ZIGBEE BASED WEATHER MONITORING SYSYTEM

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ABSTRACT

The nature of wireless sensor networks (WSN) offers several advantages on monitoring and controlling applications over other traditional technologies including self healing, self organization, and flexibility. ZIGBEE is an IEEE 802.15.4 standard for data communication with business and consumer device. The technology behind ZIGBEE specification is intended to be simpler and less expensive than WPANs, such as bluetooth and wifi. The main objective of this project is to derive the statistical information about the abnormal geological and atmospheric conditions and send data to weather stations. The IEEE 802.15.4 covers the physical layer and the MAC layer of low rate WPAN.

Keywords: Characteristics, Mesh Topology, Weather Monitoring.

I. INTRODUCTION

In an industry during certain hazards it will be very difficult to monitor the parameter through wires and analog devices such as transducers. To overcome this problem we use wireless device to monitor the parameters so that we can take certain steps even in worst case. The main use of this module helps in an industry during the worst cases as the analog devices may be damaged may be during the fire accidents, etc. But with the wireless transmission we do not have an accurate data but when compared to the analog failure the errors are very minimum so we use wireless to monitor the parameter in industry where there is no means of human operator to monitor the parameters. It leads to the cheap wireless technology so it can be used for the low rate data transfer. The ZIGBEE technology is widely used for home and industrial automation.

II. ZIGBEE CHARACTERISTICS

A. ZIGBEE stack protocol

IEEE Std 802.15.4 defines the physical layer (PHY) and medium access control (MAC) sublayer specifications for low-data-rate wireless connectivity with fixed, portable, and moving devices with no battery or very limited battery consumption requirements typically operating in the personal operating space (POS) of 10 m. It is foreseen that, depending on the application, a longer range at a lower data rate may be an acceptable tradeoff.

SEVEN LAYERS OF OSI MODEL

- Application
- Presentation
- Session
- Transport
- Network
- Data link
- Physical

B. Physical Layer

The 802.15.4 standard specifies two different services that the Physical Layer(PHY) provides.The PHY data service controls the radio, and thus, the transmission and reception .The management service performs Energy Detection in the channel, Clear Channel Assesment before sending the messages and provides LQI for the received packets.

C. Architecture

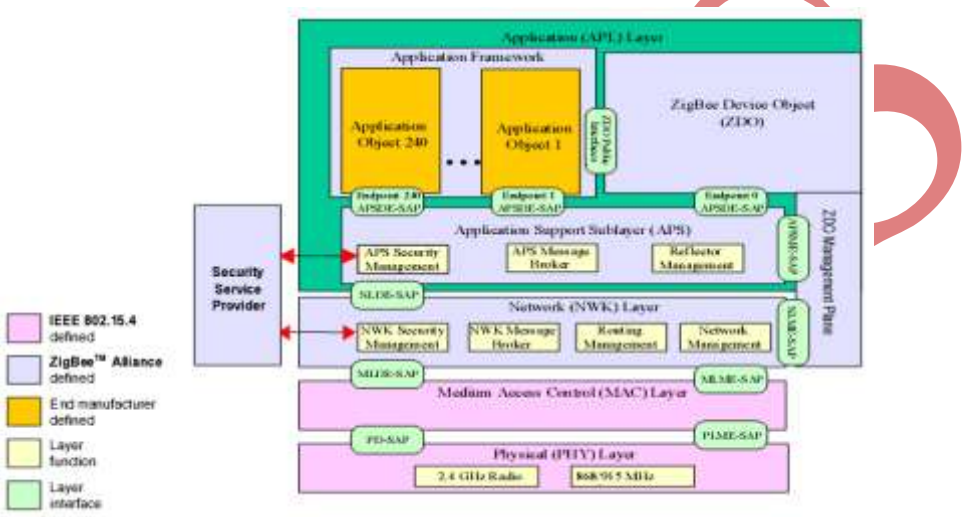

FIG 1: ZIGBEE PROTOCOL STACK ARCHITECTURE

i. MAC layer

The MAC management service, if the device is a coordinator, manages the network beacons. It is also responsible for PAN association and disassociation, frame validation, and acknowledgment providing "a reliable link between two peer MAC entities.Use the CSMA/CA for channel access and handles and maintains the GTS mechanism to device security. The IEEE 802.15.4 standard defines four different frame types: the beacon, data, acknowledgment, and MAC command frame. All frame types are based on the general MAC frame format. The frame control field describes and specifies the above different frame types.

Every MAC frame comprises a MHR, which consists of a frame control, sequence number, and the information field. It also contains the MAC payload.Different frame types have different MAC payload fields.

D. Wireless Sensor Network

The ZIGBEE (IEEE 802.15.4) is a new technology that permits the implementation of Wireless Personal Area Networks (WPAN). It is very suitable for wireless sensor networks due to the very low power consumption. This was one of the reasons why it was choose for the implementation of the system presented in this paper.

Summarizing, the main advantages of ZIGBEE in comparison with other technologies such Bluetooth or Wi-Fi are the following:

-flexible network architecture;

- Low cost.

- Low power consumption.

- Large number of nodes (≤ 65.536);

- Compatibility of equipments from producers;

The main disadvantages are:

- Low transmission speed.

- The existence of a single point of failure represented by ZIGBEE coordinator. The ZIGBEE technology allows the operation in so called mesh networks that are low cost, self organizing networks of ZIGBEE devices. The components of the mesh networks can operate over extended periods of time, even years, without changing the original battery. The ZIGBEE devices operate in unlicensed radio frequency bands (ISM). These unlicensed bands are not the same in all regions of the world, those the ZIGBEE devices can operate in three frequency bands centered on 868, 915 and 2400MHz. The most advantageous frequency band is at 2400MHz because of higher data rate (250kb/s) and the worldwide availability. In the 2402–2480 MHz frequency band is used offset phase-shift keying (O-QPSK) modulation technique. In the 868 and 902-928 frequency bands are used DSSS (Direct sequence spread spectrum) and BPSK (Binary phaseshift keying). The use of O-QPSK and BPSK minimize power consumption and reduce complexity.

In the structure of ZIGBEE networks the devices can be of tree types:

ZIGBEE Coordinator,

ZIGBEE Router,

ZIGBEE End Device.

ZIGBEE Coordinator (ZC) has the function to initiate the network structure by configuring the channels and establishing an ID for that network. It stores the security keys and is capable to bridge to the networks.

ZIGBEE Router (ZR) act as an intermediate device, its main function is to participate in multihop mesh routing of network messages. It maintains a routing table and manages local address allocation.

ZIGBEE End Device (ZED) does not participate in routing. It contains only the functionality to communicate with its parent node.

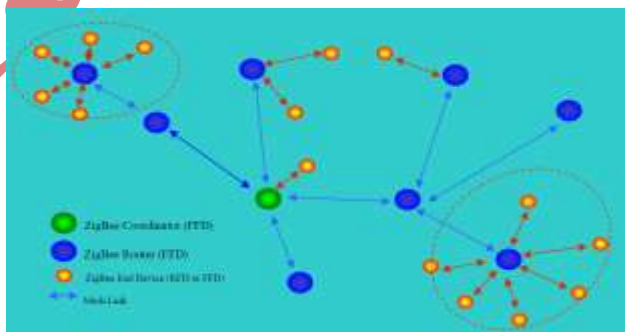

FIG 2: TOPOLOGY TYPE WIRELESS NETWORK

E. Data Transfer Types

Three different types of data transfer exist:-

Data transfer from a device to the PAN coordinator.

Data transfer from the PAN.

Peer-to-peer data Transfe

The types differ if the coordinator uses or does notbeacons

i. Data transfer from a device to the PAN coordinator

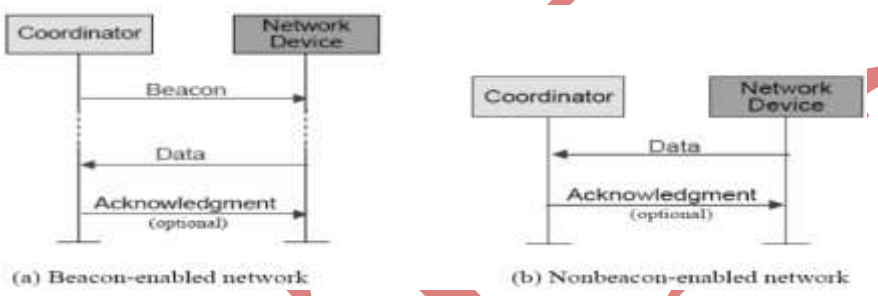

FIG 3: DATA TRANSFER FROM A DEVICE TO A PAN COORDINATOR

ii. Data transfer from the PAN coordinator

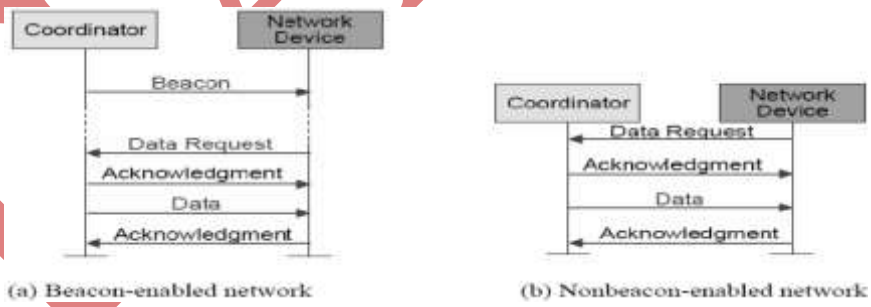

FIG 4: DATA TRANSFER FROM THE PAN COORDINATOR

iii. Peer- to-Peer data transfer

First devices are free to communicate with any other device communication range. In a peer-to-peer PAN the devices can “either receive constantly or synchronize with each other.”

F. ZIGBEE network topology

Network topology is the arrangement of the elements of a network. These elements are nodes or links. When two computers or devices are connected directly through a link then this topology is called peer-to-peer and is the simplest topology of all. The most wide spreading topologies are:-

The BUS topology

The RING topology

The STAR topology

The TREE topology

The Mesh topology

Finally there are some other types of topologies which are the result of the combination of the previous topologies. These are:

The Star-Bus topology

The Star-Ring topology

i. WPAN topologies

The main existing topologies are two that are the independent and the infrastructure. The simplest WLAN topology is the independent, which connects a pair of PCs with wireless adapters. There is no necessity of having AP (Access Point) here, because it's about a peer-to-peer connection but if an AP exists, it only acts as a repeater, in order to extend the range of the existing network.The infrastructure WLAN topology is more complex. Multiple APs link the WLAN to the wired network and allow users to efficiently share network resources. Through APs, all communications take place. APs apart from controlling communications with the workstations belonging to them, takes also care of communications with all the other APs in the network.

ii. Sort range wireless topology

Among others, there are four commonly used sort range wireless technologies. a) The IEEE 802.15.1 (Bluetooth), b) The IEEE 802.15.3 designed for High Rate WPANs, c) The IEEE 802.15.4 designed for Low Rate WPANs, and d) The ZIGBEE. Each one has advantages and disadvantages over the others in regard of power consuming, and data rate and also each of them has its own field of applications.

G. Security in ZİGBEE

The mechanism protects "the confidentiality, integrity, and authenticity of theMAC frames" An auxiliary header field in front of the MACpayload indicates if the frame is encrypted or not. The MAC frames' integrityis supported by calculating and using a MIC at the end of the MAC payload. Nonce is used to provide MAC confidentiality and authenticity**.** System consists of two parts one is transmitter and another is receiver part and both can be any number. Transmitter consists of weather sensors, icrocontroller and zigbee and the receiver part consist of PC interfaced with

zigbee through PC serial port. Here we monitor temperature, humidity and light with the help of respective sensors. The data from the sensors are collected by microcontroller and transmitted to the receiver section through wireless medium. All the parameters are viewed by the PC using visual basic program at the
receiver side.

III. SENSORS DESCRIPTION

A. *Resistive Humidity Sensor Model: Hr202*

FIG 5: RESISTIVE HUMIDITY SENSOR

HR202 is a new kind of humidity-sensitive resistor made from organic macromolecule materials, it can be used in occasions like: hospitals, storage, workshop, textile industry, tobaccos, pharmaceutical field, meteorology etc.

B. *LM35 Precision Centigrade Temperature Sensor*

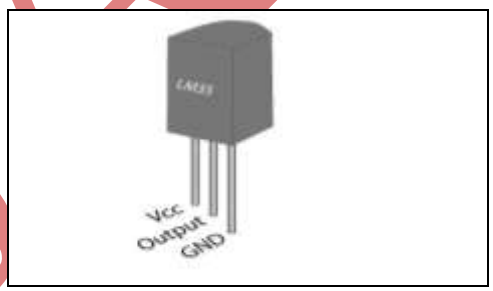

FIG 6: TEMPERATURE SENSOR

Lm35 is a precision IC temperature sensor with its output proportional to the temperature (in ^{o}c). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With lm35, temperature can be measured more accurately than with them. 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. *The Light Dependent Resistor*

Materials used as the semiconductor substrate include, lead Sulphide (PbS), Lead Selenide (PbSe), indium antimony (InSb) which detect light in the infra-red range with the most commonly used of all photoresistive light sensors being Cadmium Sulphide (Cds). Cadmium sulphide is used in the manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λp) of about 560nm to 600nm in the visible spectral range. The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photoresistive cells have a long response time requiring many seconds to respond to a change in the light intensity.

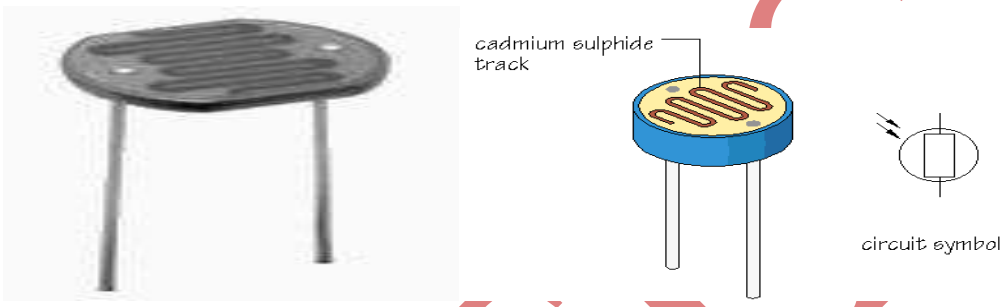

FIG 7: LIGHT SENSOR

As its name implies, the **Light Dependent Resistor** (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs in the material. The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photo resistive cells have a long response time requiring many seconds to respond to a change in the light intensity. Materials used as the semiconductor substrate include, lead sulphide (PbS), lead selenide (PbSe), indium antimony (InSb) which detect light in the infra-red range with the most commonly used of all photoresistive light sensors being **Cadmium Sulphide** (Cds). Cadmium sulphide is used in the manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λp) of about 560nm to 600nm in the visible spectral range.

D. *LDR Switch*

This basic light sensor circuit is of a relay output light activated switch. A potential divider circuit is formed between the photoresistor, LDR and the resistor R1. When no light is present ie in darkness, the resistance of the LDR is very high in the Mega ohms range so zero base bias is applied to the transistor TR1 and the relay is "OFF".

As the light level increases the resistance of the LDR starts to decrease causing the base bias voltage at V1 to rise. At some point determined by the potential divider network formed with resistor R1, the base bias voltage is high enough to turn the transistor TR1 "ON" and thus activate the relay which inturn is used to control some external circuitry. As the light level falls back to darkness again the resistance of the LDR increases causing the base voltage of the transistor to decrease, turning the transistor and relay "OFF" at a fixed light level determined again by the potential divider network.

By replacing the fixed resistor R1 with a potentiometer VR1, the point at which the relay turns "ON" or "OFF" can be pre-set to a particular light level. This type of simple circuit shown above has a fairly low sensitivity and its switching point may not be consistent due to variations in either temperature or the supply voltage. A more sensitive precision light activated circuit can be easily made by incorporating the LDR into a "Wheatstone Bridge" arrangement and replacing the transistor with an Operational Amplifier as shown.

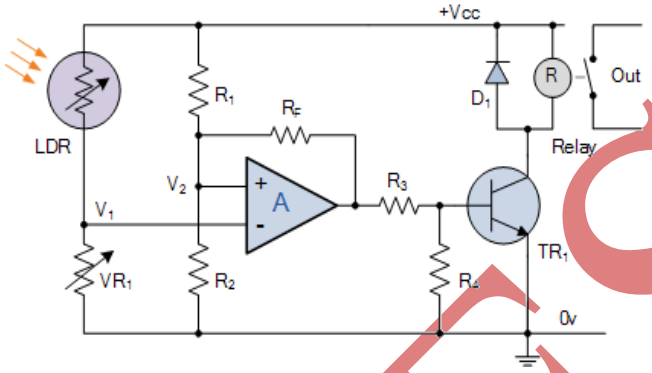

FIG 8: HIGH LEVEL SENSING CIRCUIT

In this basic dark sensing circuit, the light dependent resistor LDR1 and the potentiometer VR1 form one adjustable arm of a simple resistance bridge network, also known commonly as a Wheatstone bridge, while the two fixed resistors R1 and R2 form the other arm. Both sides of the bridge form potential divider networks across the supply voltage whose outputs V1 and V2 are connected to the non-inverting and inverting voltage inputs respectively of the operational amplifier. The operational amplifier is configured as a Differential Amplifier also known as a voltage comparator with feedback whose output voltage condition is determined by the difference between the two input signals or voltages, V1 and V2. The resistor combination R1 and R2 form a fixed voltage reference at input V2, set by the ratio of the two resistors. The LDR - VR1 combination provides a variable voltage input V1 proportional to the light level being detected by the photoresistor. As with the previous circuit the output from the operational amplifier is used to control a relay, which is protected by a free wheel diode, D1. When the light level sensed by the LDR and its output voltage falls below the reference voltage set at V2 the output from the op-amp changes state activating the relay and switching the connected load. Likewise as the light level increases the output will switch back turning "OFF" the relay. The hysteresis of the two switching points is set by the feedback resistor Rcan be chosen to give any suitable voltage gain of the amplifier.

The operation of this type of light sensor circuit can also be reversed to switch the relay "ON" when the light level exceeds the reference voltage level and vice versa by reversing the positions of the light sensor LDR and the potentiometer VR1. The potentiometer can be used to "pre-set" the switching point of the differential amplifier to any particular light level making it ideal as a simple light sensor project circuit.

IV. CONCLUSION

It is feasible to construct a WSN for emergency response notification using IEEE 802.15.4 and ZIGBEE. Moreover there is a range of sensing applications which can be developed using 802.15.4 MAC and PHY along with ZIGBEE stack this system has the potential to reduce the response time in a cost effective way. The system is robust and efficient methods can be incorporated to validate the threat by adding some additional options to the sensors, such as image processing and multiple sensors. This can help

reduce false positives. This system at the moment will be focusing on one aspect of the emergency detection which is fire which occurs mostly in many campuses across the states. The system can be further developed to detect other emergencies such as gas leaks, gunman on campus and severe weather changes. As ZIGBEE is a very fast growing technology tending to be a global standard and enters uninterruptedly in applications where only fantasy can limit, it can be safely told that there will be surprises in the next years as ZIGBEE enters the technological arena

REFERENCES

[1] IEEE Standard 802.15.3 - 2003.IEEE Standard for Information technology-Telecommunications and information exchange between systems-Local and metropolitan area networks-Specific requirements Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs)".

[2] IEEE Standard 802.15.1 - 2005.IEEE Standard for Information technology-Telecommunications and information exchange between systems-Local and metropolitan area networks-Specific requirements Part 15.1: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs).

[3] IEEE Standard 802.15.4 - 2006.IEEE Standard for Information technology-Telecommunications and information exchange between systems-Local and metropolitan area networks-Specific requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)".

[4] H. LABIOD, H. AFIFI, C. DE SANTIS, WI-FI, Bluetooth, ZIGBEE and WIMAX, Springer, The Netherlands, 2007.

[5] Hura G. S. and Sing had M 2001. Data and Computer Communications: Networking and Internetworking, CRC Press.

[6] Farahani S. ZIGBEE Wireless Networks and Transceivers Newnes2008.

[7] Gislason D ZIGBEE wireless networking, Newnes, 2002.

[8] Ergen S. C. ZIGBEE/IEEE 802.15.4 Summary, September 10, 2004.

[9] Eady F. Hands on ZIGBEE: Implementing 802.15.4 with Microcontrollers, Newnes2007.

[10] ZIGBEE Specification Document 053474r13, ZIGBEE alliance, December 1, 2006.