigated the significant challenges in the mining industry and provided recommendations to build an efficient model suitable for various mining sections such as exploration, operation and safety by deploying recent technologies such as IoT and Wireless Sensor Networks

Arif hussain et.al.,[2] Proposed ZigBee based wireless sensor network (WSN) for communication between sensors and coal mine safety monitoring system. The I Beacons were proposed for identification of miners. A service-oriented architecture (SOA) was employed to develop the system. The proposed system predicted the methane with the help of artificial neural network (ANN) technology. The proposed system was compared with other advanced systems. It was found that the proposed system outperformed all the other systems taken for comparative analysis.

Sathishkumar et.al.,[3] Proposed a uniform message space and data distribution model and implemented a lightweight services mashup method. By deploying Visualization Technology, the graphical user interface of different underground physical sensor devices was created. In addition to that, four types of coal mine safety monitoring and control automation scenarios were illustrated, and the performance was measured and analyzed. It was proved that the lightweight mashup middleware significantly reduced the costs and controlled the automation applications effectively.

Dheeraj et.al.,[4] Proposed framework that values of all the parameters that are monitored are stored and visualized in the cloud and those can be controlled using phone so that safety of the coal mine workers was maintained. The digital transformation is emerging as a driving force to revolutionize the world around us. Digitalization will play the mining industry too where connectivity plays a gigantic role. The idea is to embed more and more with electronic sensors, and software to allow things to communicate and exchange data with each other possibly but not necessarily with internet.

G. Saranya et al.,[5] Proposed a design of a wireless sensor network (WSN) with the help of ARM controller and able to monitor the temperature, humidity, gas, vibration and status of smoke in an underground mine. The system also controls the ventilation demand to mine workers depending upon present climate conditions within the mine field. The system was used low power, cost-effective ARM, DHT11 sensor, smoke detector, gas sensor for sensing the mine climate parameters and Wi-Fi for remote logging of data at central location to control the climate state with the help of motor. Traditional coal mine monitoring systems using wired network systems, plays an important role in coal mine safe production. The problems with the wireless sensor network-based coal mine safety monitoring system are improved to the point of monitoring production safety and lowering accidents in the coal mines.

Dong et al.,[6] Proposed a coal Mine safety Monitoring framework dependent on Zigbee and GPRS remote transmission was established. With GPRS innovation, remote information transmission was accomplished and informed through the short message sent to his cell phone, which adds to the early ID of genuine mishaps and continuous treatment, subsequently expanding the security of coal mining.

V. MOTIVATION AND OBJECTIVES

Mining companies are working with monitoring systems to study various changes occurring in underground mining. This system is inadequate for current environmental changes. Today, many researchers are developing various safety mechanisms to save the life of the miner. However, an improved mechanism is needed to monitor the safety of underground mining and protect human lives in case of hazards.

The main objective of the paper is to develop an advanced mechanism using IoT to monitor changes in the mining environment. The following sub-objectives are designed to achieve the objective.

- To detect and prevent the occurrence of hazardous events earlier
- To develop an automated monitoring system for ensuring coal mine safety decision-making system.

VI. PROPOSED METHODOLOGY

In this proposed method the coal mine monitoring system is classified in two different ways which are depicted in Fig .1. Firstly, it detects hazards with minimum threshold values of gas, light, temperature, and seismicity and sends the details to higher authorities.

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A decision will be taken based on the measures and the severity of the situation and will be sent to the workers for their safety. Secondly, an automated mechanism will handle all hazardous situations and safeguard the worker life in a very critical situation. With this mechanism, decisions will be taken quickly and accurately without any human intervention.

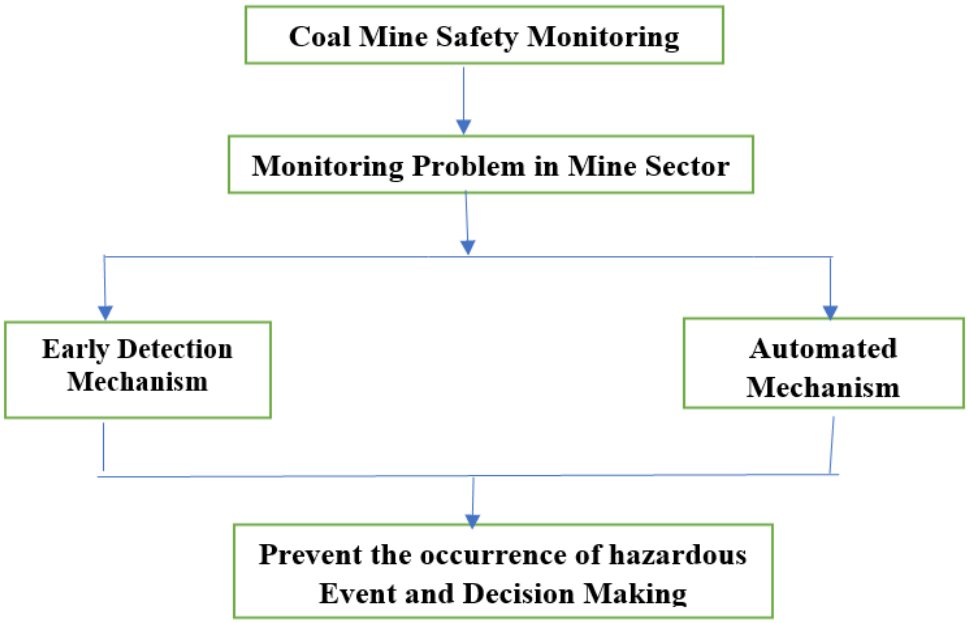

Fig:1 Proposed Methodology

6.1 Early Detection Mechanism

Four sensors namely gas, light, land vibration, and temperature are used to measure the underground mining environment. The gas sensor has 420 as the minimum and 450 as the maximum threshold. The mems (land vibration) sensor has 400 as the minimum and 450 as the maximum threshold. The light sensor will have 800 as the minimum and 850 as the maximum threshold. When any one of the sensors reaches or exceeds the minimum threshold value in the underground mine it sends the precautions alert to higher officials. Based on the sensor data and the current situation, decision will be taken under the decision-making mechanism following fig. 2 depicts the process.

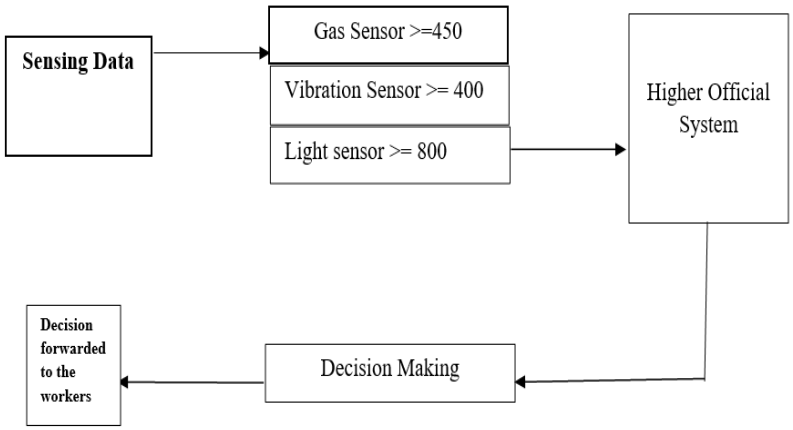

Fig 2. Early Detection Mechanism

VII. SYSTEM IMPLEMENTATION

The system is developed to detect and prevent the occurrence of hazardous events in the mining area. Some of the sensors are used to monitor the mining area.

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7.1 Raspberry pi 3 B+

The first step is downloading the latest operating system from official website. Then inserting the SD card into card reader and connect it to laptop and format it using SD card formatter software. Write Operating system to SD card. Once the SD card is ready, insert it into your Raspberry Pi then connect the Raspberry Pi to power. Once it is completed, the green LED will blink rapidly in a steady pattern. Disconnect the device from power.

Here raspberry pi pin referenced in two different ways.

1. BCM mode (GPIO pins) for physical pin 3 '3' is board number and '2' is GPIO number.
2. BOARD mode (Physical pins) for physical pin 23 '23' is board number and '11' is GPIO number. The Fig.3 show the representation of Raspberry pi board

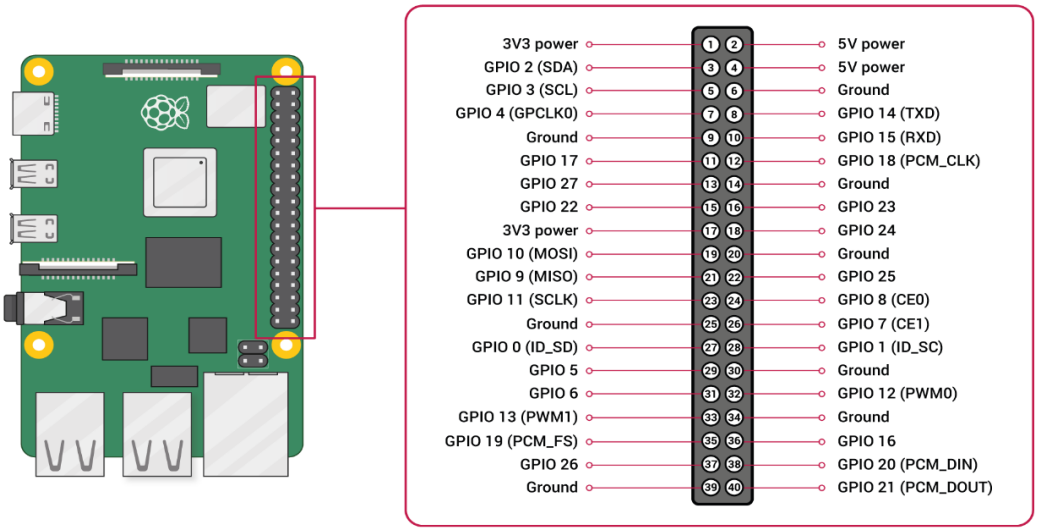

Fig.3 Raspberry pi Board pinout

7.2 Gas Sensor

The sensor is used to detect the presence of hazardous gases in coal mines. The MQ-2 sensor is triggered when there is a high presence of Tin oxide (SnO2) in the air. Gas sensing is essential within the mining industry because ventilation with fresh air from the surface is used to dilute the methane concentration and reduce the risk of explosion
Methane level in the stale air will be monitored continuously and if it exceeds a certain threshold, then the exhaust fan will be automatically switched on to reduce the intensity of the Methane gas and alert message will be immediately sent to the higher authorities.

7.3 MEMS SENSOR

The MEMS sensors can detect changes in vibration on the x, y and z axis. This spatial perception simplifies mine condition monitoring. The acceleration signal plays an important role in mine condition monitoring. It is an indicator of various symptoms, such as unbalance physical structures or crashes that may lead to mine collapse. The **MEMS Sensor** detects vibration or landslides in the mining area and alerts the miners by actuating alarm.

7.4 LDR SENSOR

The LDR sensor is a resistor whose resistance varies depending upon the amount of light falling on its surface. When the light falls on the resistor, then the resistance changes. These resistors are often used in many circuits where it is required to sense the presence of light. These resistors have a variety of functions and resistance. When the LDR is in darkness, then it can be used to turn ON a light or to turn OFF a light when it is in the light. Hence the LDR sensor automatically controls the light using the relay switch to keep the miners aware of the light level; prevent accidents and inform the higher authorities concerned.

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7.5 Buzzer

Buzzer is a kind of voice device that converts audio model into sound signal. It is mainly used **to prompt or alarm.** Based on the various designs, it can generate different sounds like alarm, music, bell & siren. In the mine area any gas leakage, landslides, accident occurs the buzzer will actuate and alert the mining workers.

The system involves number of sensor and other hardware components. Implementing the system on a broad level will require lot of technical and financial investment.

The IoT based Coal mine safety system used in given in the fig.4

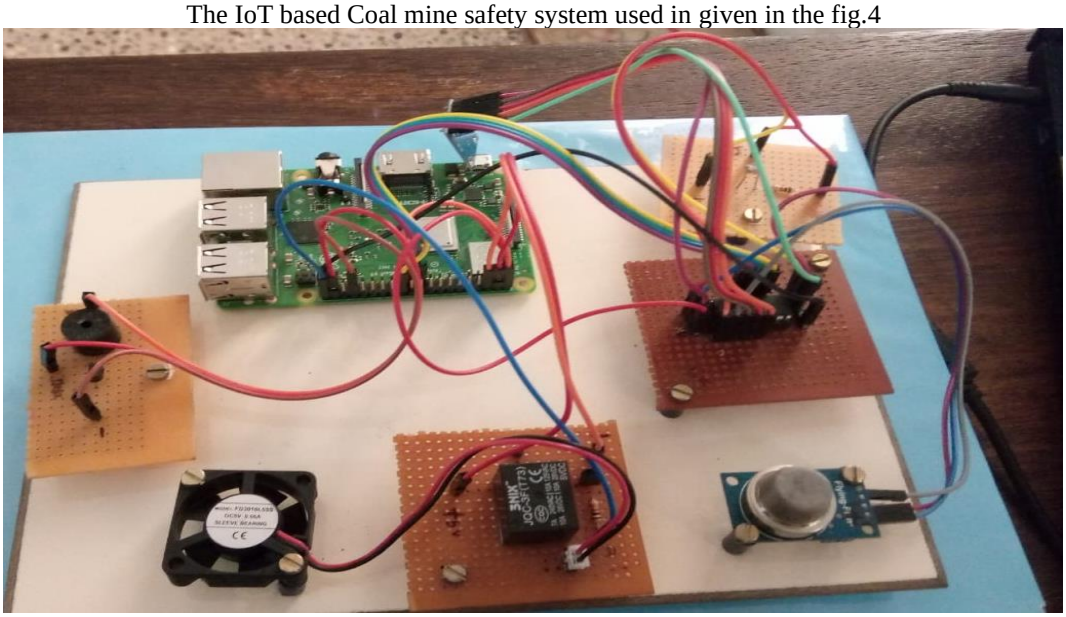

Fig 4. Hardware part of Coal mine safety system design

VIII. RESULTS AND DISCUSSION

The login page of coal mine, the output results shown in figure 5 .

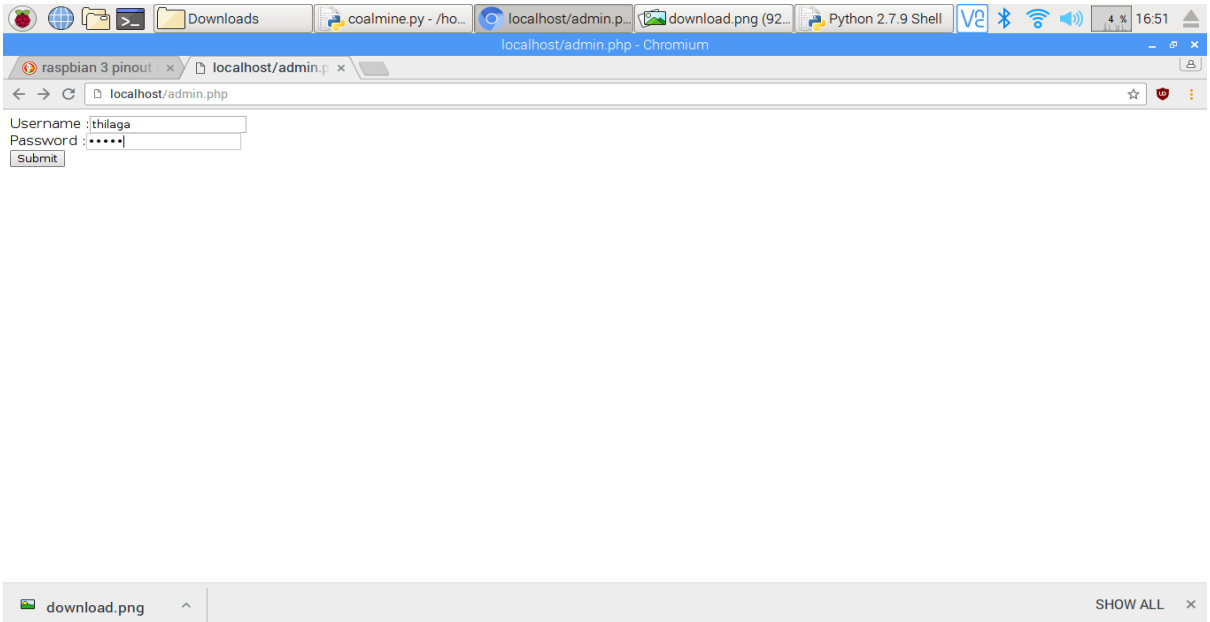

Fig 5. User name and Password Enter

The sensors are used to detect or measure the coal mine area. According to the gas level, MEMS level, LDR level, the output of the graph will be varied. The output of result is shown in figure.

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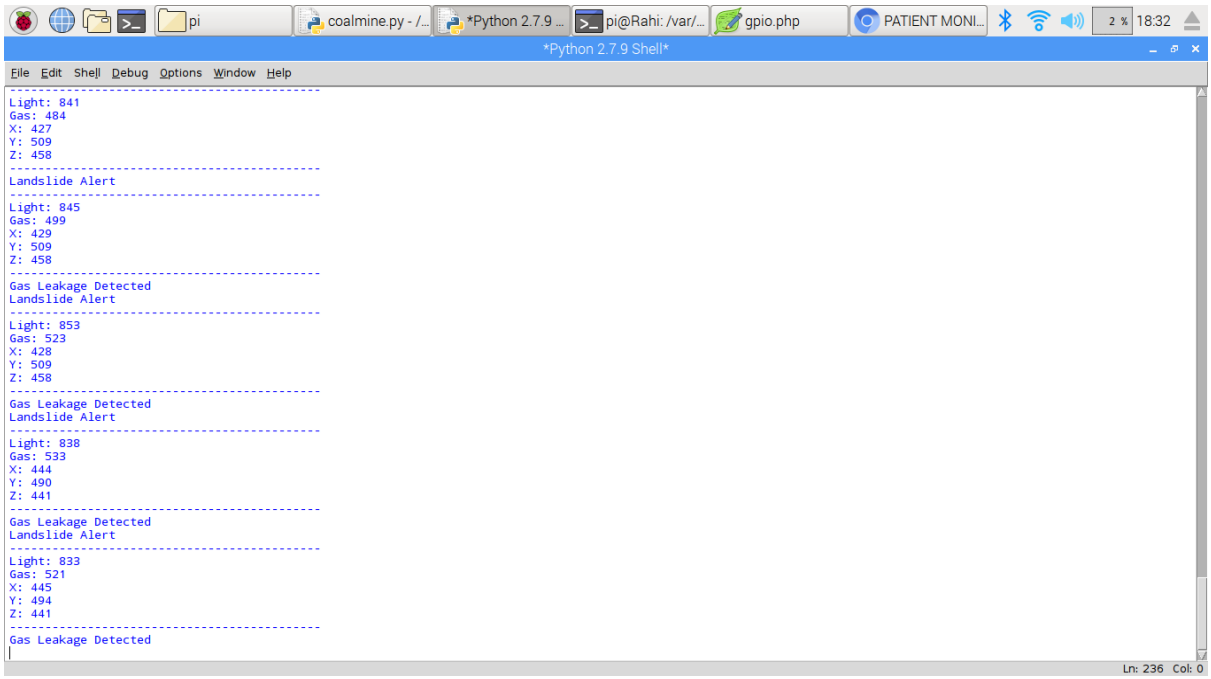

Fig 6. Measure the sensors level

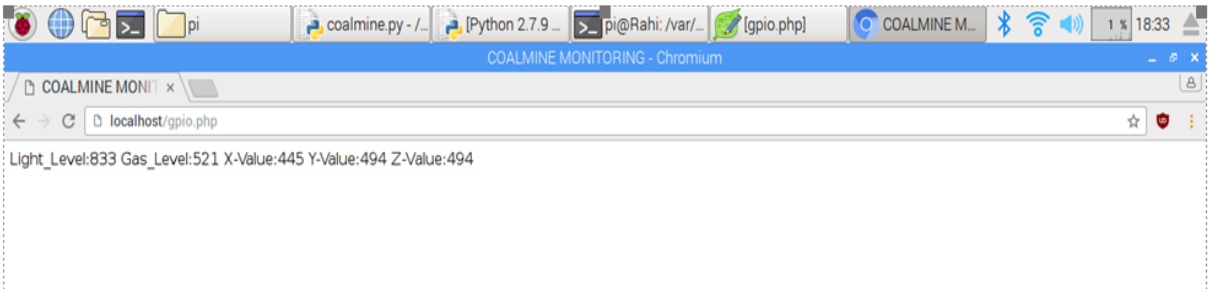

Fig 7. The output of Sensor value

IX. CONCLUSION

The Coal Mine Safety Monitoring System is developed to provide a clear and point-to-point perspective of the underground mine. It is an effective monitoring system that helps coal mining companies maintain safety in their mines and prevent hazards at an early stage. In this, the system collects and displays various sensor activities. Using these measures, the system automatically makes a decision, triggers an alarm when sensor values cross the minimum threshold level. This will help all the miners inside the mine to save their lives before any hazards occur.

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BIOGRAPHY

The author Ms. **T. Thilagavathi** MCA., M.Phil., (Ph.D), Research Scholar, Department of Computer Science, St. Joseph’s College(Autonomous), Tiruchirappalli, Tamil nadu, India. The author published one paper and also published one Indian patent. She has presented and published in national conference and received best presented award.

Dr.L. Arockiam is an associate professor in Computer Science and Head i/c of data science. St. Joseph’s College (Autonomous), Tiruchirappalli. He has done his Ph.D in St. Joseph’s college (Autonomous). He has 34 years of teaching experience and 23 years of research experience. He has published more than 350 research papers in the reputed international journals. His areas of specialization include cloud computing, Internet of Things, Mobile Cloud computing, Big Data Analytics, Data Mining, Web services, Psychology of Programming. He has guided 38 M. Phil Research Scholars and 34 Ph.D Scholars. He has successfully completed 6 projects that include 1 major project (DST) and 5 minor projects. He has filed three patents and received 12 awards. He has served as a resource person in more than 100 programmers. He has published 3 chapters and 4books.