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Research Article

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Interactive Self Monitoring Wireless Sensor for Smart Office Using Zig-Bee Communications

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Abstract –

Recent advancements in air pollution monitoring, natural disaster monitoring, forest fire detection, landslide detection, water quality monitoring, has set a new stage for wireless sensor networks (WSNs). WSNs capability to gather and process data in real time has made monitoring of various environments possible. Zig-Bee, A high level communication protocol together with WSNs finds applications in home automation, office automation and environment monitoring. This paper proposes an event based self monitoring WSNs and hardware implementation. The proposed method is used to provide smart office services that include various parameters using advanced cortex microcontroller.

Key words--Wireless sensor networks, Zig-Bee communication, smart office services, cortex microcontroller.

I. INTRODUCTION

The development of wireless sensor networks is attributed to military, industrial and consumer applications. WSNs are composed of spatially distributed autonomous sensors to monitor environment and physical parameters such as temperature, light, sound, pressure etc and pass data to main location through the wireless network.WSN is composed of "nodes", where each node is connected to one or more sensors. A sensor node, also known as a mote, is a node in a WSN that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A mote is a node but a node is not always a mote.

Each sensor network node consists of many parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, a battery. A sensor node varies in size therefore the cost of sensor nodes is similarly variable, depending on the design and complexity of the individual sensor nodes. Size and cost constraints of sensor node rely on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless peer-to-peer or mesh network. The propagation technique between the hops of the network is routing. In telecommunications, wireless sensor networks are an active research area.Fig.1. Shows a typical multi-hop wireless sensor network architecture. The architecture consists of sensor nodes that form a wireless sensor network, a sink node, internet and user. The target node communicates with the user via the other sensor nodes, sink node and internet as indicated in blue arrows.

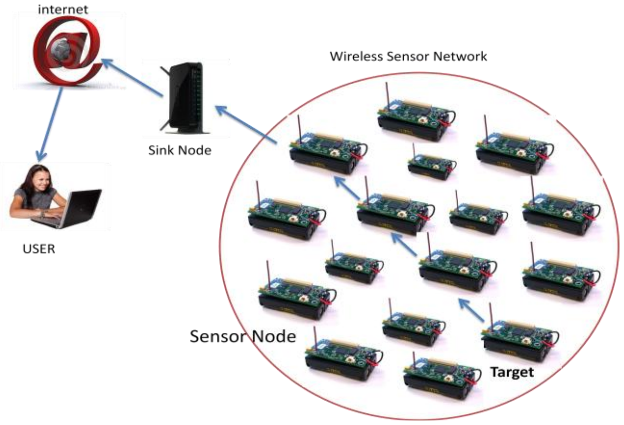


Fig.1.Typical multi-hop wireless sensor network architecture

Zig-Bee is a Technological Standard Created for Control and Sensor Networks Based on the IEEE 802.15.4 Standard and Created by the Zig-Bee Alliance. The IEEE 802.15.4 standard was completed in May 2003. The Zig-Bee specifications were ratified on 14 December 2004.The Zig-Bee Alliance announced public availability of Specification 1.0 on 13 June 2005. Zig-Bee is designed for wireless controls and sensors operating in wireless Personal Area Networks (WPAN's). Zig-Bee provides connectivity between small packet devices and used to control lights, switches, thermostats, appliances, etc.

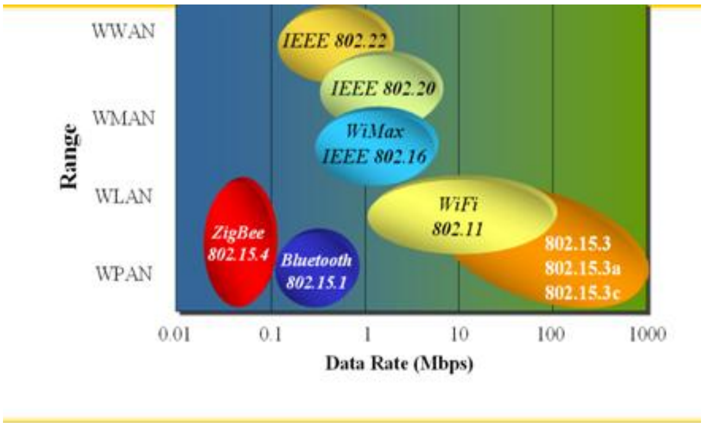


Fig.3.IEEE 802 wireless space network[11]

Fig.3. indicates the wireless space network of Zig-Bee, Bluetooth, WiMax, Mobile Broadband Wireless Access (IEEE 802.20), wireless regional area network (IEEE 802.22) and IEEE 802.15.3 which is a standard for high rate WPANs.

Zig-Bee is an Ad-hoc self forming networks that supports three topologies-Mesh, Cluster Tree and Star (Fig.4.). A Zig-Bee system consists of several components-full-function devices (FFD) or reduced-function device (RFD).FFD operates in 3 modes- a coordinator, a router, or a device. Zig-Bee finds application in Device and Service Discovery, Messaging with optional responses, Home Controls Lighting Profile and General mechanism to define private Profiles. Zig-Bee operates in industrial, scientific, medical radio bands (ISM) 2.4 GHz Global Band at 250kbps.

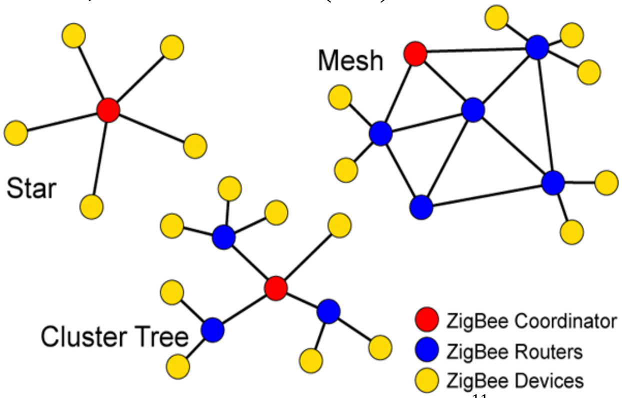


Fig.4. Zig-Bee topology models[11]

Zig-Bee architecture enables cost-effective, low power, reliable devices for monitoring and control. Zig-Bee's architecture is developed to target environments and applications best suited to the technology. Zig-Bee also provides a platform and implementation for wireless networked devices and allows future extension of Zig-Bee.

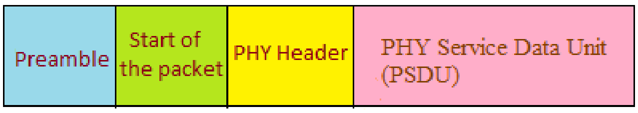


Fig.5. Zig-Bee packet structure

Zig-Bee packet structure Shown in Fig.5.consists of Preamble (32 bits) for synchronization, Start of Packet Delimiter (8 bits) for specifying one of 3 packet types, PHY Header (8 bits) for Sync Burst flag, PSDU length and PHY service data unit(PSDU) (0 to 127 bytes) for data.

II. RELATED WORKS

Briefing the existing works with regards to self monitoring for smart office based on wireless sensors technology is presented in this section.

Gaddam *et al* [5] proposed a novel smart home monitoring system based on cognitive sensor network for elders. A number of selective activity monitoring cognitive wireless sensors are used to detect current bed usage pattern, water flow and elders movement. Sensor collect these information, using RF transceiver transmit to central server. If abnormality pattern such as excess water/power usage occurs, then the system alerts the care giver by sending SMS (short message service) message. Darminder S.Ghataoura *et al* [7] proposed a cross layer approach to enable network centric capability operation within a particular mission–oriented unattended ground sensor (UGS) network surveillance setting. Self managing features of cross layer within UGS networks have ability to make decisions in distributed manner, within a uncertain situation as well as network resource constrained environment.

Darminder S.Ghataoura *et al* [2] proposed a Swarm Intelligent Odour Based (SWOB) routing strategy to allow information agents to traverse the network to the region of interest. This uses geographic location information as well as network topology. SWOB uses a virtual Gaussian odour plume technique to describe the odour dispersion effects found in nature, allowing information agents in a distributed manner to be guided towards the region of interest effectively. G.V.

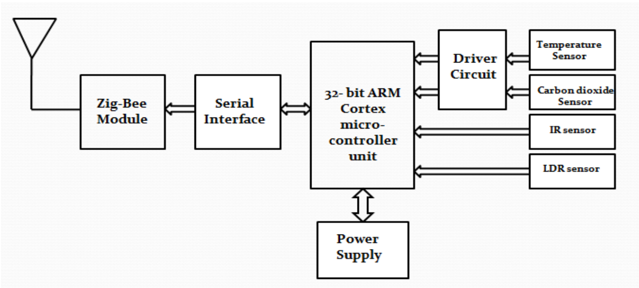
Satyanarayana *et al* [9] proposed a wireless sensor network connected to a central node using Zig-Bee, that is in turn connected to a Central Monitoring Station (CMS) through General Packet Radio Service (GPRS) or Global System for Mobile (GSM) technologies. Global Positioning System (GPS) parameters is also obtained and sent to a central monitoring station. This system meets the requirements of the temperature and humidity of soil environmental monitoring.

Imran.A.Zualkerman *et al* [3] proposed a system called Info Pods whose architecture is based on a Zig-Bee-based controller. This allows family members to simultaneously monitor their home appliances as well as external Internet resources using economical, stand-alone hand-held mobile wireless devices. This architecture is flexible and can be easily integrated with existing smart-home systems.

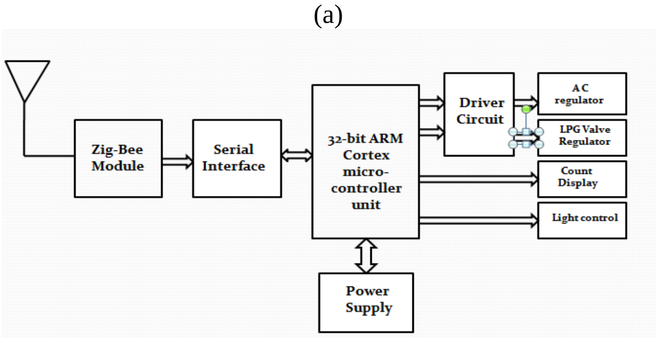
In this paper, we focus on Interactive Self Monitoring Wireless Sensor that can be employed for Smart Office as well as smart home effectively Using Zig-Bee Communications.

III. SYSTEM ARCHITECTURE

The proposed system architecture consists of a Zig-Bee module for automated wireless communications, serial interface, 32-bit ARM cortex microcontroller, driver circuit and sensors. Mesh or peer-to-peer topology model is employed to monitor large environments such as a party hall, large corridors etc. Serial communication employed in this paper has advantages over parallel communication, the binary bits of data are sent one after the other ensuring no loss or errors due to interference, and also cost is less compared to parallel communication. Serial interface aids serial communication.



(a)



(b)

Fig.5. System Architecture: (a) Input/Transmitter End and (b) Output/Receiver End

The system architecture is categorized into Input/Transmitter End and Output/Receiver End as shown in Fig.5. Both the ends consist of a Zig-Bee module that is responsible for wireless communication between the transmitter and receiver. Serial interface is responsible for serial communication to the 32-bit ARM Cortex microcontroller unit. Power supply is given to the microcontroller at both ends. At the transmitter end, the sensors such as temperature sensor, carbon dioxide sensor, infrared (IR) sensor, light dependent resistor (LDR) sensor are programmed in order to sense various parameters in a particular environment such as temperature, carbon dioxide, head count and light respectively. At the receiver end, the information received from the input end by the sensors is processed by using corresponding controllers such as AC regulator, LPG valve regulator, count display and light control.

The 32-bit ARM Cortex-M3 microcontroller released by ARM in 2006 is used for hardware implementation. The Cortex-M3 addresses the requirements in the following ways:

- Greater performance efficiency: Allowing more work to be done without increasing the frequency or power requirements.
- Low power consumption: Enabling longer battery life, especially critical in portable products including wireless networking applications.
- Enhanced determinism: Guaranteeing that critical tasks and interrupts are serviced as quickly as possible and in a known number of cycles.
- Improved Code density: Ensuring that code fits in even the smallest memory footprints.

- Ease of use: Providing easier programmability and debugging for the growing number of 8-bit users migrating to 32 bits.
- Lower Cost Solutions: Reducing 32-bit based system costs close to those of legacy 8-bit and 16-bit devices and enabling low-end.
- Wide choice of development tools: From low-cost or free compilers to full-featured development suits from many development tool vendors.

With its high performance and high code density and small silicon footprint, the Cortex-M3 processor is deal for a wide variety of applications such as:
1) Low-cost microcontrollers: Commonly used in consumer products, from toys to electrical appliances.
2) Automotive: very high-performance efficiency and low interrupt latency, allowing it to be used in real-time systems.
3) Data Communications: Low power and high efficiency make the Cortex-M3 ideal for many communications applications, such as Bluetooth and Zig-Bee.
4) Industrial control: In industrial control applications, simplicity, fast response, and reliability are key factors.

Fig.6. 32-Bit ARM Cortex Microcontroller Unit[11]

Sensor nodes are used for simultaneous monitoring of up to four parameters as follows:

(a) Temperature sensor: This is used at the transmitter end is LM35 used for AC control via AC regulator at the receiver end. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ^{o}C). With LM35, temperature can be measured more accurately than with a thermistor. The sealed sensor circuitry is not subjected to oxidation and other processes It also possess low self heating and does not cause more than 0.1 ^{o}C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ^{o}C rise/fall in ambient temperature, *i.e.*, its scale factor is 0.01V/ ^{o}C.
V_{cc}: Supply voltage 5V (+35V to -2V)
Output: Output voltage (+6V to -1V)
GND: Ground (0V)

(b) Light or LDR sensor: A photoresistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor used for light control. It exhibits Photoconductivity which is an optical and electrical phenomenon in which a material becomes more electrically conductive due to the absorption of electromagnetic radiation such as visible light, ultraviolet light, infrared light, or gamma radiation, therefore, the resistance decreases with increasing incident light intensity. In the dark, an LDR has a resistance as high as a few mega ohms (MΩ), while in the light, an LDR has a resistance as low as a few hundred ohms. LDR works like a switch.

(c) Carbon-dioxide sensor: This is used for monitoring Gas/ Fire leakage via LPG valve regulator at the receiver end. A carbon dioxide sensor or CO_2 sensor is an instrument for the measurement of carbon dioxide gas. The most common principles for CO_2 sensors are infrared gas sensors (NDIR) and chemical gas sensors. Measuring carbon dioxide is important in monitoring indoor air quality, cryogenics, ventilation management and mining.

(d) IR sensor: This is used for head count that is displayed at the receiver end as Count Display. An Infrared (IR) sensor is used to detect obstacles in front of the robot or to differentiate between colors depending on the configuration of the sensor. The sensor emits IR light and gives a signal when it detects the reflected light. An IR sensor consists of an emitter, detector and associated circuitry. The circuit required to make an IR sensor consists of two parts; the emitter circuit and the receiver circuit. The emitter is an IR LED (Light Emitting Diode) and the detector is an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, its resistance and output voltage, change in proportion to the magnitude of the IR light received.

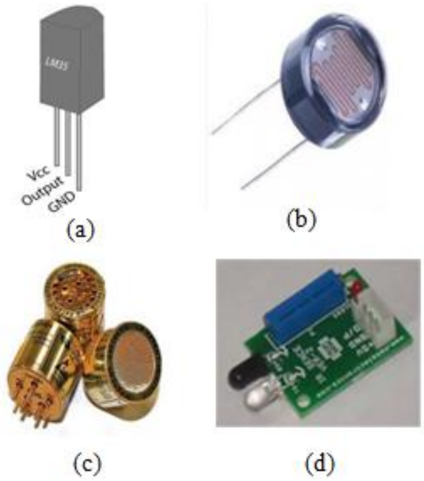


Fig.7. Sensor Nodes[11]: (a) Temperature Sensor (b) Light or LDR Sensor (c) Carbon-dioxide Sensor and (d) IR Sensor

IV. HARDWARE IMPLEMENTATION AND RESULTS

The implementation of hardware of proposed model showed improvements than the existing model in various parameters such as speed and power consumption. Graphical representation is shown in fig. 8 that represents enhancement in speed as well as low power consumption. This makes the proposed model economical and employable in real time. We can see that the power usage by ARM Cortex-M3 is less than PIC microcontroller. Also ARM Cortex-M3 provides a speed of 120MHz which is twice that of ARM and six times that of PIC. The ARM Cortex-M3 microcontroller makes it possible for up to four parameters to be monitored and controlled in a specific environment simultaneously.

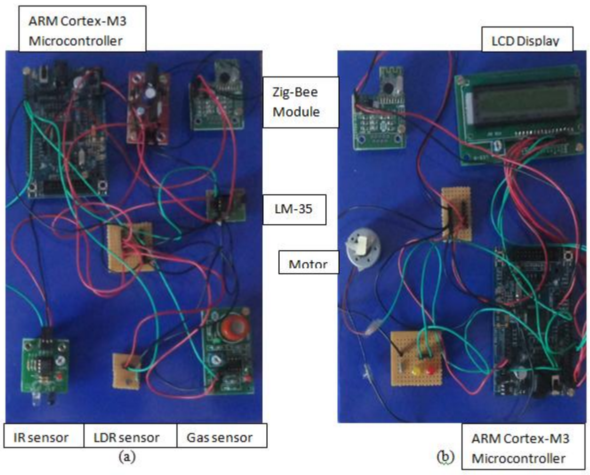
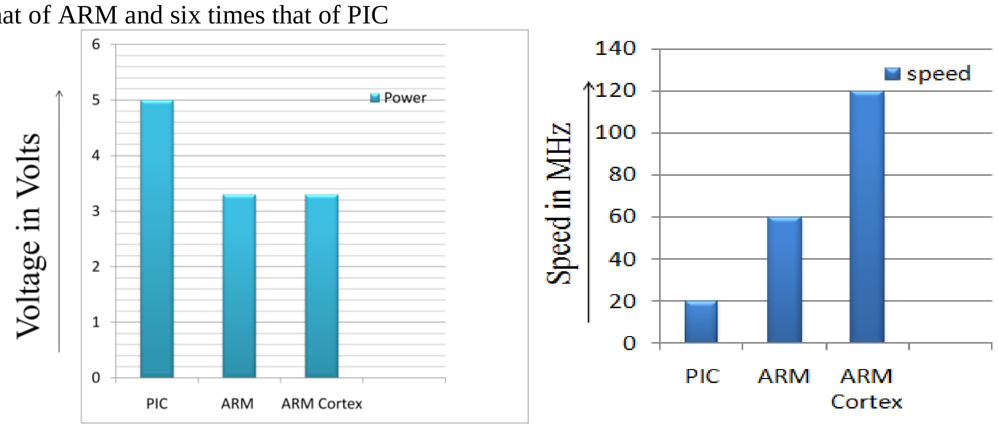


Fig.8. Developed monitoring system (a) Transmitter/ Input end (b) Receiver/Output end

Graphical representation is shown in fig. 8 that represents enhancement in speed as well as low power consumption of 3.3V. This makes the proposed model economical and employable in real time. We can see that the power usage by ARM Cortex-M3 is less than PIC microcontroller. Also ARM Cortex-M3 provides a speed of 120MHz which is twice that of ARM and six times that of PIC



(a) (b)

Fig.8.Comparision of PIC, ARM, ARM Cortex in terms of a) Power and (b) Speed

The ARM Cortex-M3 microcontroller makes it possible for up to four parameters to be monitored and controlled in a specific environment simultaneously as shown in TABLE I.

TABLE II: EXPERIMENTAL RESULTS

Components	Input	Output	Display
Temperature sensor	> Threshold	AC regulator ON	Temperature is high
	< Threshold	AC regulator OFF	Temperature Normal
LDR Sensor	High	Power supply OFF	Light is ON
	Low	Power supply ON	Light is OFF
IR Sensor	Obstacle detected	Head count increment	Head count: Numeric values
	No Obstacle	No variation	Head count : Shows previous count
C02 (Gas Sensor)	High	LPG valve regulator OFF	CO2 is High
	Low	LPG valve regulator ON	CO2 is Low

V. CONCLUSIONS AND FUTURE WORKS

Ongoing researches on WSNs have lead to improved services in home automation and office automation as well as environment monitoring. In the presented paper automated Interactive Self Monitoring Wireless Sensor for Smart Office Using Zig-Bee Communications is presented which is more reliable in real time due to its simplicity, low power consumption, ease of use and good battery life.

Monitoring of up to four parameters can be done simultaneously which is an added advantage of the presented paper. Parameters include temperature, carbon-dioxide, light and head count. The use of advanced ARM Cortex-M3 microcontroller is designed in such a way as to consume less power and provide high speed. Also Zig-Bee communication provides faster interaction between the Transmitter and the Receiver compared to Bluetooth.

This work can further be extended with Wi-Fi that can cover larger range compared to Zig-Bee communications for various environments. Wi-Fi provides higher speed and flexibility. The cost of Wi-Fi technology is reasonable and can be implemented for monitoring specific environments and situations.

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