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Smart Sensor Interface over IOT Using Raspberry PI Board



M. Nagulu Naik
M.Tech Student
Farah Institute of Technology
Shabad Ring Road, Chevella,
R.R.Dist., Hyderabad.

Sreekanth
Associate Professor
Farah Institute of Technology
Shabad Ring Road, Chevella,
R.R.Dist., Hyderabad.

Sooram Anil
Associate Professor
Farah Institute of Technology
Shabad Ring Road, Chevella,
R.R.Dist., Hyderabad.

Abstract:

A sensor interface device is essential for sensor data collection of industrial wireless sensor networks (WSN) in IoT environments. However, the current connect number, sampling rate, and signal types of sensors are generally restricted by the device. Meanwhile, in the Internet of Things (IoT) environment, each sensor connected to the device is required to write complicated and cumber-some data collection program code. In this paper, to solve these problems, a new method is proposed to design a reconfigurable smart sensor interface for industrial WSN in IoT environment, in which Raspberry Pi board is adopted as the core controller. Thus, it can read data in parallel and in real time with high speed on multiple different sensor data. The standard of IEEE1451.2 intelligent sensor interface specification is adopted for this design. It comprehensively stipulates the smart sensor hardware and software design framework and relevant interface protocol to realize the intelligent acquisition for common sensors. A new solution is provided for the traditional sensor data acquisitions. Performance of the proposed system is verified and good effects are achieved in practical application of IoT to water environment monitoring.

Keywords: ***Raspberry Pi Board (ARM11), X-bee wireless communication, GAS Sensor, LM35, IoT, Ethenet, Sensor data acquisition, LINUX OS***

1. INTRODUCTION

Wireless sensor Network have been employed to collect data about physical phenomena in various applications such as habitat monitoring, and ocean monitoring, and surveillance [1]–[3]. As an emerging technology brought about rapid advances in modern wireless telecommunication, Internet of Things (IoT) has attracted a lot of attention and is expected to bring benefits to numerous application areas including industrial WSN systems, and healthcare systems manufacturing [4], [5]. WSN systems are well-suited for long-term industrial.

Environmental data acquisition for IoT representation [6]. Sensor interface device is essential for detecting various kinds of sensor data of industrial WSN in IoT environments [7]. It enables us to acquire sensor data. Thus, we can better understand the outside environment information. However, in order to meet the require-ments of long-term industrial environmental data acquisition in the IoT, the acquisition interface device can collect multiple sensor data at the same time, so that more accurate and diverse data information can be collected from industrial WSN.

With rapid development of IoT, major manufacturers are dedicated to the research of multisensory acquisition interface equipment [8]. There are a lot of data acquisition multiple-interface equipments with mature technologies on the market. But these interface devices are very specialized in working style, so they are not individually adaptable to the changing IoT environment [9]. Meanwhile, these universal data acquisition interfaces are often restricted in physical properties of sensors (the connect number, sampling rate, and signal types). Now, micro control unit (MCU) is used as the core controller in mainstream data acquisition interface device. MCU has the advantage of low price and low power consumption, which makes it relatively easy to implement. But, it performs a task by way of interrupt, which makes these multisensory acquisition interfaces not really parallel in collecting multisensory data.

On the other hand, ARM fammily has unique hardware logic control, real-time performance, and synchronicity [10], [11], which enable it to achieve parallel acquisition of multi sensor data and greatly improve real-time performance of the system [12]. Raspberri Pi boad has currently becomes more popular than MCU in multisensor data acquisition in IoT environment. However, in IoT environment, different industrial WSNs involve a lot of complex and diverse sensors. At the same time, each sensor has its own requirements for readout and different users have their own applications that require different types of sensors [13]. It leads to the necessity of writing complex and cumbersome sensor driver code and data collection procedures for every sensor newly connected to interface device, which brings many challenges to the researches [14]–[16].

II.SYSTEM ARCHITECTURE

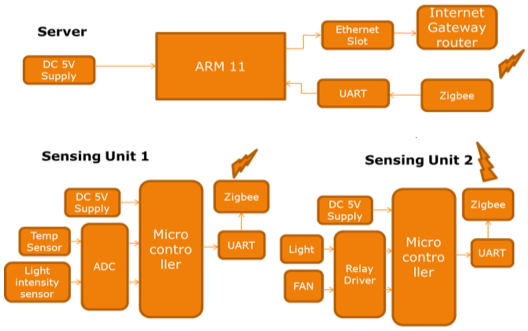

Figure.1 System block diagram

Sensor data acquisition surface device is the key part of study on industrial WSN application [17]. In order to standardize a wide range of intelligent sensor interfaces in the market and solve the compatibility problem of intelligent sensor, the IEEE Electronic Engineering Association has also launched IEEE1451 smart transducer (STIM) interface standard protocol suite for the future development of sensors [18]. We design a reconfigurable smart sensor interface device that integrates data collection, data processing, and wired or wireless transmission together. The device can be widely used in many application areas of the IoT and WSN to collect various kinds of sensor data in real time. We program IP core module of IEEE1451.2 corresponding protocol in its Pi board. Therefore, our interface device can automatically discover sensors connected to it, and to collect multiple sets of sensor data intelligently, and parallel with high-speed.

Raspberry Pi board is core controller of the interface device. It is used to control data acquisition, processing, and transmission intelligently, and make some preprocessing work for the collected data [38]. The driver of chips on the interface device is also programmed inside the processor.

Multiple scalable interfaces are designed on the equipment. It can be extended to 8-channel analog signal interface and 24-channel digital signal interface. This ensures that our device can connect with a number of sensors among the application of industrial IoT or WSN and guarantees the diverse collection of the information.

In terms of data transmission, our design can achieve wired communication through Universal Serial Bus (USB) interface and wireless communication through Zigbee module. Therefore, we can choose different transmission mode of the device in different industrial application environments.

Fig. 1 is the application and working diagram of the reconfigurable smart sensor interface device.

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In practice, the designed device collects analog signal trans-mitted from light intensity sensors, and other similar sensors through an analog signal interface. It can also collect digital signal transmitted from the digital sensors, such as temperature sensors, Gas sensor, digital humidity sensors, and so on, through a digital signal interface. The Analog to Digital Converter (ADC) module and signal interface on the interface device are controlled by the ARM11, which makes it possible to collect the 8-channel analog signals and 24-channel digital signals circularly, and sets these collected data into the integrated Static Random Access Memory (SRAM) on the interface device. The collected data can be transmitted to the host computer side by way of USB serial wired communication or Zigbee wireless communication, so that the user can analyze and process the data.

By focusing on the above issue, this paper designs and realizes a reconfigurable smart sensor interface for industrial WSN in IoT environment. This design presents many advantages as described below. First of all, ARM11 is used as the core controller to release the restriction on the universal data acquisition interface, and realize truly parallel acquisition of sensor data. It has not only improved the sensor data collection efficiency of industrial WSN, but also extended the application range of the data acquisition interface equipment in IoT environment. Secondly, a new design method is proposed in this paper for multi sensor data acquisition interface that can realize plug and play for various kinds of sensors in IoT environment. In this paper, this design take full advantage of ARM11 characteristics, such as high execution speed, flexible organization structure, IP design could reuse, etc. The design adopts IEEE1451 smart transducer (STIM) inter-face standards, which makes our device better compatible in the field of industrial WSN in IoT environment.

The rest of this paper is organized as follows. The architecture is presented in Section II, and detailed hardware and software implementations are described in Section III. The application in water quality monitoring is discussed in Section IV. Finally, we conclude our work in Section V.

III.HARDWARE IMPLEMENTATION

3.1. Raspberry Pi Board

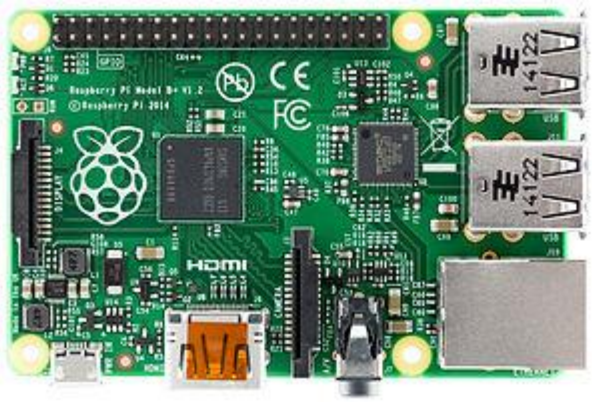

Figure 2: Raspberry Pi Board

Raspberry Pi (shown in Fig. 2) is a has 5 12Mb RAM, 2 USB ports and an Ethernet port. It has a Broadcom BCM2835 system on a chip which includes an ARMl176JZF -S 700 MHz processor, Video Core IV GPU, and an SD card. The GPU is capable of Blu-ray quality playback, using H.264 at 40MBits/s. It has a fast 3D core accessed using the supplied OpenGL ES2.0 and Open VG libraries. The chip specifically provides HDMI and there is no VGA support. This includes but is not limited to education tools, especially the use of GPIO (General Purpose Input/Output) which allows automated data acquisition and producing simple digital control systems in a school laboratory setting. The most distinctive feature of the Raspberry Pi when used for educational purposes is the GPIO module, which allows interfacing with general purpose electronics.

3.2. Zigbee wireless communication

The wireless sensing units with internal sensors to measure temperature, light, humidity, electrical parameters, etc., are deployed at the house as shown in Fig. 3. Electrical sensing units are fabricated in such a way that they can be easily plugged into power points and can operate according to their functional

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characteristics within an indoor range of about 70-80 meters provided an XBee S2 Pro module is used. We considered Xbee-S2 modules in the present setup as they provide sufficient indoor range (i.e. up to 40 meters).

3.3 IoT Application Gateway -Address Transformation

The key element in the data transformation from ZigBee to IPV6 format is the address translation. This was implemented by the application gateway program for determining the source or destination address of a packet that encapsulates a ZigBee packets' payload. The corresponding application gateway performs the address transformation mechanism for ZigBee to address non ZigBee nodes. ZigBee is based upon the 802.14.5 protocol which uses a 64 bit address for each node on a PAN, and 16 bits to identify the PAN ID. IPv6 uses 128 bits to address a node on the network, of which 48 bits represent the network, 16 bits represent the local network (PAN ID), and 64 bits represent the host id (sensor node). Therefore, the node address for 802.15.4 can placed in an IPv6 address, and the PAN ID can be used to identify the ZigBee network in an IPv6 address.

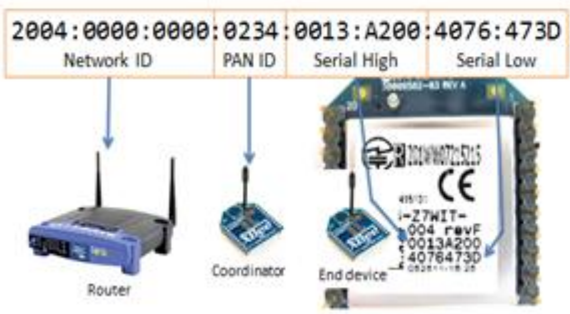

Figure 3: Address transformation from ZigBee sensing unit to Internet Packet

3.3. Sensor Characteristics

The environmental parameters (temperature, humidity and light) are important aspects for deciding whether equipment such as (fans, electric heaters or lamps) should be switched on or off in a wireless monitoring network used for energy management in the home. The following sensors are used in the present setup. The sensor nodes used in the ZigBee WSN have a temperature sensor (TMP 36) [25] operating in the range of -20°C to +125°C. The output voltage out of this sensor varies 1°C for every 10mV with 500mV offset voltage. The light sensor used was LDR.

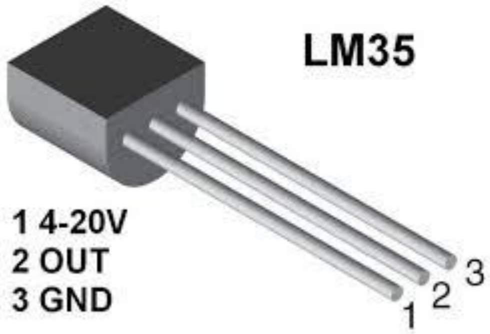

Figure 4: Temperature sensor

ULTRA SONIC SENSOR:

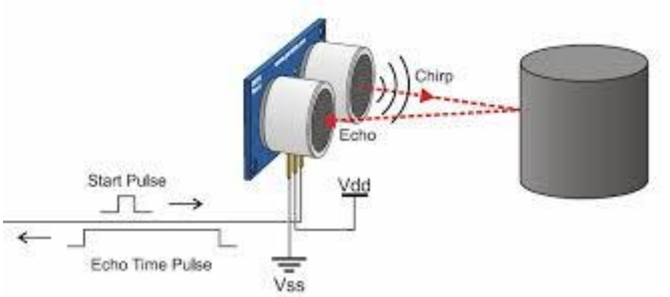

Figure 5: Ultrasonic sensor

Ultrasonic transducers are convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit. These devices work on a principle similar to that of transducers used in radar and sonar systems, which evaluate attributes of a target by interpreting the echoes from radio or sound waves, respectively. Active ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present

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under certain conditions, convert it to an electrical signal, and report it to a computer.

GAS SENSOR

Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacture processes and emerging technologies such as photovoltaic. They may be used in firefighting.

Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Common sensors include infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and semiconductor sensors. More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries, waste-water treatment facilities, vehicles, and homes.

Figure 6: GAS sensor

V.EXPERIMENTAL RESULTS

The developed system is tested by installing the Smart sensing units and setting up a ZigBee based WSN at few houses. Interconnecting ZigBee network with IPv6 network is performed by connecting and configuring the modified router (IoT application gateway) as discussed in section III. Integrated system was continuously used and generated real-time graphical representation of the sensing information.

Fig. 6(a,b,c) shows the type # 1 sensing unit information in real-time on the IoT website. Measurements related to temperature, light intensity, Gas leakage detection are shown in Fig. 6(a), system of the sensor entities has been reflected in the form of IoT for better remote utilization and controlling through an internet website.

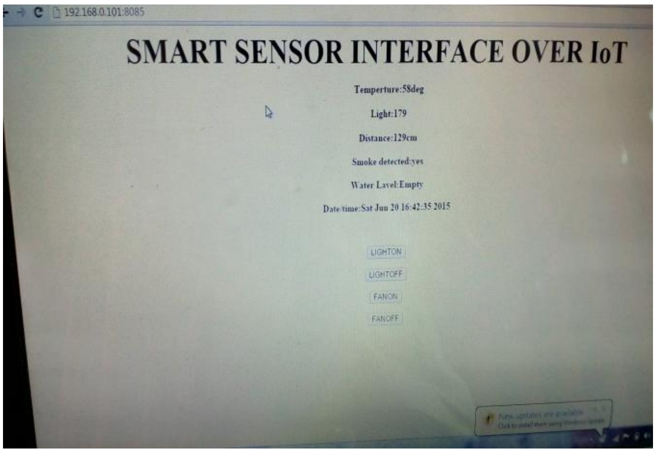

Figure7: sensor values on web page

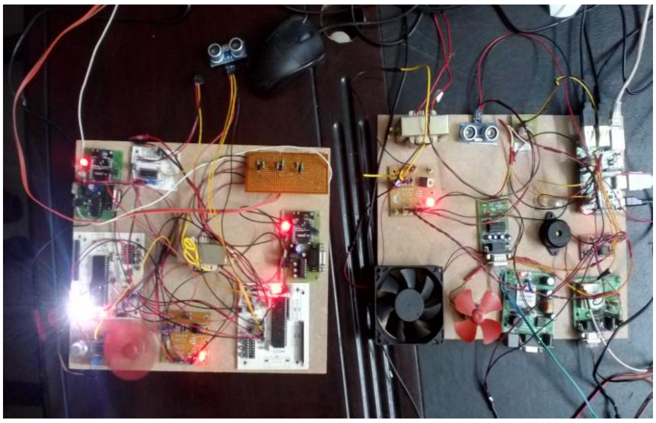

Figure 8: hardware setup

According to Figure 6(a), massage was received when motorcycle falls Figure 6(b), shows massage from nonlinear Fall detection using MEMS accelerometer has been implemented and tested by using bicycle instead of motorcycle because it is less dangerous and the basic structure is like motorcycle. However, some parameters such as mass of rider and motorcycle were ignored in this experiment. Typical data for motorcycle fall without external force or linear fall is shown in Fig 4. For linear fall, only acceleration on z-coordinate is used to determine the accident.

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VI.CONCLUSION

This paper describes a reconfigurable smart sensor interface for industrial WSN in IoT environment. The system can collect sensor data intelligently. It was designed based on IEEE1451 protocol by combining with ARM11 and the application of wireless communication. It is very suitable for real-time and effective requirements of the high-speed data acquisition system in IoT environment. The application of ARM11 greatly simplifies the design of peripheral circuit, and makes the whole system more flexible and extensible. Application of IEEE1451 protocol enables the system to collect sensor data intelligently. Different types of sensors can be used as long as they are connected to the system. Main design method of the reconfigurable smart sensor interface device is described in this paper. Finally, by taking real-time monitoring of water environment in IoT environment as an example, we verified that the system achieved good effects in practical application.

Nevertheless, many interesting directions are remaining for further researches. For example, the IEEE1451 protocol can be perfected and the function of spreadsheet should be expanded. It will have a broad space for development in the area of WSN in IoT environment.

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Author Details

M. Nagulu Naik
M.Tech Student
Farah Institute of Technology
Shabad Ring Road, Chevella,
R.R.Dist., Hyderabad.

Sreekanth Graduated in B.Tech ECE in 2008 from JNTU Hyd. He received Masters Degree in M.Tech [ECE] from JNTUH University, Hyderabad. Presently he is working as Associate Professor in ECE Dept. in Farah Institute of Technology, Chevella, R.R. Dist Telangana State, India. His research interests include Wireless Communications, Embedded Systems.

Anil Sooram Graduated in B.Tech ECE in 2007 from JNTU Hyd. He received Masters Degree in M.Tech [ECE] from JNTUH University, Hyderabad. Presently he is working as Associate Professor in ECE Dept. in Farah Institute of Technology, Chevella, R.R. Dist Telangana State, India. His research interests include Wireless Communications, Embedded Systems. He has published 3 research papers in International Conferences, Journals. He has received best Teacher award from Farah Group.