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Zigbee & Ethernet Based Monitoring & Controlling Of Real Time Industrial Parameters

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Abstract-
Networked embedded systems have become quite important nowadays, especially for monitoring and control the industrial devices. The World wide web is a global system of interconnected computer networks that used the standard Internet Protocol Suite (TCP/IP) to serve billion of users worldwide and allows the user to interface many real time embedded applications like data acquisition ,Industrial automations and safety measures etc,. This paper presents the design and application of wireless sensor network web server based on ARM and Zigbee protocol. It consists of the co-coordinator & sensor node. Coordinator is the centralized unit which collects the data from nodes and provides to the end user through TCP/IP protocol .These nodes are attached to Zigbee for remote monitoring & controlling action. Coordinator is implemented using ARM7. In industries or in home appliances, most of the time we need to monitor and control different parameters using controllers. There are several I/O pins available at the controller which were used to interface with sensors and relays for monitoring and controlling operations. Sensors acquired data from Zigbee. That data transfers to the client on remote location with the help of Ethernet. from that data acquisition controlling action was performed by the client on remote location.

Index Terms- **ARM , IDACS, RTOS, , SCM, TCP/IP**

I. INTRODUCTION

In numerous environmental factors, temperature, pressure are most important and the most difficult to control environmental factors. In some industrial areas there are some special requirements for it. In addition in recent years, energy and environmental problem becomes the hot topics that people concern, so we need energy conservation and environmental protection. [1] Monitoring and control is very important in realizing industrial automatization and high efficiency [2]. With the development of modern industry, the requirement for industrial monitoring system is getting higher. The system is required to be able to acquire, save, analyze, and process real time data. It is also required controlling related instruments to change those environment factors and monitoring in long distance so that it realizes modern, intelligent, and accurate control [3]. Currently, most environment monitoring systems are using a distributed framework .However, under the framework, wired communication is usually used between host and front-end node, because of difficult wiring ,limitation of control range of the system and high maintenance cost, these system cannot be use widely. In order to solve these problem, focus on the combination of embedded technology, GPRS & internet technology to realize industrial monitoring. system.[4].So, we use embedded technology& Ethernet technology for monitoring & controlling action .We will replace SCM (single chip microprocessors) with microprocessors based on ARM technology, which will greatly improve the overall performance of the system. The application of ethernet and embedded technology makes the remote monitoring possible and give the stability, reliability, security, and real-time of the data transmission. [5] It will effectively improve the scalability and maintainability of the control system and reduce the cost of the equipment maintenance. Base on these reasons, the system will meet the requirement of the centralized control.

In many process plants, the network is also expected to be intrinsically safe, meaning that a cable break will not cause flammable gases to ignite. Wireless networks definitely have the advantage of not using wire and are inherently safe. So we use a system that contains inbuilt Data Acquisition and Control system (DACS).In data acquisition unit data collected from Zigbee sensor nodes & in control system user on remote location takes controlling action. It is the great demand in consumer applications and many industries. There are data-acquisition and control devices that will be a substitute for a supervisor in a multisite job operation.[6] User who use web browser in the remote area can easily access wireless sensor network with help of Boa server.[7] Boa server is the single tasking HTTP server. Currently it is developed on Linux platform. Linux operating system is simple but difficult to recognize so to overcome this limitation we use ARM 7 processor which has Real Time Operating system & we design data acquisition unit with embedded language. For better industrial automation we can use modbus enabled Zigbee WSN. The modbus protocol is embedded into Zigbee stack. The modbus protocol allows the user to select the particular node & keep all other nodes deactivated for saving lot of power.[8].

Fig.1 shows Zigbee web server wireless sensor network. Every client can access the industry directly without any interaction with additional server and modules. This system contains single (ARM7/9) processor which is portable with Real Time Operating System (RTOS). It handles two modes at same time, DAC and Web server. During DAC mode Processor collects the data from wireless sensor node. There are two types of node one is sensor node which consists of sensor, ADC, controller. Other node is master node which consists of Zigbee, MAX232. During signal measurements Analog to digital converter is very important, because almost every external source is giving analog signal only. The real time operating system manages all the tasks such as measuring signals, conversion of signals, data base up-dation , and connecting/communicating with new users etc. The RTOS manages all the required tasks in parallel and in small amounts of time.

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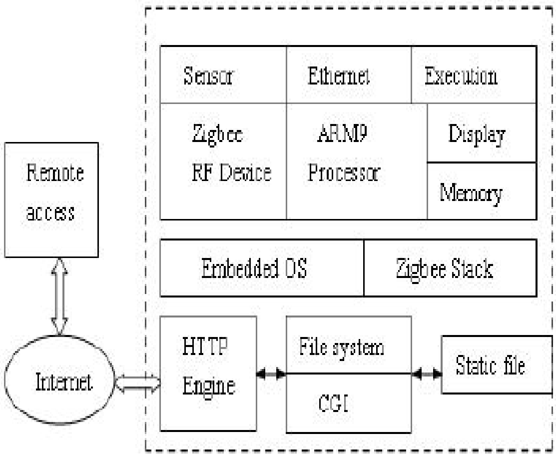

Fig. 1 System Overview

Similarly during web server mode processor will handle client request and response to the particular client. Client can interact the industry by giving instruction on remote location. This setup can be suitable for inter communication with other nodes via Ethernet and higher end ports. This system has many advantages: user-friendly, low-development cost and high maintainability.

II. STRUCTURE OF THE SYSTEM

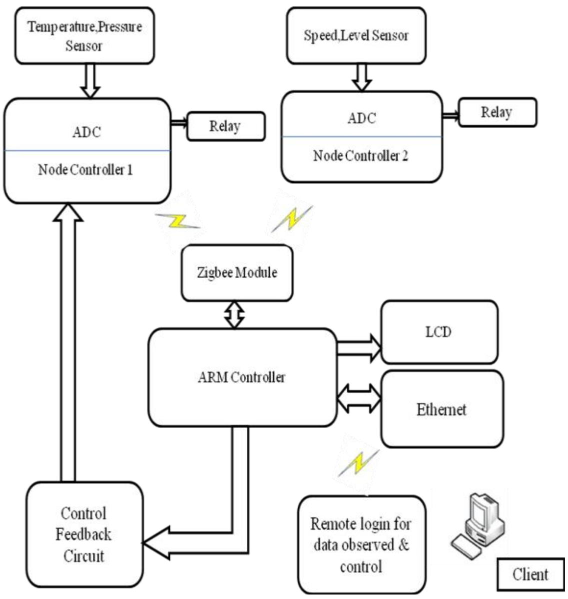

Fig. 2 Block Diagram

Fig. 2 shows the block diagram of the overall system. ARM controller is the main centralized unit, which collects the data from Zigbee master node through wireless sensor node .The sensor nodes consists of the Sensor, ADC controller .Sensor node 1 collects the data from Temperature & Pressure sensor. Sensor node 2 collects the data from Speed & Level sensor. Digital acquisition is done by ADC. The measured data is stored in external memory in which memory is act as data base during web server mode.

The ARM processor directly supports the Ethernet service communication. Hence the data has been stored and controlled by some other PCs or network via Ethernet. Remote data exchange between the application becomes easy due to Ethernet interface. This system has 16*2 LCD to display the information and measured parameters which makes the debugging and modification of the parameter easy. The controlling action of industrial process parameter is done through control feedback circuit via client through Ethernet modem when value exceeds above threshold value.

III. HARDWARE IMPLEMENTATION

A. LPC 2148(ARM 7 Processor):

Fig. 3 shows ARM 7 controller. The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those micro programmed Complex Instruction Set Computers. LPC 2148 has two UART ports UART0 & UART1.

Fig. 3 ARM 7 Controller

This is used for communication with external RS 232 based peripherals. This UART is used by controller for communication with Zigbee & Ethernet at a time. It has In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software. 8 to 40 KB of on-chip static RAM & 32 to 512 KB of on-chip flash program memory. USB 2.0 Full Speed compliant Device Controller with 2 KB of endpoint RAM. [9].

B .Serial to Ethernet Module:

Fig. 4 shows Serial to Ethernet module which is used in system. The Serial-to-Ethernet (S2E) module is a simple product that provides serial to Ethernet communications. Existing systems that lack Ethernet connectivity but have a UART or RS-232 port can be easily upgraded by the addition of the S2E module. Client can access this serial to Ethernet Module on remote location through IP address.TCP/IP protocol is used for communication to the client on remote location. [10]

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Fig.4 Serial to Ethernet Module

The MDL-S2E module provides the following features:

- LM3S6432 microcontroller.
- 10/100 Mbit Ethernet port.
- Two serial ports, configured as data communication equipment (DCE), include RTS/CTS for flow control.
- Module supports 5 V and 3.3 V supplies.
- Protocols include ARP, IP, ICMP, UDP, TCP, HTTP, DHCP, and Telnet.
- Multiple mounting options.

C. LM 35 Temperature Sensor:

As per system requirements for measuring Temperature the Precision Centigrade Temperature Sensor LM 35 is selected as shown in Fig.5.The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies.

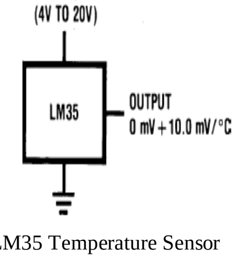

Fig. 5 LM35 Temperature Sensor

The operating range of this sensor is 4-30 volts. It gives 10mv/^{0}c output. Rated for full −55° to +150°C range. [11]

D. Level Sensor:

As per system requirements for measuring level of liquid selected Level Sensor as shown in Fig. 6. This level sensor gives the output in the form of resistance. So, by using constant current source supply converted that value into voltage.

Fig .6 Level Sensor

So we got level of liquid in the form of voltage. That voltage is amplified by using differential amplifier.

E. Speed Sensor MOC 7811:

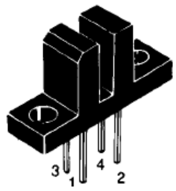

Fig. 7 MOC 7811

Fig.7 MOC 7811 shows Speed Sensor. It has internally LED & transistors. It gives output in between ground & +vs. By measuring pulses in between these two outputs we measured the speed of device in rpm. That output of speed sensor is directly connected to the interrupt pin of LPC 2148. [12]

F. Pressure Sensor MP3V5050:

As per system requirements for measuring pressure of device the MP3V5050 series silicon piezoresistive Pressure Sensor is selected. This sensor provides a very accurate and linear voltage output, directly proportional to the applied pressure. Fig.8 shows various types of pressure sensor. [13]

Fig.8 Pressure Sensor

IV. Wireless Sensor Network

A. Zigbee Architecture:

Zigbee is a Ad-hoc networking technology. It is Based On IEEE 802.15.4 standard that defines the PHY and Mac Layers. Zigbee technology is a low data rate, low power consumption, low cost; wireless networking protocol targeted towards automation and remote control applications. It is

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operated on three frequency bands these are 2.45 GHz , 868 MHz and 915 MHz Band. It is transmitted the data at the rate of 250Kbps for 2.45GHz ,40 Kbps for 915MHz and 20Kbps for 868MHz band. Fig 9 shows the architecture of Wireless sensor Nodes. It consists of the Power unit, 8 bit controller, Sensors & Transreceiver.

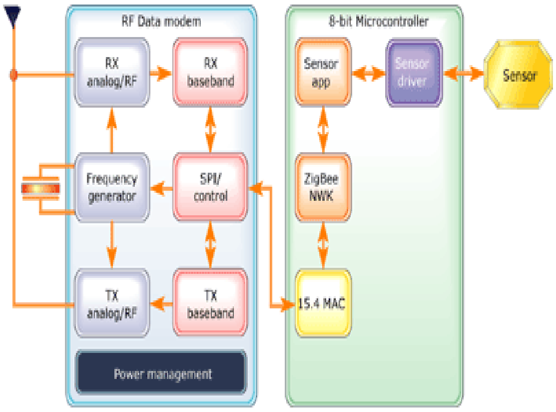

Fig. 9 Architecture Of WSN

B. Zigbee Network Initialization:

The coordinator is responsible for starting a Zigbee network. Network initialization involves the following steps:

1. **Search for a Radio Channel:**

The Co-coordinator first searches for a suitable radio channel. This search can be limited to those channels that are known to be usable.

2. **Assign PAN ID:**

The Coordinator starts the network, assigning a PAN ID (Personal Area Network identifier) to the network. The PAN ID can be pre-determined, or can be obtained dynamically by detecting other networks operating in the same frequency channel and choosing a PAN ID that does not conflict with theirs.

At this stage, the Coordinator also assigns a network (short) address to itself. Usually, this is the address 0x0000.

3. **Start the Network:**

The Coordinator then finishes configuring itself and starts itself in Coordinator mode. It is then ready to respond to queries from other devices that wish to join the network.

Once the network has been created by the Coordinator, other devices (Routers and End Devices) can join the network. Both Routers and the Coordinator have the capability to allow other nodes to join the network. The join process is as follows:

1. **Search for Network:**

The new node first scans the available channels to find operating networks and identifies which one it should join. Multiple networks may operate in the same channel and are differentiated by their PAN IDs.

2. **Select Parent:**

The node may be able to 'see' multiple Routers and a Co-coordinator from the same network, in which case it selects which one it should connect to.

3. **Send Join Request:**

The node then sends a message to the relevant Router or Co-coordinator asking to join the network.

4. **Accept or Reject Join Request**

The Router or Co-coordinator decides whether the node is a permitted device, whether the Router/coordinator is currently allowing devices to join and whether it has address space available. If all these criteria are satisfied, the Router/Co-coordinator will then allow the device to join and allocate it an address.

C .Sensor Network Topology:

The way that a message propagates through a ZigBee network depends on the network topology. However, in all topologies, the message usually needs to pass through one or more intermediate nodes before reaching its final destination. The message therefore contains two destination addresses:

- Address of the final destination
- Address of the node which is the next "hop"

The way these addresses are used in message propagation depends on the network topology, as follows:

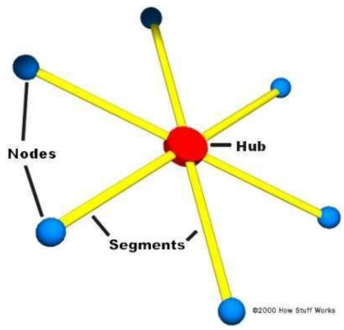

Fig.10 Star Topology

It is a group of nodes that are hooked up to a coordinator. If one connection fails it doesn't affect the others.Fig.10 shows the star topology architecture. All messages are routed via the Co-coordinator. Both addresses are needed and the "next hop" address is that of the coordinator.

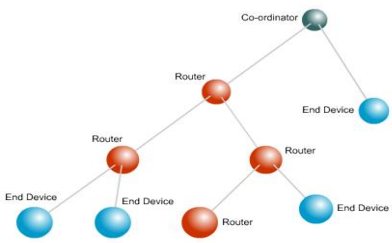

Fig.11 Tree Topology

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It connects multiple star networks to other star network. If one cable between each of the two star topology networks failed then these network would be unable to communicate with each other. However nodes on the same star topology would still be able to communicate with each other.Fig.11 shows the star topology architecture. A message is routed up the tree until it reaches a node that can route it back down the tree to the destination node. Both addresses are needed and the initial "next hop" address is that of the parent of the sending node. The parent node then resends the message to the next relevant node - if this is the target node itself, the "final destination" address is used. The last step is then repeated and message propagation continues in this way until the target node is reached.

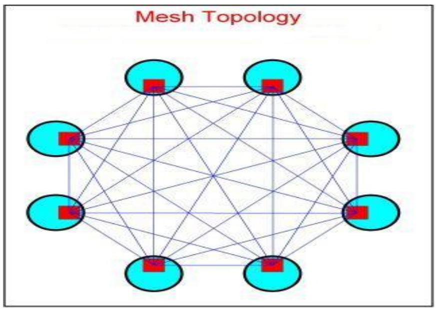

Fig.12 Mesh Topology

In this topology every node has connection to the other node in the network. This network also allows multiple hope communication for increased reliability. Routers on this network characterize the alternative routes available to them& choose best path. So this network extends widely. Fig 12 shows the mesh topology architecture. In this case, the propagation path depends on whether the target node is in range:

- If the target node is in range, only the "final destination" address is used.
- If the target node is not in range, the initial "next hop" address is that of the first node in the route to the final destination. The message propagation continues in this way until the target node is reached.

V. RESULTS

Fig.13 LCD parameter Results

This system uses 4 sensors these are Temperature Sensor, Level Sensor, Pressure sensor & Speed sensor.Fig.13 shows the sensor outputs on LCD. If centralized unit collects the data from WSN through Zigbee master node, then we can see the above results on LCD. On LCD T: indicates the monitoring value of the Temperature. P: indicates the monitoring value of pressure. L: indicates the monitoring value of Level & S: indicates monitoring value of Speed.

Ethernet is used in the system to access the whole system on remote location. It is accessed by client on remote location through IP address. When Zigbee master node transmits data to the controller, then that data is transferred to the client on remote location with the help of Ethernet. The Fig 14 shows testing of the Ethernet on HyperTerminal through TCP/IP protocol by typing IP address with port no 23. Fig. 14 shows the Ethernet access, with the help of this procedure we connects the Ethernet to the system & it transfers all the parameter results on HyperTerminal as shown in Fig 15.

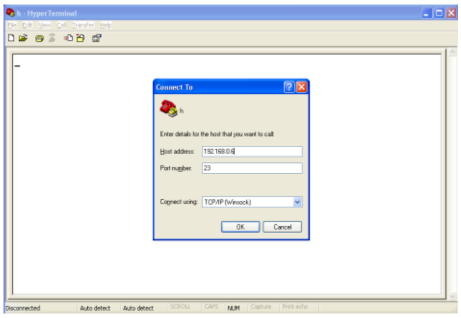

Fig.14 Ethernet Access

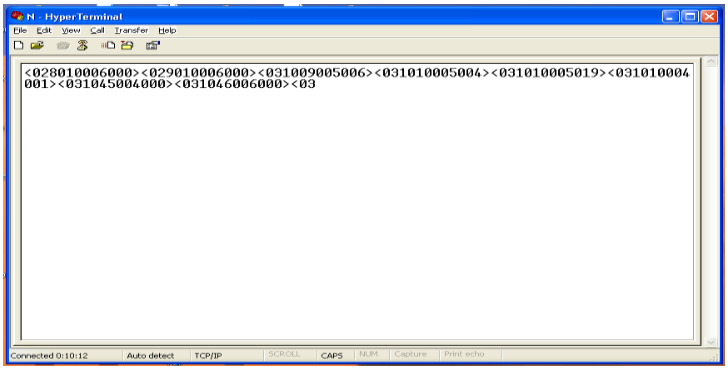

Fig.15 Parameter Results on HyperTerminal

The results on HyperTerminal is the 14 bits long. Out of which 1st three digits are Temperature Sensor parameter result. Next three digits are the Level Sensor parameter result. Further next digits for the Pressure & Speed parameter results.

Fig.16 shows the GUI of the system. When user on remote location access the whole system by IP address of Ethernet then this parameter results on HyperTerminal transfers to the GUI of the system. So client gets all the information of the system on remote location. The GUI shows the monitoring value & set point values of the sensors. Also shows the control circuit. The client on remote location can change the set point of these sensors manually on GUI. When monitored value exceeds the set point then control circuit takes an action through relay.

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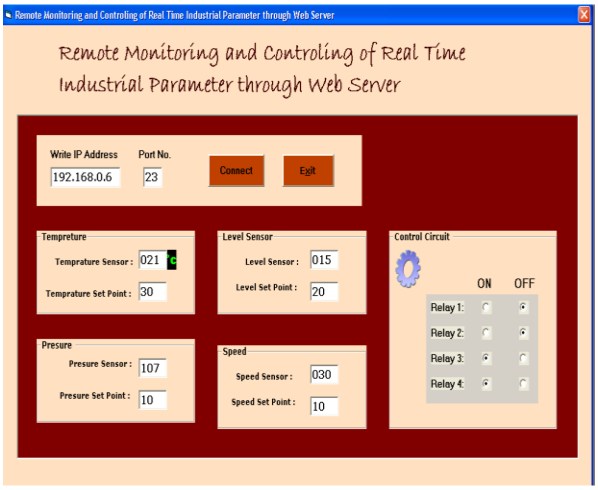

Fig16 GUI Of The System

VI CONCLUSION

Thus we can design real time monitoring & controlling of industrial parameters with the help of Zigbee & Ethernet. IEEE 802.15.4 provides authentication, encryption, and integrity services for wireless system that increases security level of the system. Total reliability of the system depends upon the accept packet data rate. Accept packet data rate of each sensor node is more than 90%.The main advantages of the system are low power consumption, easy access, and high performance.

Our system can be extended for sensing malfunctioning in industrial machines and making corrective measures in it. More and more automation is being handled via remote communication. This Zigbee web server WSN gives the way to numerous applications for development in the area of monitoring and automation.

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