Emergency Response System

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Abstract— In today's world we are faced with many different types of emergencies in the indoor environment. Response to such emergencies is critical in order to protect resources including human life.
With advancements in wireless communication and the development of multifunctional sensors, has lead to the birth of a new technology named Wireless Sensor Networks.
This paper, presents an emergency response system which is easy to deploy and with low cost and the flexibility of reporting emergencies to the users in various forms, such as live streaming video feeds on a computer screen, an audio alert using APR 9600 and also a mobile device is used to set or reset any specified parameters of devices when required.
In this paper we present a design for such a system using temperature sensors as a proof of concept. The design for this system can be realized using Adhoc Network protocols.

Index Terms- PIC microcontroller, Protocols, APR, Sensor Networks, Network models, Sensors.

INTRODUCTION

Today's world we are faced with increasingly many types of emergencies in our environments. One example which stands out is the disastrous variation in parameters such as temperature of blast furnaces which has plagued our steel manufacturing industries and industries alike. In addition, industries with poor infrastructure may not be able to minimize loss of resources and human life in times of unnatural catastrophes. The objective of this project is to design a wireless sensor network using Zigbee/MiWi to respond to any emergency and inform appropriate individuals in a timely and cost effective manner so that the required device parameters which are out of a pre specified range can be set or reset by the user.

The project further aims to enable ease of installations of variety of sensors and networking possibilities with a variety of networks

WIRELESS SENSOR NETWORK

A wireless sensor network is as a wireless network which consists of equally distributed autonomous devices using sensors capable of monitoring the physical conditions such as temperature, voltage, sound, pressure, or motion, at various sites especially for machinery's in factories [2]. In addition to one or more sensors, each node here is typically equipped with a web camera, a communications device, a small microcontroller, and an energy source. Depending on the size of the sensor network and the complexity required of individual sensor nodes the network cost is determined. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as memory, bandwidth, computational speed and energy source [1].

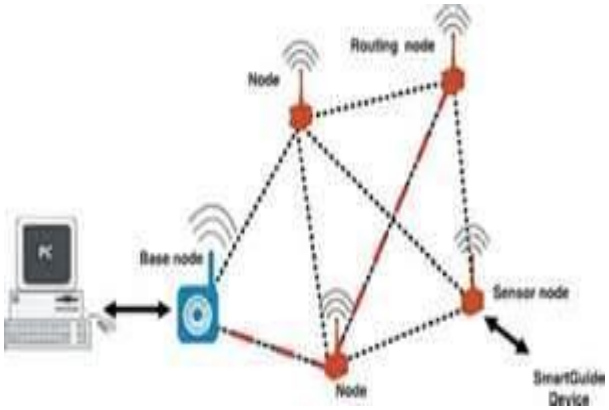

Figure1: Wireless Sensor Network Architecture

EMERGENCY RESPONSE SYSTEM

A. Illegal Variations Intimation System

In Wireless Emergency Notification System (WENS) by Inspiron Logistics an authorized person chooses a group to notify emergency. The WENS system tries every 5 seconds, indefinitely, until the message is delivered. WENS can track each and every message with a delivery receipt and subsequent report [4]. This gives factory officials a way to know that the message was delivered. The WENS system has a proprietary service called an Imaging and Video Delivery System (IVDS). IVDS provides the industry community with the ability to send images and video to campus police [4].

Wireless Illegal Variation Intimation System uses True audio alert and video of the specified site and is the top recommendation for implementing a industry-wide notification solution. [1].

Since TCP is used here it is a reliable transmission. This provides the industrial community with the ability to send video to the appropriate person [17].

B. Mobile Device Video streaming

This method is an active emergency response and hence competes with others in its time efficiency. The videos of the monitored area which the PC obtains from the web cameras are displayed on the monitor. Video from single camera or multiple cameras can be viewed simultaneously. In case the authorized person is not present at the site these video images are further streamed to his mobile device which is connected to the PC through WAN using GPRS. The authorized person has the ability or options to set or reset the monitored device parameters from his mobile device [16].

C. Audio Alert

Mainly APR9600 is used for audio notification for multiple purpose [15].The APR9600 samples incoming voice signals and stores the instantaneous voltage samples in non-volatile FLASH memory cells. Each memory cell can support voltage ranges from 0 to 256 levels. During playback the stored signals are retrieved from memory, smoothed to form a continuous signal, and then amplified before being fed to an external speaker.

In case of emergencies the PC plays a voice alert which was previously recorded. Depending on the given alert the parameters are adjusted to suite the specifications required.

D. Internet

By using the internet the alerts can be updated on the websites of a campus (monitored area), which has the various procedures to be taken in case of emergency.

RESPONSE TIME

Based on the study from this project [2], in the event of any emergency it will take few seconds after the variation occurred for us to hear an alert from the system. The response time of the authorized person or the client depends on severity of abnormality, load, and time taken for their detection [3].The average response time to such emergency in industries is the range of few seconds to one or two minutes. Effort is being made to reduce response time to as short as possible such as easy reporting platforms and installation of smart sensors, increase patrol of the devices by monitoring the required site continuously [3].

Given below are some key factors that we need to focus on to develop a Wireless Emergency Response System [3] using appropriate sensors:

- Effectiveness of the sensors such as temperature sensor, to detect deviation in device parameters, from their specified normal range.
- Reduce the data loss which occurs while the video is being converted to byte form and transmitted from web cameras to the authorized person's mobile device.
- Reduce the transmission delay between sensing and reporting of information from the sensor to the PC.
- Overall notification delay to end user.

IMPLEMENTATION GOAL

The project will utilize open hardware for realizing its goals. Specifically we intend to use APR9600 solution to conduct a feasibility study. The reason to choose this is to have a cost effective and a robust design. The eventual goal is for the project to use PC's as the 'sink' in order to collect data from various sensors and provide them in a user friendly fashion. This data can then be stored appropriately as well. The PC also outputs an audio alert to notify the user the variations in parameters that are deemed as emergency based on a preexisting criterion. Client software can be developed and can be programmed to play video. This project will focus on variation in any specified device temperature emergency in any industrial devices using temperature sensors that are used to conduct the feasibility study of the system.

PROTOCOLS USED

E. General Network Model

A network is a combination of hardware and software that sends data from one location to another. The hardware consists of the physical equipment that carries signals from one point of the network to another. The software consists of instruction sets that make possible the services that we expect from a network [15].
The network model having seven layers performs various functions. It is given in figure2 below.

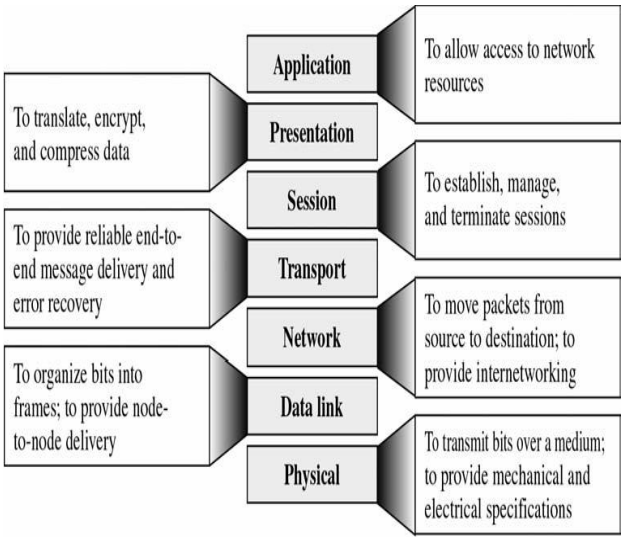

Figure2: Layers of Network model and their functions.

F. General Packet Radio Services

General Packet Radio Services (GPRS) is an enhancement to GSM or TDMA (IS-95) network. That's why GPRS is often touted as a 2.5G technology. GPRS has two important entities:

Servicing GPRS support node (SGSN) and Gateway GPRS support node (GGSN). GPRS is typically deployed in two phases.

A GPRS software upgrade can be performed efficiently.

- GPRS typically supports up to 100 users with one to eight channels. GPRS supports broadcast and multisessions. GPRS requires an investment in new infrastructure. A desirable characteristic of GPRS protocol is that each layer can be reused to support features in different GPRS nodes.

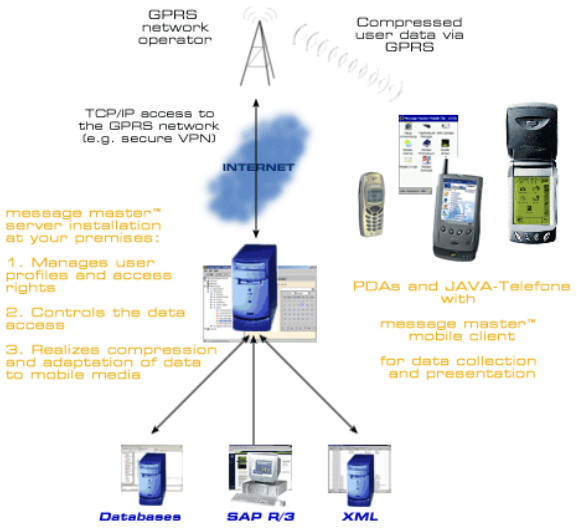

Figure3: GPRS network.

- Several potential GPRS applications have been identified: Vertical applications for specific data communication requirements of companies and Horizontal applications for individual users [16].

G. File Transfer Protocol

File Transfer Protocol (FTP) is a standard network protocol used to copy a file from one host to another over a TCP-based network, such as the Internet.

FTP URL syntax is described in RFC1738 [20], taking the form [17]:

ftp://[<user>[:<password>]@]<host>[:<port>]/<url-path> (1)

FTP sets the rules for transferring files between computers. FTP is built on a client-server architecture and utilizes separate control and data connections between the client and server. UDP cannot be used when FTP is made use. The primary objective in the formulation of File Transfer Protocols was to make file transfers uncomplicated

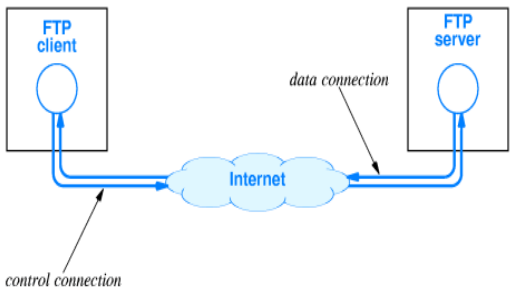

Figure4: FTP Client and server connection.

H. Transmission Control Protocol

The Transmission Control Protocol (TCP) provides full transport-layer services to applications. TCP is a reliable stream transport protocol [21].

TCP transmits data in full-duplex mode and socket programming is done in TCP for this purpose [22].

To provide different services TCP has several features

- Numbering System: There are two fields called the sequence number and acknowledgement number. These two refer to the byte number.
- Flow Control: The receiver of the data controls the amount of data that are to be sent by the sender. The numbering system allows TCP to use a byte-oriented flow control.
- Error Control: To provide reliable service, TCP implements an error control mechanism.

Figure5: Data transmission using TCP.

- Congestion Control: The amount of data sent by a sender is not only controlled by the receiver (flow control), but is also determined by the level of congestion in the network.

I. Internetworking Protocol

Internetworking Protocol (IP) is a transmission mechanism used by the TCP/IP protocols. It is a best-effort delivery service [18]. IP transports data in packets called datagram's, each of which is transported separately [17].

IP provides several services:

- Addressing: IP headers contain 32-bit addresses which identify the sending and receiving hosts.
- Fragmentation: IP packets may be split, or fragmented, into smaller packets. This permits a large packet to travel across a network which can only handle smaller packets.
- Packet timeouts: Each IP packet contains a Time To Live (TTL) field, which is decremented every time a router handles the packet. If TTL reaches zero, the packet is discarded, preventing packets from running in circles forever and flooding a network.
- Type of Service: IP supports traffic prioritization by allowing packets to be labeled with an abstract type of service.

  Options: IP provides several optional features, allowing a packet's sender to set requirements on the path it takes through the network (source routing), trace the route a packet takes (record route), and label packets with security features.

NETWORK AND HARDWARE USED

The main hardware components which are used in this proposed system are PIC16f877 and APR9600.The IEEE 802.11-WLAN is also made use of for video transmission using FTP and also ZIGBEE is used in WSN. These are briefed below.

J. IEEE 802.11 - WLAN/Wi-Fi

Wireless LAN (WLAN, also known as Wi-Fi) is a set of low tier, terrestrial, network technologies for data communication. The WLAN standard's operates on the 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands. It is specified by the IEEE 802.11 standard and it comes in many different variations like IEEE 802.11a/b/g/n. The application of WLAN has been most visible in the consumer market where most portable computers support at least one of the variations [14].

K. APR9600: Single Chip Voice Recording and Playback Device

One of our main design goals is to be able to interface APR9600 devices to a PC [15]. The APR9600 device offers true single-chip voice recording non-volatile storage and play back capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages. Its main features are as follows:

- Single-chip, high–quality voice recording and playback solution.

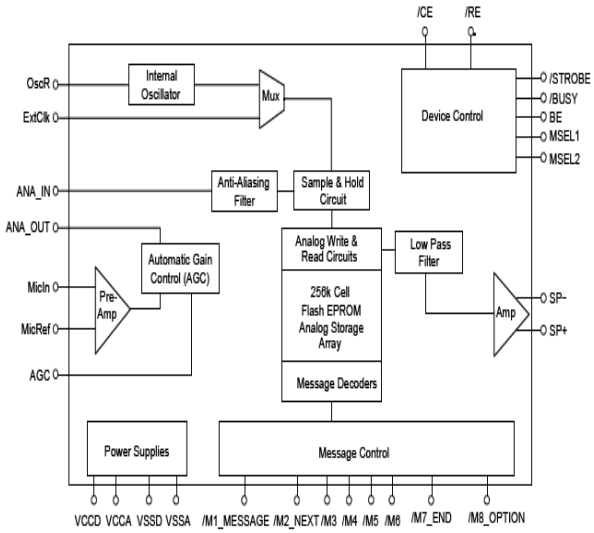

Figure6: APR9600: Block Diagram

- User-friendly, easy-to-use operation.
- Low power consumption.
- Non-volatile flash memory technology.
- User-selectable messaging options.
- Operating current: 25mA typical.
- Standby current: 1µA typical
- Chip enable pin for simple message expansion.

L. Zigbee

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard for WSN. ZigBee devices can be interfaced to the computer or other end points [8]. We need a ZigBee modem in order to connect to user understandable digital interface, such as the computer. Zigbee Modems connect to the USB port of the computer, and mounts on a COM port (a standard serial port). The ZigBee provisions for devices to communicate with each other using a Mesh, Tree or star topology.

As a result, ZigBee modems can be used to talk to many ZigBee devices and we can choose which device we want to talk to at any time. There are two ZigBee modules, series 1 and series 2. A ZigBee Series 2 Modem is needed to talk to ZigBee Series 2 devices. ZigBee Series 2 offers a new feature called mesh networking. Mesh networking allows our computer to talk to devices that are out of range by talking to devices that are in between [23].

One of the main design goals of our emergency response system is to have a cost effective WSN.

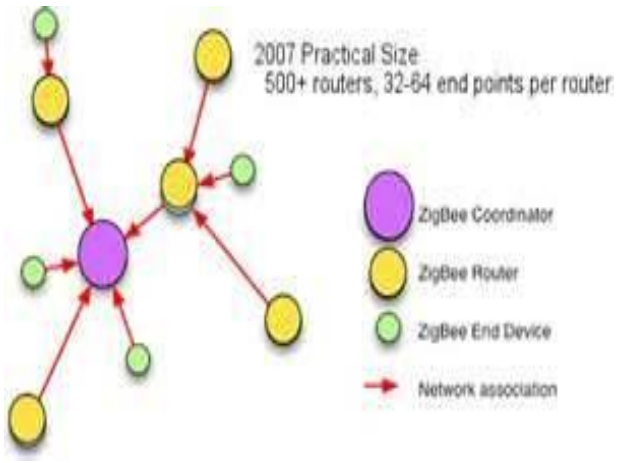

Figure7: Zigbee Network Architecture

Currently blue tooth offers short personal area coverage however it does not offer the Mesh or Tree networking of ZigBee. Bluetooth is also an IEEE 802.15 WPAN standard and also uses the 2.4-GHz unlicensed frequency band. Like ZigBee Bluetooth also uses small form factors and low power.

M. PIC16f 877 Microcontroller.

Microcontroller is nothing but microprocessor with memory in-built. It is used for specific purpose. Peripherals are connected internally [5].

TABLE I. KEY FEATURES OF PIC16F877.

Key features of microcontroller	**PIC16f877**
Operating Frequency	DC-20 MHz
Resets (and delays)	POR,BOR(PWRT,OST)
FLASH Program Memory(14 bit words)	8K
Data memory(bytes)	368

Interrupts	14
I/O Ports	Ports A,B,C,D,E
Timers	3
Capture/compare/PWM modules	2
Serial communications	MSSP,USART
Parallel communications	PSP
10-bit Analog-to-Digital Module	8 input channels
Instruction set	35 instructions
EEPROM Data Memory	256

NETWORK STRUCTURE FOR WSN

Wireless networks can have two distinct modes of Operation: Ad hoc and infrastructure. Infrastructure wireless networks usually have a base station which acts as a central coordinating node. The base station is usually AC provided in order to enable access to the Internet, an intranet or other wireless networks. The bottle neck of this over ad hoc networks is that the base station is a central point of failure.

SENSORS

A sensor node is also typically known as a 'mote'. Sensor nodes are conventionally made up of four basic components as shown in figure8.

A sensor node in a sensor network is capable of gathering sensory information, processing and communicating with other connected nodes in the network. The microcontroller in the sensor performs tasks such as data processing and controls the functionality of other components in the sensor node.

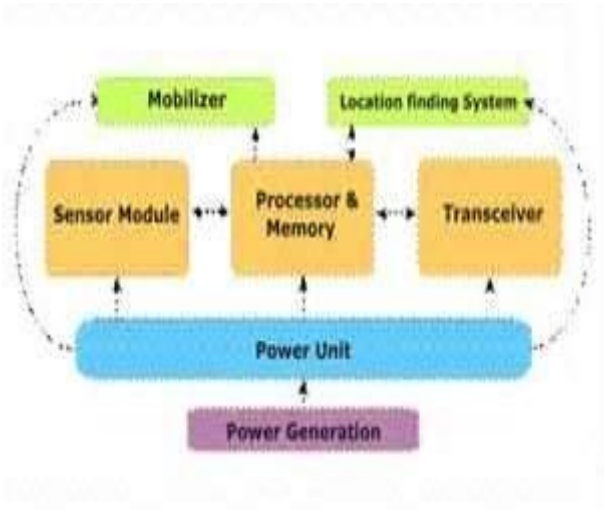

Figure8: Sensor Node Architecture

Most of the sensor nodes make use of the ISM band which gives free radio, a huge spectrum allocation and global availability. The Radio Frequency (RF) based communication is the most relevant form of communication that fits to most of the WSN applications. The WSN use the communication frequencies between about 433 MHz and 2.4 GHz.

Batteries are the main source of power supply for sensor nodes[8].They are also classified according to electrochemical material used for electrode such as NiCd (nickel-cadmium), NiZn (nickel-zinc), Nimh (nickel metal hydride), and Lithium-Ion.

N. Temperature Sensing

We take temperature sensing using LM35,as a case study to show the validity of WSN in the field of emergency responses. A temperature sensor produces a voltage that is proportional to the temperature of the die in the device. This voltage is supplied as one of the single-ended inputs to the Analog to Digital Converter (ADC) multiplexer. When the temperature sensor is selected as the ADC input source and the ADC initiates a conversion, the resulting ADC output code can be converted into a temperature in degrees. The increase of temperature in the blast furnace/room due to rise in fuel levels or due to exothermic reactions between Carbon and Oxygen to form Carbon dioxide, will increase the voltage of the sensor. In order to find the ambient temperature, the temperature increase due to self-heating must be subtracted from the result. The chief factors that contribute to the amount of device self-heating are: power supply voltage, operating frequency, the thermal dissipation characteristics of the package, device mounting on the PCB, and airflow over the package [6]. The temperature increase can be calculated to the first order by multiplying the device's power dissipation by the thermal dissipation constant of the package. One method is to initiate a conversion soon after applying power to the device to get a 'cold' temperature reading, and then measure again after about a minute of operation, to get a 'hot' temperature reading [6]. The difference between the two measurements is the contribution due to self-heating.

O. Equation to calculate the temperature:

The temperature sensor produces a voltage output which is proportional to the absolute temperature of the die in the device. The relationship between this voltage and the temperature in degrees C is shown in Equation 1 [13].

$$V_{temp} = (2.86\ \underline{mV}/^{\circ}C) \times Temp + 76mV \quad (1)$$

Vtemp = the output voltage of the temp sensor in mV
Temp = the die temperature in degrees C

The temperature sensor voltage is not directly measurable outside the device. Instead, it is presented as one of the inputs of the ADC multiplexer, allowing the ADC to measure the voltage and produce an output code which is proportional to it [13]. The code produced by the ADC in left-justified single-ended mode is proportional to the input voltage as follows:

$$CODE = V_{in} \times \underline{GAIN}/V_{REF} \times 2^{\wedge}16 \quad (2)$$

CODE = the left-justified ADC output code
Gain = the gain of the ADC's PGA
VREF = the value of the voltage reference, which is around 2.43 V if the internal VREF is used.
Substituting Equation 1 into Equation 2,

assuming Gain=2 and VREF = 2.43V,
solving for Temp and rearranging, we obtain an output temperature which in terms of CODE and a pair of constants.

$$\text{Temp} = \frac{(\text{CODE}-41857)}{154} \quad (3)$$

Temp = the temperature in degrees C
CODE = the left-justified ADC output code.

P. Sensor Unit

The project will be utilizing Zigbee and temperature sensor (LM35) and APR 9600. The temperature sensor has a wide range of applications and is designed for monitoring sensitive environments.
Product specifications for Temperature Sensor :

- Type: Precise integrated-circuit temperature sensor.
- Power: 1mW
- Range: -55 to + 150˚c
- Meshing capability: Range extended with APR 9600 technology
- Compatible Receivers: USB, RS232, GSM/GPRS
- Reporting Interval: Programmable 6s to 18h
- Logging: Up to 6 weeks data logged when out of range
- Other parameters: Reports calibration and service dates as well as device description, serial number and part number
- Memory type: Non volatile memory retains data permanently.

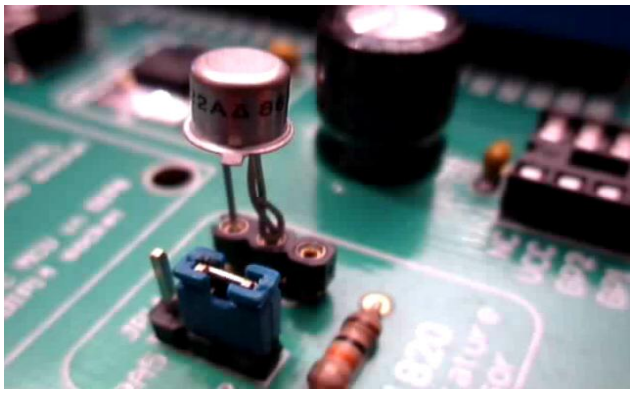

Figure9: Temperature sensor.

Some important features of LM35:

- Calibration: Calibrated directly in ˚ Celsius (centigrade).
- Has an accuracy of +/- ¼˚C at 25°C, 3/4˚C across full range
- Has resolution of 0.01°C. It is calibrated directly in ˚Celsius (centigrade).
- Has low cost due to wafer-level trimming.
- Operates from 4 to 30 volts.
- Has low self-heating, 0.08˚c in still air.
- Can be easily deployed in sensor networks.

APPLICATIONS OF EMERGENCY RESPONSE SYSTEM USING SENSOR

Q. Early detection of deviations in parameter values

Autonomous early detection of an emergency is a primary way of minimizing damages or life threatening events on campus. If any parameter such as temperature deviates from its prespecified range immediately the authorized user is intimated about these abnormal and unacceptable variations.

We model the emergency detection problem as a node k-coverage problem (k >= 1) in wireless sensor network [4]. Constant-factor centralized algorithms are used to solve the node K problem.

R. Real Time Video Streaming

WSN are attached with web cameras to record a certain area in the building. This system can be used as a surveillance network. Existing research discusses optimizing image segmentation algorithms based on image properties without manual intervention [14]. These methodologies compute image properties such as average edge gradient strength, inter- vs. intra-cluster distances using image color features, and color purity of resultant regions, to train a neural network that maps these to ground-truth labeling on the acceptability whether it is good or bad of the solution in the resultant segmentation .There are methodologies that perform extremely well by correctly predicting the optimal parameters of image segmentation algorithms used [11]. Improvement of data quality: Images viewed by human operators can be enhanced by the computer so that contraband appears in stark contrast to its surroundings so that humans can easily detect it [10].

Automated detection of dangerous explosives: The methodology will depend on the modality of gathering data. In the case of video images, the system will have to automatically process such data to enhance its quality, segment objects of interest and then use some features to characterize the resulting regions. However, if the data for analysis is a one-dimensional signal or spectra, the task involves template matching where test spectra are matched with known templates. The data could be simply a measurement or a point in n-dimensional feature space that needs

WSN can be attached with the camera, to record a certain area. This system can be then used as a surveillance network. Existing research discusses optimizing image segmentation algorithms based on image properties without manual intervention [10].

S. Self Powered Sensors

With current advancements in alternative energy the sensors used in this system can be powered with battery or solar powered. Such systems can benefit outdoor sensing and indoors where there are huge skylights or open areas with access to sunlight. Power consumption is a problem currently being addressed in WSN. Using such systems we can benefit in many ways.

Solar powered sensors can provide value to WSN for emergency response by prolonging the life-times of the sensing nodes and may give long lasting shelf-life.

Experimental results have proved that certain prototypes like the MPWiNodeX, can manage simultaneously energy from Solar, wind and for charging a NiMH battery pack, resulting in an almost perpetual operation of the evaluated ZigBee network router. In addition to this, the energy scavenging techniques double up as sensors, yielding data on the amount of solar radiation, water flow and wind speed, a capability that avoids the use of specific sensors.

COMPARISON WITH OTHER SYSTEMS

T. Existing Systems

However a part of this technology has been used in other types of emergency situations such as forest fire detection, navigation during emergency situations, wireless internet information system for medical response in disasters and many more. And currently some home appliances such as air conditioners, lights, microwave ovens can be set on or off from remote places using remote controllers. And also cars can be run using remote controller from far off distances.

U. Proposed System

There is currently no such system which is specially developed for small industrial emergencies wherein the required device parameters, here in case of temperature, can be set or reset by the authorized person from any far off location by just using his mobile device which has some extra features programmed in it. Also the video feeds of images of monitored site from more than one web camera can be streamed to the authorized person's mobile device.

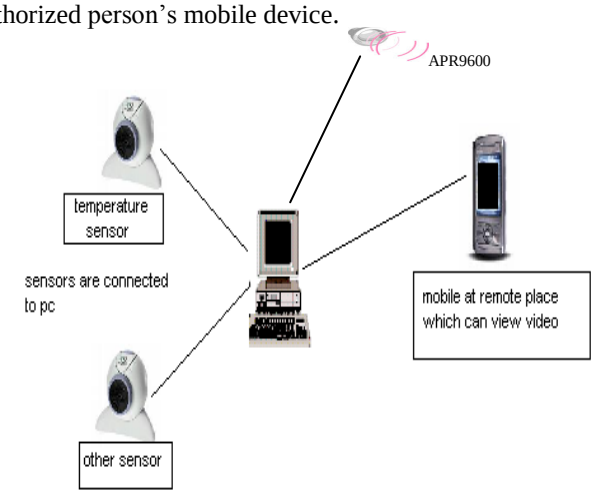

Figure10: Model of proposed system.

DISADVANTAGES AND IMPLEMENTATION ISSUES

The disadvantages of the system will be inherited from the APR9600 and ZIGBEE. Another problem in response to emergency situation which hugely depend on the validity of the threat or situation of a real emergency in which emergency service can cut cost by not responding to false emergencies and their time can be better utilized to fight or manage real emergencies.

CONCLUSION

It is feasible to construct a Sensor Network for intimation of deviation of specified parameter from their prespecified normal range values using LM35 and APR9600. Moreover there is a range of sensing applications. This system has the potential to reduce the response time in a cost-effective way. This system is robust, few more efficient methods can be incorporated to validate the threat by adding some additional options to the sensors.

Currently this system will be focusing on two aspects of the abnormality detection which is deviation of temperature or voltage from their normal range which occurs mostly in many industries across the states. The system can be further developed to detect other emergencies such as fuel tank monitoring, Hydro power plant, forest fire, human tracking, Wildlife monitoring, traffic monitoring, Industrial quality control, Observation of critical infrastructures, Smart buildings, intelligent communications and so on.

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