A New System By Using GPRS Technology Along With Raspberry Pi & A Smartphone For The Secured Wireless Communication In Industrial Automation & Control

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Abstract — **An embedded system is a computer system designed for specific control function. When the embedded devices are provided with internet access the demand will rise due to the remote accessing capability of these devices. Users can monitor & control remote systems by using embedded Web server. Day by day the scope of networked embedded system is rapidly increasing for monitoring & controlling the industrial devices.**

Wireless technologies are being more and more used in automation. This paper presents a new system by using the GPRS technique for the wireless communication in automation. A new processor such as ARM 11-Raspberry Pi is used in the development of this system. Various Sensors are interfaced with microcontroller. Real time sensed data is available on the remote pc as well as on the android Smartphone. Due to the use of GPRS technology we can achieve super speed transmission of large amount of data in very less time. The system is much secured than all the previous systems because we are using dynamic IP address. Thus Proper use of wireless sensor networks (WSNs) lowers the rate of failures, overall cost of the system, increases the productivity & efficiency of overall industrial operations.

Index Terms — **Embedded Web Server, GPRS, Raspberry Pi, Real Time.**

I. INTRODUCTION

Wireless based industrial automation is a prime concern in our day-to-day life. The approach to Wireless Network for Industrial Applications standardized nowadays. Wireless communication is very important concept and it plays an important role in various industries of automation field. Today the application of wireless communication in industrial automation is increasing rapidly as in [1]. The method of communication which was used previously is not so beneficial and efficient for the fulfillment of today's industrial needs. Data Acquisition systems with remote accessibility are in great demand in industry and consumer applications [2]. A single person can monitor and even interact with the ongoing work from a single base station. Some applications are built to collect and send data through a modem to a server.

Intelligent and low-cost automation of industrial processes are crucial in order to improve process efficiencies, deliver quality products, and ensure timeliness and accuracy of systems [4]. Wireless is predicted to be one of the fastest growing technologies in the area of process automation sector. Wireless Sensors Network (WSN) is having wide applications in various sectors. In these applications, it is necessary to monitor & control of physical environments remotely with great accuracy & ease [5]. A wireless sensor network is a system combination of radio frequency (RF) transceivers, microcontrollers, sensors and power supply source [6]. Wireless communication is the transfer of information over a distance without the use of electrical conductors [7]. The distances involved may be short or very long. Wireless communication involves - Radio frequency communication, Microwave communication, Infrared (IR) short-range communication. Applications of this communication may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks and other wireless networks. Wireless sensor network consists of various sensors and an ARM controller. There are several systems that allow data to be remotely accessed. As a solution to wireless data collection through the Internet, General Packet Radio Service (GPRS) is a popular choice in several applications [8].

❖ MOTIVATION FOR WIRELESS TECHNOLOGY

There are various things which motivate us to use the wireless technology in the field of automation. Brief information of few of them is given as follows.

a) Flexibility:

The use of wireless technology is very flexible. These technologies together with the other technologies like service oriented architectures, web services & the use of agent technology play an important role towards the flexible and self reconfiguring systems.

b) Economical:

The overall installation cost of wireless system is very low because there is no need of wiring and rewiring the system. Thus these systems are more economical than the previous wired systems.

For developing the system we require remote pc & a Smartphone along with the internet facility at the remote locations. Here the approach is to develop GPRS based wireless network for the various industrial

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applications. We present a system which is portable, low cost & having less maintenance by using GPRS technology. A GPRS is a new type of data transmission technology based on the existing GSM network. It transmits data in encapsulation way. It has lots of advantages such as super speed transmission, always on-line and charging according to rate of flow [9]. A novel approach is to develop a system which helps to minimize the operational costs while operating with a large amount of data with very less time.

In this paper, we proposed a GPRS-based portable low-cost data-acquisition system, which can establish a reliable bidirectional connection for data-acquisition. As in [10], a data acquisition system is used to collect the data in the simplest form. The basic idea behind real-time processing is that the embedded system is expected to respond to the queries in time. As in [11], Real time should be fast enough in the context in which the system is operating and reliable as well. Real-time system correctness depends not only on the correctness of the logical result of the computation but also on the result delivery time. The system runs on the Linux operating system and is popular choice for many embedded PC systems [12]. As in [13], thus the old system with central server can be replaced with the help of this advanced embedded web server.

II. BLOCK DIAGRAM OF SYSTEM

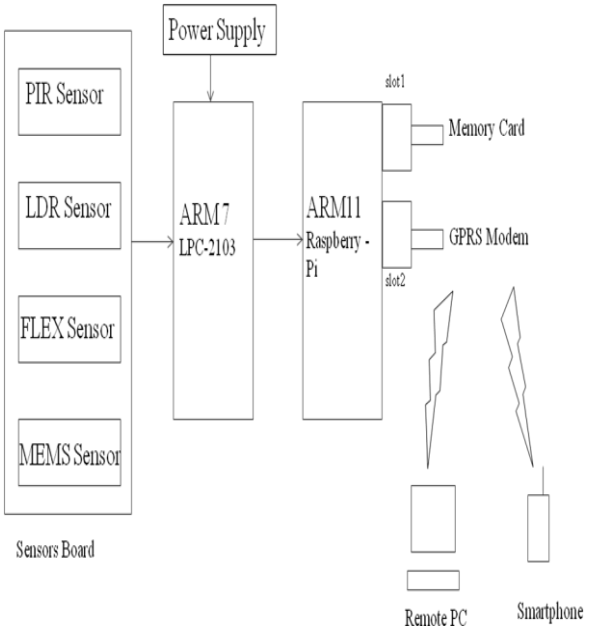

Figure1. Block Diagram of System Designed

Fig1. Shows the block diagram of the proposed system. The system consists of an embedded web server ARM11 Raspberry Pi. This ARM11 acts as main processor. A wireless sensor network containing the ARM7 as master controller along with the various sensors such as PIR (Passive Infrared), LDR (Light Dependent Resistors), FLEX Sensor & MEMS (Micro Electro Mechanical Systems) Sensor is also used. The ARM hardware is built on single chip module. There are various slots to the ARM11 processor for connecting the various external devices such as GPRS modem. A memory card can be inserted into the one of the available slot. A regulated power supply is provided to the overall system as shown in fig1.

All the sensors sense the respective data in the plant and send this data towards the controlling unit such as ARM7. Thus all the data is collected by the ARM7 and is maintained at this location. Here the data is stored in the data base. At this stage signal conditioning is done and only required amount of data is sent forward. Thus a successful communication is achieved between a server and client side by using this type of system. GSM (Global Service for Mobile Communication) network has in-built powerful TCP/IP protocol stack for internet data transfer over GPRS technology. Therefore the status of different sensors installed at working place is monitored at anywhere in the world. Thus personal computer & a Smartphone will continuously monitor all the data from remote processing unit and compare with the value preloaded process structure. In [13], thus reporting of this real-time data corresponding to the process plants can therefore be of great use for future analysis.

III. DEVELOPMENT OF THE SYSTEM

The development of the system consists of following two sections.

1) Hardware Development
2) Software Development

The hardware design consists of Microcontroller ARM7 LPC2103, various sensors, Raspberry Pi processor kit, GPRS modem, a remote pc & an android Smartphone. All these hardware's are interfaced with each other as shown in fig.1. We are developed a coding in embedded C in Keil software. Also we are using RTOS to manage the entire task and to provide a result in real time.

1) Hardware Development

To develop the overall system we used different hardware's, which are described in this section.

1.1) ARM7 Microcontroller:

This section is the main control part of the system. Here we are using microcontroller ARM7 LPC2103. Here the word LPC denotes the low power consumption. This part consists of all the associated circuitry such as Reset button; pull up resistors, crystal with capacitors etc. This microcontroller is manufactured by Philips & is used as main & master controller of the system [18]. LPC2103 is the widely used IC from the ARM7 family. It is more efficient as well as reliable one. ARM is the abbreviation of Advanced RISC Machines. As it is having RISC architecture it becomes the heart of the overall system. Fig 2. Shows the ARM7 microcontroller chip.

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Figure2. ARM 7 Microcontrollers

1.2) Raspberry Pi Processor:

The Raspberry Pi is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation. It has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU. Its GPU provides Open GL ES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high profile decode which is capable of 1Gpixel/s, .5Gtexel/s or 24GFLOPs with texture filtering with 512 MB RAM [16]. It does not include a built-in hard disk or solid-state drive, but uses an SD card for booting and persistent storage. It can be connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter. Generic USB keyboards and mice are compatible with the Raspberry Pi. The Raspberry Pi primarily uses Linux-kernel-based operating systems. A GPRS modem is directly inserted in one of the processor's slot. Fig.3 Shows the Raspberry Pi Module.

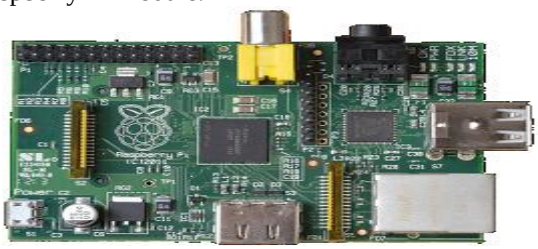

Figure3. Raspberry Pi Module

1.3) PIR Sensor (Passive InfraRed):

PIR sensor is as shown in fig.4. PIR sensors allow you to sense motion, almost always used to detect Human motions. They gives the output when digital pulse high (3V) when triggered (motion detected) & digital pulse low when idle (no motion detected) [23]. They are having sensitivity range up to 20 feet (6 meters). They are small, inexpensive, low-power, easy to use and are commonly found in appliances and gadgets used in homes or businesses.

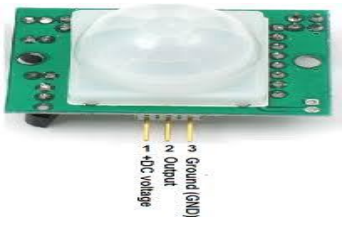

Figure4. PIR Sensor

1.4) LDR Sensor (Light Dependent Resistors):

An LDR or a photo resistor has a resistance which changes based on the amount of visible light that falls on it. A photo resistor is made of a high resistance semiconductor. As in [23], LDR is found in many consumer items such as, Camera light meters, Street lights, Clock radios, Alarm devices etc. The light falling on the zigzag lines of the sensor (usually made of Cadmium Sulphide), causes the resistance of the device to fall. Fig.5 shows the LDR sensor.

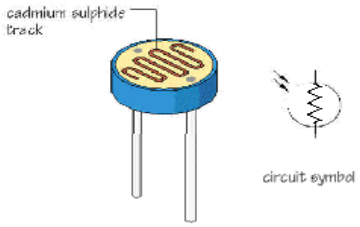

Figure5. LDR Sensor

1.5) FLEX Sensor:

FLEX sensor is as shown in fig.6. FLEX sensors are analog resistors. They have carbon resistive elements within a thin flexible substrate. Resistance changes depending on the amount of pressure or bend on this sensor. They give more the resistance value if we apply more the bend. In [23], they are used in various applications such as Robotics- to determine joint movements or placements, Auto controls- In automobile industry.

Figure6. FLEX Sensor

1.6) MEMS Sensor:

The word MEMS is an acronym for Micro Electro Mechanical Systems. They are micron-size devices that interact with external world for sensing and actuation. They Measures the angular rate (°/s or dps), number of revolution (spin) & rotation of mechanical part [23]. These sensors are having wide applications such as Sports & fitness industries, Portable devices etc. We have MEMS sensor as shown in fig.7 below.

Figure7. MEMS Sensor

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1.7) GPRS Modem/Dongle:

As in [18], after a GPRS connection has been established data will be relayed to the client via the embedded server. In the system, the GPRS architecture works with GSM protocols [19]. Because of GSM network, this system is configured to be virtually online at all times. It is Very compact in size and is easy to use as plug in GSM Modem. It provides inbuilt powerful TCP/IP protocol stack for internet data transfer over GPRS. GPRS is a best-effort service, implying variable throughput and latency. It provides fast-speed data transfer, by using unused time division multiple access (TDMA). Here we are using GPRS dongle for getting the GPRS network. All GSM system providers provide the GPRS facility. Thus it is very useful for worldwide connectivity.

2) Software Development

The Raspbian wheezy is important software part which deals with the Raspberry Pi. Raspbian wheezy is an unofficial port of Debian Wheezy armhf with compilation settings adjusted to produce code that uses hardware floating point, the "hard float" ABI and will run on the Raspberry Pi. CPU).Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware.

The software coding is written in embedded C language in Keil software. In developing the system we are using RTOS (A real-time operating system). The application runs in the form of tasks. Tasks are created by each user connecting to the server. Thus RTOS is required to manage these tasks, which perform the operations in real time. It processes the data as it comes in, typically without buffering delays. As in [25], a key characteristic of an RTOS is the level of its consistency concerning the amount of time it takes to accept and complete an application's task.

There are various languages used for web design that have developed over the life time of World Wide Web. Generally web pages are designed using HTML or Hyper Text Markup Language. HTML pages are used for data communication between the client and the server. In the embedded web server, web pages are selected as the media of interaction. Here we are developed a PHP page. The PHP Hypertext Pre-processor (PHP) is a programming language that allows web developers to create dynamic content that interacts with databases. PHP is a server side scripting language that is embedded in HTML [25]. The software running on the embedded web server follows the same layered structure as used in the TCP/IP protocol suite. The TCP/IP Protocol suite is a combination of different protocols at various layers [25]. Every layer acts independently from each other. The Internet Protocol (IP) delivers packets to Transmission Control Protocol (TCP) and Internet Control Message Protocol (ICMP) answers to PING requests and TCP delivers data to the application layer. This application layer communicates with the transport layer through buffers with data and variables with control information.

IV. EMBEDDED WEB SERVER

Here the embedded web server network consists of advanced processor ARM11-Raspberry Pi. It is having RISC architecture. An embedded web server creates an easy way for monitoring & controlling any device which is at remote place [14]. The block diagram of the embedded web server is given as follow.

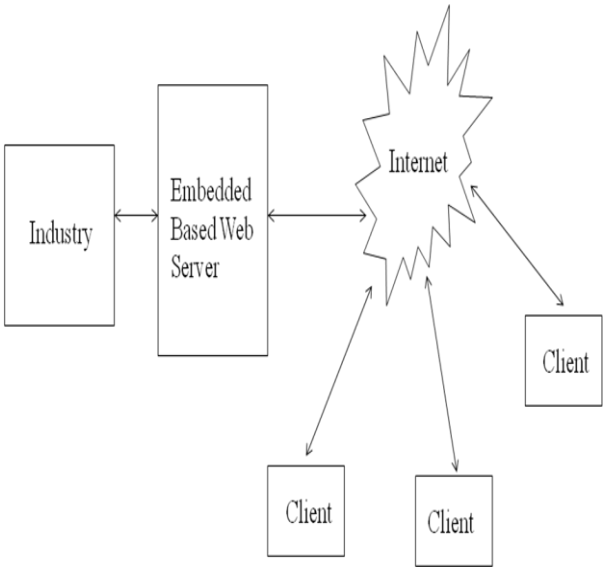

Figure8. Block Diagram of Embedded Web Server

The implementation of embedded internet technology is done with the help of embedded web servers. An embedded web server provides remote access to devices from a web browser. ARM processor contains an internet software & application code for monitoring & controlling the systems. Embedded server is a single chip implementation of the Ethernet networking standard. The client computer sends & receives data to & from the arm microcontroller using TCP/IP packets. The client has to enter IP address to access this server. The IP address of embedded devices will be available at client side to directly access the system. By using this IP address people from remote location will access the information on pc as well as on their Smartphone's [20]. The operating system manages the request of the client and gives to the LAN (Local Area Network) controller of the client system. The LAN controller sends the request to the router which processes and checks for the system connected to the network with that particular IP address. If the IP address entered matches to that of the server, a request is sent to the LAN controller of the server to the client and hence a session is established between server and the client and the server starts sending the web pages to the client. There are two types of IP address i.e. static IP & dynamic IP. Dynamic IP assigned through a Dynamic Host Configuration Protocol (DHCP) server of the GSM provider for every connection established. The

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embedded system updates IP information on the server upon every reboot, which causes an IP refresh from the GSM service provider.

As in [20], the dynamic IP address is of very great use as it is more flexible and it gives good secured result. Web pages are designed using HTML (Hyper Text Markup Language). HTML presents the user with a page of Information. So here we use HTML language to build embedded web pages [21]. Embedded web servers have lot of advantages such as, low cost, supports to real time application, low maintainability, security etc [18].

V. CONCLUSION

The new system proposed here is mainly based on GPRS technology and the powerful processor ARM11 Raspberry Pi is used very effectively for the overall development. The use of wireless technology in the automation field is increasing very fastly. For the fast and secure communication in this field we have to develop new systems which can fulfill the modern industrial needs. Thus the new system proposed here can overcome all the existing systems and will give the result very efficiently within very less time period.

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