Wireless Sensor Network for Industrial Applications

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Abstract**—** The Wireless Sensor Networks are nowadays widely considered as a one of the most important technologies for the twenty-first century. Over recent years, the WSN and their applications were under the focus of both academia and industry all over the world. Nowadays, the WSN are widely used in various applications areas, including but not limiting to: health care and medicine, home or office automation; industry; road traffic control; farming and forestry; civil infrastructure monitoring; disaster detection and alarm systems. Each of these areas has specific environment and certain application requirements for the WSN. We are presenting the results and lessons learned during evaluating WSN in the real-life industrial environment and two industrial WSN applications development and deployment that have been done within the use of Real Time Data Acquisition Process for Industrial Applications. For real time data acquisition system microcontroller Atmega32u4 is easily interfaced with nRF24.This sensor continuously generates enormous amount of data in the form of packets and frame (date, time, source address, destination address, data, ERC) which can easily reach to the destination and monitor on cloud by using open source API i.e. Thingspeak which is a part of Internet of Things.

Keywords—*ATmega32U4, nRF24L01, Wireless Prtocol.*

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I. INTRODUCTION

A wireless sensor network consisting of spatially distributed autonomous sensor equipped with low power transceivers can be an effective tool for gathering data in variety of environments. These nodes perform certain measurements and need to transmit all the collected information to base station over a wireless channel. The data are then processed in the base station to draw some conclusions about the current activity in the area. The idea of wireless sensor network is to interact with the environment. Wireless sensor network are usually embedded in an environment. Fig. 1 depicts Wireless sensor network connected to the internet.

Number of sensor nodes combinely form a network. These wireless sensor nodes are equipped with sensors which are capable to measure environmental parameters i.e. temperature, pressure, humidity and more others. The measured data is processed into certain format and makes it available to different applications. The Internet of things is the network of physical objects with embedded technology to sense, communicate and interact with their internal states or the external environment [1]. In the WSN context, data may transmit by using different hardware nodes which can be transmit data to the cluster head of a network then cluster can transmit it to the base station. In this technique data can transmit over a small distance. Data can be transmitted over a large distance but it requires large power otherwise data may loss.

I. OBJECTIVE

- To study different techniques of large data transmission over Wireless Sensor Networks.
- To study and analyze design routing protocol and their specification.
- To implement network nodes to transfer data using different sensors from different wireless sensor network.

II. WORKING AND DESIGN PRINCIPLE

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The design principles and technical approaches in IWSNs are broadly classified into three categories:

- Hardware development
- Software development
- System architecture and protocol design

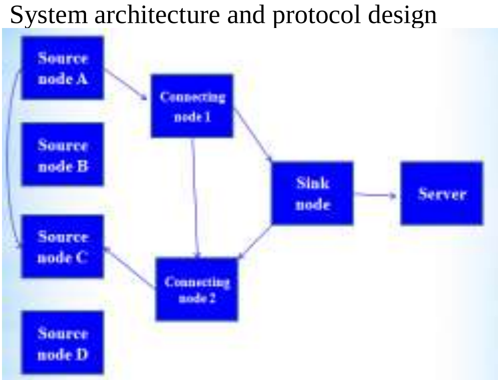

Fig.1 Block diagram of WSN

III. TOOLS USED AND METHODOLOGY

Wireless node consists of:

- Microcontroller
- Sensors
- Power supply
- Communication modules
- SD card

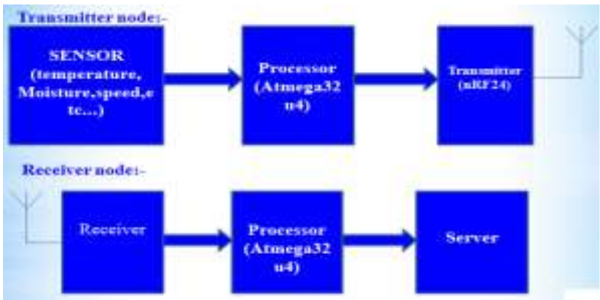

Fig.2 Block diagram of node

A. *Microcontroller (ATmega32U4)*

The ATmega32U4 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32U4 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

B. *nRF24L01 transreceiver*

The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced Shock Burst), designed for ultra low power wireless applications. The nRF24L01 is designed for operation in the world wide ISM frequency band at 2.400 -2.4835GHz. An MCU (microcontroller) and very few external passive components are needed to design a radio system with the nRF24L01. The nRF24L01 is configured and operated through a Serial Peripheral Interface (SPI.)

Through this interface the register map is available. The register map contains all configuration registers in the nRF24L01 and is accessible in all operation modes of the chip. The embedded baseband protocol engine (Enhanced Shock Burst) is based on packet communication and supports various modes from manual operation to advanced autonomous protocol operation. Internal FIFOs ensure a smooth data flow between the radio front end and the system's MCU. Enhanced Shock- Burst™ reduces system cost by handling all the high-speed link layer operations. The radio front end uses GFSK modulation. It has user configurable parameters like frequency channel, output power and air data rate.

The air data rate supported by the nRF24L01 is configurable to 2Mbps. The high air data rates combined with two power saving modes makes the nRF24L01 very suitable for ultra low power designs. Internal voltage regulators ensure a high Power Supply Rejection Ratio (PSRR) and a wide power supply.

C. *Sensors used:*

- DHT11 (humidity and temperature)
- BMP180 (digital barometric pressure sensor)
- LDR(Light intensity sensor)
- PIR(motion sensor)

D. *Software (Arduino)*

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, and MaxMSP).

Arduino is serving as the basis of breathalyzers, for home automation systems, screens with Twitter messages of DNA testing kits, traffic lights, art installations, 3D printer, or system to detect earthquakes and report via Twitter if the tremor occurs less than five kilometers. A major milestone has been connecting Arduino to mobile phones with Arduino boards. Google launched an ADK (Android Open Accessory Development Kit) an interface for communicating with the operating system Android Hardware devices (Arduino).

IV. SENSORS

The best part of this application is sensors employed in this wireless module. In Wireless sensor networks, Desirable functions for sensor nodes include: ease of installation, self-identification, self-diagnosis, reliability, time awareness for coordination with other nodes. The wireless nodes are equipped with sensors due to which they are able to measure different parameters.

A. *DHT11 Temperature and Humidity Sensor*

DHT11 temperature and humidity sensors are digital sensors. DHT11 elements are extremely accurate on temperature and humidity calibration. Calibration Coefficients are stored in the OTP memory of DHT11 in the form of programme, which are used by internal signal detecting process of sensors. The sensor provides single-wire serial interface, this makes the system integration easier. DHT11 sensors are small in size, it consumes less power and up to20 meters signal transmission. Because of these advantages of DHT11 sensors are used in various applications. It is a 4-pin single row pin package [6]. It is convenient to connect to the sensor node. The interfacing of DHT11 sensor with microcontroller is shown in Fig. 4.

Fig. 4: DHT11Temperature and humidity sensor

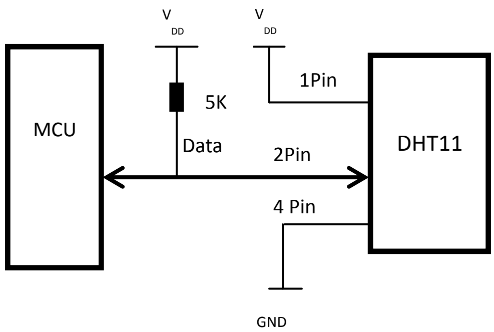

Fig. 5 Interfacing of microcontroller with DHT11

B. PIR Sensor

The pyroelectric infrared sensor detects infrared radiation on the basis of the characteristics that the polarization of pyroelectric material changes with temperature. Dual compensated sensing elements are applied to suppress the interference resulting from temperature variation. As a result, the operating stability of the sensor is greatly improved [7].

Address (Hide)	Date (YY:MM:DD)	Time (HH:MM:SS)	Node Name	Data	ERC

Fig. 6 Packet Format

V. LITERATURE SURVEY

In 2001, *Schurgers* et al worked on 'Energy Efficient Routing in Wireless Sensor Networks'. His first approach was to use a concept termed as Data Combining entities or DCE's. This concept is similar to clustering, instead of designating a cluster head; it picked up a node that has other streams of network traffic flowing through it as the DCE [8]. The second approach discussed by *Schurgers* et al to reduce energy consumption in a wireless sensor network is the spreading of network traffic over the entire network. In the same year, *Slijepcevic et al* in the paper 'Power Efficient Organization of Wireless Sensor Networks' discussed on reducing the overall power in the network system by grouping the sensor nodes into mutually exclusive sets in 2001 [9]. This technique assumed that the nodes are placed stochastically.

"Maximizing System Lifetime in Wireless Sensor Networks" by *Dong*, is one of the first papers to differentiate between the "time" and "transmission" approaches to overall lifetime of a wireless sensor node network in 2005 [10]. He considered many different time based and packet based models. *Chao-Lieh Chen et al* authored the paper "Energy-proportional Routing for Lifetime extension of Clustering-Based Wireless Sensor Networks" in 2007. He presented an algorithm to determine the energy usage for nodes in an upcoming round of data collection and transmission; it then determines if a cluster-head or a node should be used for forwarding tasks or transmits data to intermediate hops [11].

In 2008 *Kim et al* in his paper 'Minimizing Delay and Maximizing Lifetime for Wireless Sensor Networks with Anycast' pertained a unique type of wireless sensor network, namely an event-driven network that uses ''Anycast". Utilized a wake-sleep cycle for the sensor nodes, i.e. instead of having one node that a sensor node will transmit its messages to, a node will have a group of candidate nodes that it can transmit to [12]. *Jiang et al* worked on classification of WSN clustering schemes based on 8 clustering attributes in 2009. He also analyzed popular WSN clustering algorithms and also comparision between those algorithms [13]. *Vipul Gupta* worked on developing a web-based service called Sensor network that facilitates a heterogeneous mix of devices to interact with one another in the paper 'Sensor Network: An open data exchange for the web of things' in year 2010 [14].

VI. SOFTWARE

In this project we used Arduino software available as an open source platform which makes it easier to write program and upload it to the circuit boards. Basically there are two nodes used in any network i.e. Server node and Client node. Server node is always connected to the serial port of the computer. During initialization, server node initializes RTC (Real time Clock) for real time data acquisition, nrf24L01 (transceiver) for packet data transceiver and SD card for data storage and other parameter which are connected. On the other hand the client node also initialized by software with to observe packet data transmitted or not then it will be powered by an adapter and kept it away from server node in range of transceiver. Client node will send the measured data in the form of packets to the server node.

Fig. 6 shows the packet format of data transmits and received by client node and server node.1st block indicated by source and destination address, 2nd and 3rd block for date in YY: MM: DD and time in HH:MM:SS format, 4th block indicate node name which is mentioned in program, 5th block indicate data collected by the sensors connected with client node and send it to server node, 6th block for error check whether data is properly send by client node and received by server node.

VII. CONCLUSIONS AND FUTURE SCOPE

Although the use of WSN provides many benefits for industry and there are many various potential application areas for Industrial WSN, the problem of implementing reliable wireless communication in real-life industrial environment is still very complicated and requires further research.

Currently the project would deal with communication between nodes placed in a single industry. In future, it could be further expanded to communication between nodes placed in different industries of a particular firm using a secured channel. We plan to make our nodes autonomous by interfacing them with solar panels.

It has been conclude that we can design the WSN's for different application where the data transmitted by client node, received by server node and the same is made available on an open source API i.e. Thingspeak. The same data can also monitor by serial monitor by using COM port (Shown in aoe figure) and also store in SD card for future use. This shows that WSNs are fully capable of robust and reliable communication in the harsh environment found on industrial platforms. Although the use of WSN provides many benefits for industry and there are many various potential application areas for Industrial WSN, the problem of implementing reliable wireless communication in real-life industrial environment is still very complicated and requires further research. In future, it could be further expanded to communication between nodes placed in different places where we can also apply security and also work on different protocols.

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