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Risk Optimization in Industrial areas by using Smart Sensor Network with Internet of Things (IOT)

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ABSTRACT:

The concept of Internet of things (IoT) involves interaction of users with smart devices like mobile phones and tablets over the internet network and many applications depend on these objects on the daily basis. This will help the user to communicate with the smart objects, collect data from the surroundings and store it onto cloud database for further transactions. Such an IoT technology can be applied to various applications. One such application is Risk Optimization in Industrial areas by using Smart Sensor Network with Internet of Things (IoT) where industrial areas are risk optimized in cases like detection of fire, harmful gas leakages.

This application also helps in reducing power consumption by using Light Dependant Resistor (LDR). MQ-2 gas sensor and LM393 fire sensor module are used to detect gas leakages and fire respectively. All the sensor data information is processed and sent to the IoT gateway through the GSM module. After the sensor data is being received onto the cloud, it is sent to the designed webpage. ATmega 8 microcontroller is responsible for the data flow between the two entities i.e., smart sensors and the GSM module. This project not only helps in monitoring the industrial areas but also provides security to the data that is being transmitted and reduces power consumption.

Keywords:
Risk Optimization, Internet of Things (IoT), Smart Sensor Network.

Introduction:

The word ‘risk’ is often thought as a probability of loss or injury and is ubiquitous in all areas of life. As there is a continuous growth in having number of threats and vulnerabilities, a strategy for mitigating all risks equally becomes unsustainable. This paper mainly focuses on optimizing the risks with the help of Internet of Things (IoT). The concept of Risk Optimization can be viewed as a maximization of positive outcomes by minimizing the negative consequences from the expected return risk. Due to decades, internet grew as far as availability and connectivity of devices with different diversities. Today, these devices can serve as notebooks, personal computers and sensors. Together with this development also, a wide variety of applications arise i.e., starting from personal networks to a worldwide network and a low security applications to high security applications. Today, the community is speaking a lot on ‘Internet of Things (IoT)’. This can also be described as ‘Future Internet’ which can be foreseen as a worldwide network of interconnected objects that are uniquely addressable. Because of its unique addressability, the devices are enabled to join the network and help in co-operating efficiently to achieve different tasks.

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These conditions make wireless sensor network (WSN) to open new perspectives.

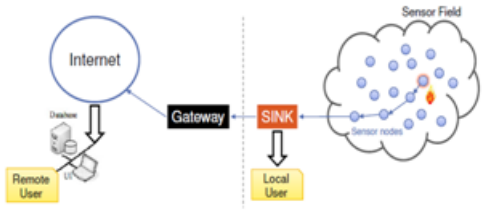

Fig 1: Overview of Wireless Sensor Network (WSN)

A simple wireless sensor network (WSN) can be defined as a network of devices or collection of nodes. To each node, a single sensor or multiple sensors can be connected. These nodes help in sensing the environment and communicating the gathered information from the monitored field through the wireless links. Here, the data is sent through multiple hops that are relayed to a sink node. The sink nodes can be used locally, or is connected to other networks (e.g., the Internet) through a gateway. These nodes can be stationary or moving. These smart sensor networks have been employed to collect data in various applications such as industry, science, transportation, civil aviation etc [1]-[3]. This paper focuses on smart sensor networks that are well suited for long term industrial environmental data acquisition for IoT representation [4]. Sensor data acquisition surface device is the key part of study on industrial WSN application [5].

However, different industrial WSNs involve a lot of complex and diverse sensors in IoT environments. At the same time, each sensor has its own requirements for readout and different users have their own applications that require different types of sensors [6]. It leads to the necessity of writing complex and cumbersome sensor driver code and data collection procedures for every sensor that are newly connected to interface device, which brings many challenges to the researches [7]–[9]. Thus a research methodology is adopted as follows: Section II presents the complete architecture of Internet of Things (IoT). Section III gives the overview i.e., basic block diagram for risk optimization in industrial areas.

Section IV covers briefly on designing of a webpage using PHP language. Section V presents experimental setup and it's results. section VI finally provides for conclusion.

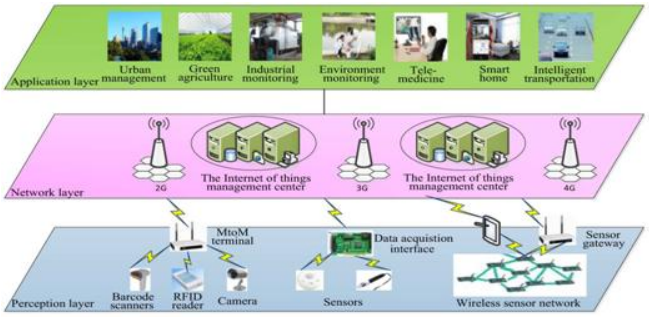

Fig 2: Architecture of Internet of Things (IoT)

ARCHITECTURE OF IoT

The term Internet of Things (IoT) can be considered as a technological revolution emphasizing on future of computing and communications. Today, it has become an emerging technology that it has grown to link all signs of intelligence around the world. IoT is going to be omnipresent for connecting things like sensors, actuators, and other smart technologies, and thus enabling for object-to-object and person-to-object communications. Sensors are the edge of electronic ecosystems in IoT. It also plays a vital role in bridging the gap between the physical world and the virtual one and because of this, it provides for rich array of data. Currently, the accessing of information from internet is done by inputting to keyboard.

But this scenario will be changed with the concept of internet of things i.e., we reached to an inflexion point where sensors originate internet data rather than giving inputs through keyboard. The IoT needs an open architecture to maximize interoperability among heterogeneous systems and distributed resources including providers and consumers of information and services, whether they be human beings, software, smart objects or devices. Architecture standards should consist of well-defined abstract data models, interfaces and protocols, together with concrete bindings to neutral technologies (such as XML, web services etc.) in order to support the widest possible variety of operating systems and programming languages.

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The architecture should have well-defined and granular layers, in order to foster a competitive marketplace of solutions, without locking any users into using a monolithic stack from a single solution provider. Like the Internet, the IoT architecture should be designed to be resilient to disruption of the physical network and should also anticipate that many of the nodes will be mobile, they may have intermittent connectivity and also they may use various communication protocols at different times to connect to the IoT. Most of the works relating to IoT architecture have been from the wireless sensor networks perspective [11]. European Union projects of SENSEI [12] and Internet of Things Architecture (IoT-A) [13] have been addressing the challenges particularly from the WSN perspective and have been very successful in defining the architecture for different applications. There are several application domains which will be impacted by the emerging Internet of Things. The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact [14].The architecture of IoT is illustrated in fig. 2. It consists of three layers.

1. Perception Layer
2. Network Layer and
3. Application Layer

Perception Layer

Perception layer in an IoT can be divided into perception components layer, perception network layer and perception co-ordination layer [10]. The perception component layer can be abstracted as sensing components and actuator components. Sensing components include RFID, barcodes, sensors etc and actuator components include valve switch, relay, etc. Sensing components and actuator components help in realizing signal acquisition and control functions. Network layer include various buses such as the controller area network (CAN) bus, the RS-485 bus etc. , or wireless network such as wireless sensor network (WSN), Bluetooth, Wi-Fi, etc.

It realizes communication connection between perception components, or between perception components and IoT gateway (coordinator). Perception coordination layer, the IoT gateway, is responsible for collecting data from sensing components, controlling actuator components to perform some action, coordinating each components to work orderly, and realize unity management for perception components. The real-time scheduling strategies of coordination layer can make perception layer more real-time and reliable.

Network Layer

The network layer is responsible for delivering the sensor data from source to destination across multiple links. IP is the network layer protocol of the internet. Because it provides unique IP address to its devices, the routing of data is done through the network. These devices carry IP packets from one device to another.

Application Layer

The application layer governs the data flow and is responsible for data formatting. The importance of this layer for the IoT is that it has the ability to provide high-quality smart services to meet customer's needs [15]. HTTP meaning Hyper Text Transfer Protocol was created to transfer web content over the internet. Internet of Things (IoT) application layer protocols are gaining popularity in a wide range of scenarios, where low-cost, low-power or resource constrained devices are present.

BLOCK DIAGRAM

The basic block diagram is shown in fig. 3. It consists of power supply, gas sensor, light dependant resistor (LDR), fire sensor, ATmega 8 microcontroller, GSM module, Webpage, relay and bulb. A simple 5V power supply is given to the ATmega 8 microcontroller. This microcontroller is responsible for providing data flow between two entities. These two entities are sensors and GSM module. Through this power supply unit voltage is supplied to all hardware components to work. The GSM module is provided with external 12V power supply from the same designed circuitry.

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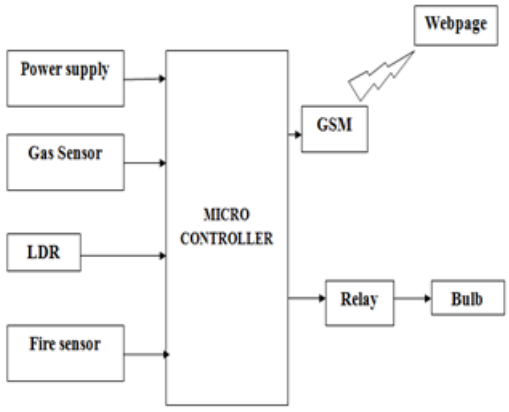

Fig. 3: Block Diagram for Industrial Risk Optimization

Power supply unit (PSU)

A power supply unit supplies an electrical energy to an output load or a group of loads. This electronic device is composed of transformer, rectifier, filter and a regulator. Transformer basically converts the input voltage to a higher or lower AC voltage. Rectifier converts the transformer output voltage to varying DC voltage which is later on passed through a filter to produce unregulated DC voltage and the regulator regulates the current flow.

GSM

GSM meaning Global System for Mobile Communications is a widely accepted standard in telecommunications. This digital cellular technology is basically used to transmit mobile voice and data services. The GSM module used for testing is SIM900_AT. This GSM modem can be easily interfaced with microcontroller, personal computer and provide easy or direct integration with RS232 applications. This modem can accept any GSM network which is operated by a SIM card and act like a mobile phone with its unique phone number. This modem provides for RS232 output and onboard switching type power supply by indicating the status of a modem with an LED (Light Emitting Diode).

Microcontroller

Microcontroller generally facilitates the operation of electromechanical systems found in everyday convenience items. It is nothing but a control device which helps in incorporating a microprocessor. For testing purpose, ATmega 8 microcontroller is used. It is a high performance, low per CMOS 8-bit single chip microcontroller created by Atmel in the mega AVR family with its advanced RISC architecture. This controller combines 1Kb EEPROM, 2kB SRAM, 23 general purpose I/O lines and also 32kB ISP flash memory with read while write capabilities. By executing powerful instructions in a single clock cycle, ATmega 8 achieves throughputs approaching 1MIPS per MHz, allowing the system designer to optimize power consumption.

Fire/Flame sensor

Sensor is basically a sensing device which first detects some type of inputs from environment and then responds to it as per the requirements. Fire/Flame sensor module is very sensitive to the flame and radiation. It can detect an ordinary source of light in the range of a wavelength 760nm-1100 nm. It also can detect and respond to presence of fire. It may respond to the detected fire/flame based on the installations in which alerts may include activation of a fire suppressing system, alarm sound etc. The detection distance is up to 100 cm. The Flame sensor can output digital or analog signal. It can be used as a flame alarm or in fire fighting robots. Small plate output interface and a single-chip can be directly connected to the microcomputer I/O port. The sensor and flame should keep a certain distance to avoid high temperature damage to the sensor. The shortest test distance is 80 cm. If the flame is bigger, it is mandatory to test it with farther distance. The detection angle is 60 degrees so the flame spectrum is especially sensitive. When used in industrial areas, the role of this sensor module is to provide confirmation that the furnace is properly lit.

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Gas sensor

A good sensor is sensitive to its measured attributes and also it should not be influenced to other environments. Its sensitivity can be put as a ratio of output signal and its measure attributes. Gas sensors are small like a nose which reacts very fast to the gas present and hence keeps the system updated about changes that occurred in the concentration of molecules of a gaseous state. For testing purpose MQ-2 gas sensor is used. This **gas sensor module** consists of a sensing element housed by a steel exoskeleton. This sensing element is subjected to current through connecting leads. This current is known as heating current. Through it, gases come close to the sensing element and get ionized. These are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.

Light Dependant Resistor (LDR)

Light Dependent Resistor (LDR) is a light controlled variable resistor. With increase in the incident light, the resistance of a photo resistor decreases. Photo resistor or LDR is a passive component which works on the principle of photo conductivity. This principle can be defined as an optical and electrical phenomenon in which any material becomes conductive electrically due to absorption of electromagnetic radiations. When a light (beam of photons) falls, the electrons in the valence band of any semiconductor material are excited to conduction band. Its resistance decreases when light falls on them and is increased in the darkness. When LDR is kept in a dark room, its resistance is very high and is called dark resistance. Light dependent resistors are generally used in circuits where it is necessary to detect the presence of light, or the ambient level of light, often to create a light triggered switch.

Relay

A relay is an electrical device which incorporates an electromagnet and is usually activated by a signal in one circuit to open or close another circuit.

Electromagnet is a heart of relay that consists coil of wires and becomes a temporary magnet when an electricity flows through it. As relay can be used as a switch or amplifier, for this implementation relay is considered to be a switch. Relays are like remote control switches and are used in many applications because of their relative simplicity, long life, and proven high reliability. Relays are used in a wide variety of applications throughout industry, such as in telephone exchanges, digital computers and automation systems. Highly sophisticated relays are utilized to protect electric power systems against trouble and power blackouts as well as to regulate and control the generation and distribution of power.

WEBPAGE DESIGNING

Web design is the process to create websites. It circumscribes several aspects which include content, production, graphic design and webpage layout. Web content is dominated by a page concept which include text, sounds, images, animations etc. the production servers also called web servers delivers 'live sites' which is typically available to the entire web. Webpage layout refers to the arrangement of images, texts and other objects on a page. It encompasses many different skills and disciplines in the production and maintenance of websites. The different areas of web design include authoring; interface design; web graphic design, including standardized code and proprietary software; user experience design; and search engine optimization. It is also used to describe the design process relating to the front-end (client side) design of a website including writing mark up. Web design partially overlaps web engineering in the broader scope of web development. The PHP Hypertext Preprocessor (PHP) is a programming language that allows web developers to create dynamic content that interacts with databases. PHP is basically used for developing web-based software applications.PHP started out as a small open source project that evolved as more and more people found out how useful it was. Rasmus Lerdorf unleashed the first version of PHP way back in 1994. PHP is a recursive acronym for "PHP:

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Hypertext Preprocessor". PHP is a server side scripting language that is embedded in HTML. It is used to manage dynamic content, databases, session tracking, even build entire e-commerce sites. In order to develop and run PHP Web pages, three vital components need to be installed on any computer system.

1. **Web Server** - PHP will work with virtually all Web Server software, including Microsoft's Internet Information Server (IIS) but then most often used is freely available Apache Server.
2. **Database** - PHP will work with virtually all database software, including Oracle and Sybase but most commonly used is freely available MySQL database.
3. **PHP Parser** - In order to process PHP script instructions, a parser must be installed to generate HTML output that can be sent to the Web Browser.

PHP performs system functions, i.e. from files on a system it can create, open, read, write, and close them. The other uses of PHP are: PHP can handle forms, i.e. gather data from files, save data to a file, through email you can send data, return data to the user. It helps to add, delete, modify elements within your database through PHP. Access cookies variables and set cookies. Using PHP, some pages of any website can also restricted from accessing i.e., providing security by encrypting the data.

EXPERIMENTAL SETUP AND RESULTS

The experimental setup is shown in fig. 4. It consists of power supply unit, gas sensor, Light Dependant Resistor (LDR), fire sensor, ATmega 8 microcontroller, GSM module, Webpage, relay and bulb. A simple 5V power supply is given to the ATmega 8 microcontroller. Through this power supply unit voltage is supplied to all hardware components to work. This microcontroller is responsible for providing data flow between two entities. These two entities are sensors and GSM module.

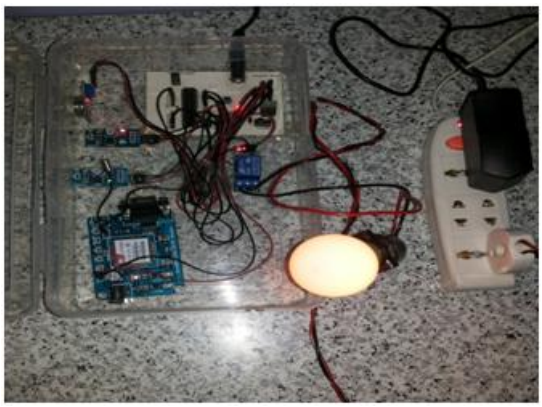

Fig. 4: Experimental Setup

To know the network of GSM module, LED was designed to indicate various status of GSM module like GPRS connectivity, power ON and network registration. When a modem is powered up, the network LED will blink fast for every second. After registering to the network (about 10-30 seconds), this LED will blink at a very slow rate. At this stage, GSM modem is ready to read the sensor data through microcontroller. The gas sensor, fire sensor and LDR are connected to port C0, C1, C2 Pins respectively. The GSM module is provided with external 12V power supply from the same designed circuitry. The relay is connected to port PB0 general purpose input/output pins.

The controller used here is an ATmel AVR ATmega 8-bit microcontroller. It is high performance, low power CMOS 8-bit microcontroller that is based on advanced RISC architecture. This controller executes powerful instructions in a single clock cycle and hence achieve throughputs approaching 1MIPS per MHz. It consists of 23 general purpose I/O lines, 3 ADC pins are used by the sensors. As these sensors are given analog inputs, the microcontroller converts this analog input into digital input for the signal to be processed. Relay uses 1 general purpose I/O line. Firstly, when the power supply is given to the microcontroller it gives power supply to all hardware components. The GSM module will then be activated manually. Considering for fire sensor, i.e., when a low intensity fire is lit near the sensor, the analog data is first received by the

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micro controller. This microcontroller converts the analog signal in to digital signal. The GSM module collects the sensor data and transmits the information onto the designed webpage through an IoT gateway. Gateway is nothing but a network node which is equipped for interfacing with another network which uses different protocols. It may contain devices such as impedance matching devices, rate converters, protocol translators etc. All the sensor data that is being processed will be transmitted on to the cloud database. The cloud computing concept helps in sending the desired data to webpage.

Fig. 5: Results being displayed on a Webpage

The above figure shows display on a webpage whenever there is a fire detected or gases being leaked. In case of light dependant resistor (LDR), when a light is detected the bulb is turned off and turned on when light is not detected.

CONCLUSION:

This paper presented how industrial areas are protected and risk optimized in cases like fire detection and gas leakages. This application collects sensor data very intelligently and sends this information onto the cloud through an IoT gateway. Because of the concept internet of Things (IoT) involved in it, risks observed in industrial areas are reduced to a great extent. With ATmega 8 micro controller, the communication or data flow between sensors and GSM module is very convenient. Different sensors can be used as long as they are connected to the system. Though wireless sensor networks (WSN) provide efficient communication, cloud computing concept overcomes it challenges like power consumption, memory capacity and data storage. Main design method for risk optimization in industrial areas is described in this paper. Finally, by giving analog inputs to each sensor, it is verified that results displayed on the designed webpage are effective.

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