

Comparison of Remote Monitoring Systems - A Review

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Abstract— This paper presents a detailed study on comparison of different remote monitoring systems. There are many systems for remote monitoring and control, designed as either commercial products or experimental research platforms. It is noticed that most of the research are carried out in categories such as Internet based Monitoring via Servers, GPRS modems, etc. There are different other approaches for GSM-SMS protocols using GSM module individually or in combination besides using Wireless technologies such as Sensor Networks, Bluetooth, Wi-Fi, Zigbee and RF. For choosing the appropriate monitoring system for an application, a number of characteristics are important. A review of different monitoring systems with their characteristics is presented.

Keywords— Remote monitoring, internet-based monitoring, , Wireless technologies, Bluetooth, Zigbee, Wi-Fi, General Packet Radio Service (GPRS).

INTRODUCTION

Remote monitoring includes data from gauges and sensors like soil moisture, pressure, environmental, etc. It is used to know the status of farm gates and building doors (open/close), irrigation valves and pumping equipment. It helps to view the video of operation in live mode, monitoring of greenhouses, livestock enclosures and storage facilities.

Conventional wired monitoring system provides reliable solution in data transmission but suffers from several limitations. Apart from the physical constraints during laying of the data cables, the use of these cables also increases installation and maintenance cost. Besides, for outdoor application such as PV systems, continuous exposure to sun beam and rains may reduce the lifespan of the system (Spertino & Corona, 2013). To overcome these issues, wireless monitoring system is favoured over its cable-based counterpart. In this project, a Zigbee-based wireless monitoring system is designed and built as a replacement to the conventional cable-based monitoring system for a grid-tied PV system. Various aspects of the system, from design to construction and testing, are detailed here. Besides that, a PC-based application integrated with web-based function is designed and implemented in order to allow remote control of the system as well as easy access of the data over the internet.

CLASSIFICATION OF REMOTE MONITORING SYSTEMS

In a monitoring system, it is important to choose a method through which the users can access the monitored data effectively. For the monitoring of a system, users should have easy and prompt access to the data, in order to provide timely evaluation on the system performance, as well as to provide counter measures should any failure is detected. Based on the previous works surveyed, it is found that web-based monitoring system can be an attractive monitoring method, as it enables data to be distributed among remote users and users can view data from any device with internet connectivity.

INTERNET BASED MONITORING

Internet monitoring is one of the common approaches for remote monitoring. Many researchers have worked in field of Internet based remote monitoring. They developed home gateway system for interconnecting home network consisting of IEEE 1394 AV network and X10 power line home automation network with Internet. This provided remote access functions from Internet for digital AV appliances like Digital Video Camera, Digital VCR connected to IEEE 1394 network and home appliances like TV, desk lamp, electric fan connected to X10 controller.

Java based home automation system via World Wide Web were developed. The home appliances were controlled from ports of embedded system board connected to PC based server at home. X10 controller interfaced through serial port to PC server for control of devices was invented. The Common Gateway Interface (CGI) is used to interface between the browser and the X10 protocol via http connection. The server executes CGI programs in order to satisfy a particular request from the browser, which expresses its request using the http.

Model of web services based email extension for remote monitoring of embedded systems which integrates web services into emails. It uses a general purpose email messaging framework to connect devices and manipulators. This low cost model fits for systems with low connection bandwidth, small data transportation volume and non-realtime control, e.g., monitoring of home appliances and remote meter-reading.

A system for controlling home electrical appliances over the internet uses Bluetooth wireless technology to provide a link from the appliance to the Internet and Wireless Application Protocol (WAP) to provide a data link between the Internet and a mobile phone. However, technical details relating controller are not revealed.

Design and implementation of an Internet home automation system was made available. The design uses an embedded controller based on C8051F005 microcontroller which is connected to a PC-based home Web server via RS232 serial port. The home appliances are connected to the input/output ports and the sensors are connected to the analog/digital converter channels of the embedded controller. The software of the system is based on the combination of Keil C, Java Server Pages, and JavaBeans, and dynamic DNS service (DDNS) client. Password protection is used to block the unauthorized user from accessing to the server [5].

A remote wireless monitoring system for off grid Wind turbine based on the GPRS and the Internet was developed. The remote monitoring system is made up of three parts: controlling terminal, central monitoring computer and communication network. Controlling terminal consists of microcontroller ARM7 LM3S1138, data acquisition module and GPRS communication module WAVECOM Q2406B connected to ARM7 system using serial port. GPRS module sends parameters relating wind turbine to central monitoring computer. The client can access central monitoring computer server through Internet and know parameters of different wind turbines[12].

Key Press Markup Language (KPML) and SIP Event Package was introduced to control devices in the home environment remotely without the need for specialized hardware in the home devices. KPML provides an efficient, reliable protocol for the remote control of consumer devices using plain old telephones with 12-digit keypads using Internet transport technologies. Figure 1 shows Key Press Markup Language (KPML) with two sites.

The architecture of embedded remote monitoring system based on Internet has been developed by the researchers. The system adopts embedded web server as a central monitoring node and results in improvement in stability and reliability of system. Moreover, utilization of dynamic monitoring web based on Java Applet improves the response capability and brings convenience for complex monitoring web design.

Wireless remote monitoring system based on the GPRS (General Packet Radio Service) and the MCU (Micro programmed Control Unit) was designed. System is based on 89C58 microcontroller and PIML GPRS-MODEM as the core, can collect data from

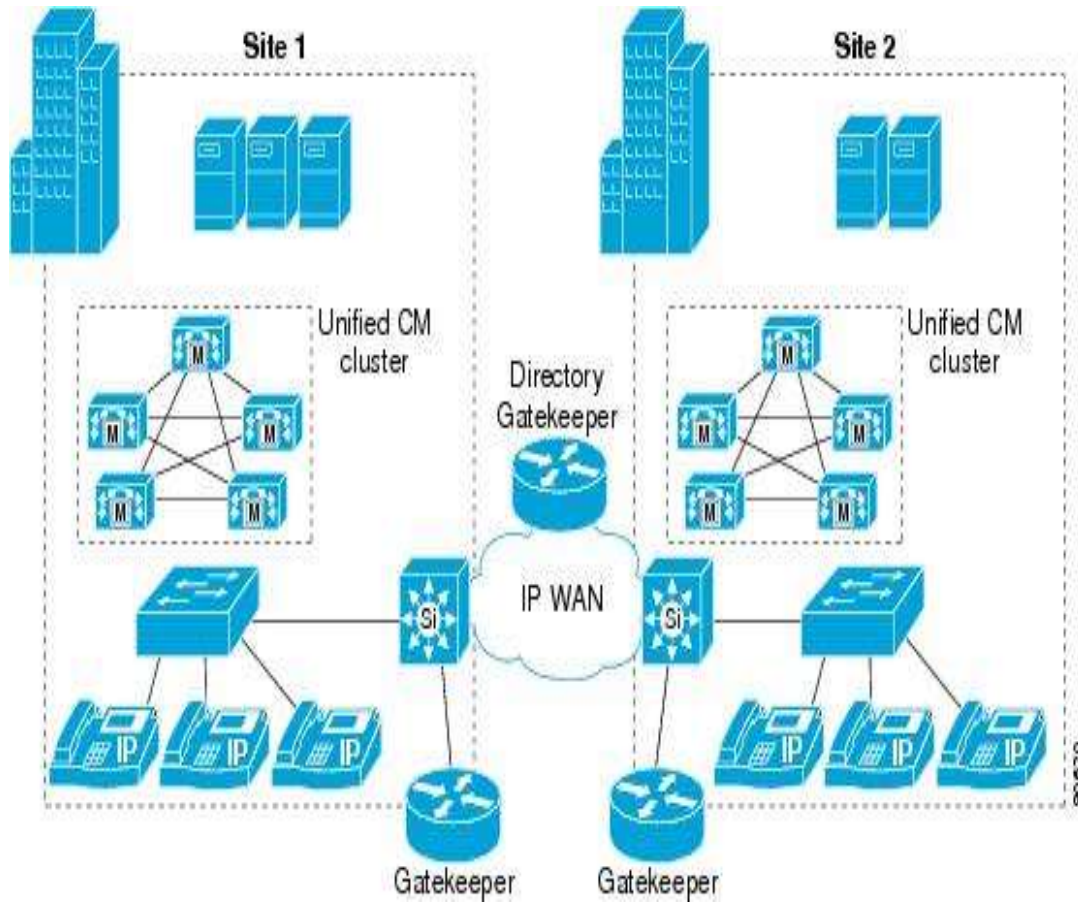


Figure 1: Key press markup language (KPML)

Eight sensors control two-way Data Acquisition, in the local real-time display and support remote Internet monitoring. The data from sensors are encoded, sent to the WEB server (fixed IP address or fixed domain name website) through the GPRS channel. The system also accepts commands from remote monitoring centre.

Table 1: Comparison of different remote monitoring systems

| Sl.no | Technology | Processor | Monitoring Station | Modules Interfaced | Tools | Programming Code |
|-------|------------|-----------------|--------------------|------------------------|-------------------------------|-----------------------|
| 1. | Internet | 8051 family | PC | None | Keil IDE | Java, Interactive C |
| 2. | Internet | PIC16 | PC | None | MPLAB IDE | UML, C |
| 3. | Bluetooth | Atmega64 | PC | TDK Blu2i | AVR Studio | C |
| 4. | Bluetooth | Atmega168 | Mobile | Bluegiga WT11 | AVR Studio, Symbian | Interactive C, Pythan |
| 5. | Bluetooth | Atmega32 | Mobile | CBOEMSPA312 | AVR studio, Eclipse 3.2.2 | C, Java |
| 6. | RFID | Parallex P8X32A | PC | RFID Reader, ENC 28J60 | Propeller tool, Spin compiler | Spin |
| 7. | RF | Atmega 48 | PC | RDM-A4FZ | AVR Studio | C |

| | | | | | | |
|-----|---------------------|--------------------|------------|----------------------------|-----------------------|------------|
| 8. | RF | 8051 family | PC | nRF905, Si4421 | Keil IDE | C51 |
| 9. | GSM | 8051 family | Mobile | Sony Ericsson GM47 | Keil IDE | Visual C++ |
| 10. | GSM-FPGA | 8051 | Mobile | MAXON MM-6854 | Xilinx ISE 6.2i | VHDL |
| 11. | GSM | MSP430F149 | PC | Siemens TC35 | C430 IDE | C |
| 12. | GSM | ARM7 | PC, Mobile | Siemens TC35 | Flashmagic | C |
| 13. | GSM-Internet | Atmega128, PIC 18 | PC, Mobile | Siemens TC35 | AVR Studio, MPLAB IDE | C |
| 14. | GSM | 8051 family | PC | Nokia FBUS | Keil IDE, Linux | C, Java |
| 15. | GSM-Internet-speech | PIC16 | Mobile | Siemens TC35 | MPLAB | C |
| 16. | GSM-WSN | 8051 family | PC, Mobile | Siemens TC35, CC1100 | Keil IDE | C51 |
| 17. | GSM-Zigbee | Atmega 128 | Mobile | Sony Ericsson T290i, EM357 | IDE & C compiler | C |
| 18. | GSM-Zigbee | 8051 | Mobile | GM862QUAD-PY, CC2430 | Keil IDE, Symbian | C, Pythan |
| 19. | GSM-Zigbee | 8051 | PC/Mobile | Siemens TC35 | Keil IDE | C/C++ |
| 20. | GPRS | ARM7 | | CC2430 nRF24E1 | µC/OS-II | |
| 21. | GPRS | 8051 family | PC | SIM300, SN65LBC184 | Keil IDE | Visual C |
| 22. | RF | Atmega128, APXA271 | PC | CC2420 | AVR Studio, TinyOS | C |
| 23. | RF | APXA271 | PC | CC2420 | TinyOS | nesC |

Table 1 explains the comparison of different remote monitoring systems with respect to its technology, processor used, Monitoring station, Modules Interfaced, tools and programming code.

Wireless remote image monitoring system based on GSM/GPRS and ARM_Linux developing environment was developed. The monitoring system uses S3C2410 RISC MCU -ARM920Core, USB Web camera, SD Card and UART GPRS module. ARM Linux operating system is loaded on SD Card. APIs of Video4Linux kernel are used to realize image acquisition of the system, through PPP dial-up to access the GPRS, through network programming to realize the transmission of the image.

Application on remote monitoring system of reservoir based on GPRS was developed. GPRS data terminal hardware includes the intelligent processing module, remote communication module, serial interface module and display module. Intelligent processing module contains two chips AT89C55 microcontroller and serial E2PROM X25045. AT89C55 is used to transmit data between remote communication module, A/D conversion module and display module. To ensure that data will not be lost because of power outages, serial E2PROM X25045 devices is adopted for data storage. Remote communication module includes GPRS wireless module, SIM card and serial module MAX3238. Database mainly stores various parameters of the flood accommodation procedures for the user and reservoir historical hydrological data, such as electric power generated, relation curve of water level flows, the water storage capacity curve, and discharge curve, unit's efficiency curve of different conditions, historical flood data and flood information.

A system composed of server which interfaces several video surveillance cameras including several microphones for audio surveillance is designed. This server captures video and audio streams from the video cameras and microphones and operates on these streams according to the configuration of the local control software module. This module can store the video and audio streams on local hard-disks, index video and audio captures by time and place, retrieve images and sound based on user specified time intervals and deliver them to the user via Internet, or deliver (streaming) live images and sounds from a predefined camera. The system is connected to the building power supply and can be connected to the Internet via several communication solutions based on their availability. In case of power grid failure the system is provided with a secondary power supply based on rechargeable batteries which can keep the system functional for several hours. The main weaknesses of this system are the power supply and the Internet connection. To improve the reliability of this system, an autonomous diagnosis system has been added to the main monitoring server. The system will detect any change in the functioning state of the main system, like communication link failure, power grid failure or internal power source depletion and will report these events by sending a short message (SMS).

Wireless home automation system by merging communication technologies of GSM, Internet and speech recognition was developed. GSM and Internet methods were used for remote access of devices of house whereas speech recognition was designed for users inside the house. The communication between the user and the home is established by the SMS (Short Message Service) protocol. A GSM modem is connected to the home automation server. The communication between the home automation server and the GSM modem is carried out by the AT (Attention) commands. To accomplish Internet connectivity, a web server is built to take requests from remote clients. The clients can send requests to the home appliances. The home appliances can send their statuses to be displayed for the remote client through the server. A web page is constructed as an interactive interface where commands can be submitted by the client to change and also monitor the status of the devices. A speech recognition program is written to control the house by means of human voice. Dynamic Time Warping (DTW) algorithm is used for speech recognition [5].

The mobile telephone is then configured with a mobile-to-host GPRS connection (GPRS attachment and PDP context activation). Patient data are recorded and stored in the processor's memory module, typically for 10 min. Then the processor transmits an AT-command to the mobile phone to initiate data transmission via the GPRS network [12].

GSM-SMS BASED MONITORING

With the wide spread use of cellular networks, this approach is also popular when small amount of data is to be transferred through the network. Extensive work has been carried out by researchers using this approach especially in medical field.

A remote monitoring system based on SMS of GSM was described. The system includes two parts which are the monitoring center and the remote monitoring station. The monitoring centre consists of a computer and a TC35 GSM communication module. The computer and TC35 are connected by RS232. The remote monitoring station includes a TC35 GSM communication module, a MSP430F149 MCU, a display unit, various sensors, data gathering and processing unit.

A tele-monitoring system, based on short message service (SMS), to remotely monitor the long-term mobility levels of elderly people in their natural environment was developed. Mobility is measured by an accelerometer-based portable unit, worn by each monitored subject. [3] The portable unit houses the Analog Devices ADuC812S microcontroller board, Falcon A2D-1 GSM modem, and a battery-based power supply. Two integrated accelerometers are connected to the portable unit through the analog inputs of the microcontroller. Mobility level summaries are transmitted hourly, as an SMS message, directly from the portable unit to a remote server for long-term analysis. Each subject's mobility levels are monitored using custom-designed mobility alert software, and the appropriate medical personnel are alerted by SMS if the subject's mobility levels decrease.

A system for early diagnosis of hypertension and other chronic diseases was proposed. The proposed design consists of three main parts: a wrist Blood Pressure (BP) measurement unit, a server unit and a terminal unit. Blood Pressure is detected using data acquired by sensors intelligently using DSP microchip. The data is then transmitted to the remote server unit located at Community Healthcare Centres/Points (CHC/P) by using Short Messaging Service (SMS), and notification information is sent to the terminal unit to inform users if patient's BP is abnormal.

Home security system by means of GSM cellular communication network using microcontroller 89X52 and Sony Ericsson GM-47 GSM module was developed. This system enables far end user through SMS facility to monitor the state of home door, provide password facility for key based door lock and control home lighting system.

A remote medical monitoring system based on GSM (Global System for Mobile communications) network was described. This system takes advantage of the powerful GSM network to implement remote communication in the form of short messages and uses FPGA as the control centre to realize the family medical monitoring network. The system is made up of user terminal equipments, GSM network and hospital terminal equipments. Hospital terminal equipments can be a personal computer (connected with GSM modules) or other receiving equipment's such as the mobile phone of the related doctor, while user terminal equipments are used to collect, demonstrate and transmit kinds of physiological parameters. User terminal devices include the temperature acquisition module, blood pressure/heart rate acquisition module, FPGA of Actel Fusion series, information-sending and information-receiving module --Siemens TC35 GSM module, LCD displays and expansion modules [11].

A mobile-based home automation system that consists of a mobile phone with Java capabilities, a cellular modem, and a home server was designed. The home appliances are controlled by the home server, which operates according to the user commands received from the mobile phone via the cellular modem.[50]

Figure 2 shows short message service/ General Packet Radio Service consists of GPRS modem, GPRS network, and base station Ervice. Here, the home server is built upon an SMS/GPRS (Short Message Service/General Packet Radio Service) mobile cell module Sony Ericsson GT48 and a microcontroller Atmel AVR 169, allowing a user to control and monitor any variables related to the home by using any java capable cell phone [5].

A role-based intelligent mobile care system with alert mechanism in chronic care environment was proposed and developed [12]. The roles included patients, physicians, nurses, and healthcare providers. Each of the roles represented a person that uses a mobile phone to communicate with the server setup in the care. For mobile phones with Bluetooth communication capability attached to chronic patients, physiological signal recognition algorithms were implemented and built-in in the mobile phone without affecting its original communication functions. Several front-end mobile care devices were integrated with Bluetooth communication capability to extract patients' various physiological parameters [such as blood pressure, pulse, saturation of hemoglobin (SpO₂), and electrocardiogram (ECG)], to Monitor multiple physiological signals and to upload important or abnormal physiological information to healthcare centre for storage and analysis or transmit the information to physicians and healthcare providers for further processing. An alert management mechanism has been included in back-end healthcare centre to initiate various strategies for automatic emergency alerts after receiving emergency messages or after automatically recognizing emergency messages.

A remote data collection and monitoring system was designed and implemented. The system communication is based on GSM short messages from cell phones using Siemens cell phone module TC35. The serial interface of TC35 is directly connected to the serial interface of PC computer. The system hardware includes remote client monitoring hardware, central monitoring module, and 0809 A/D converter.

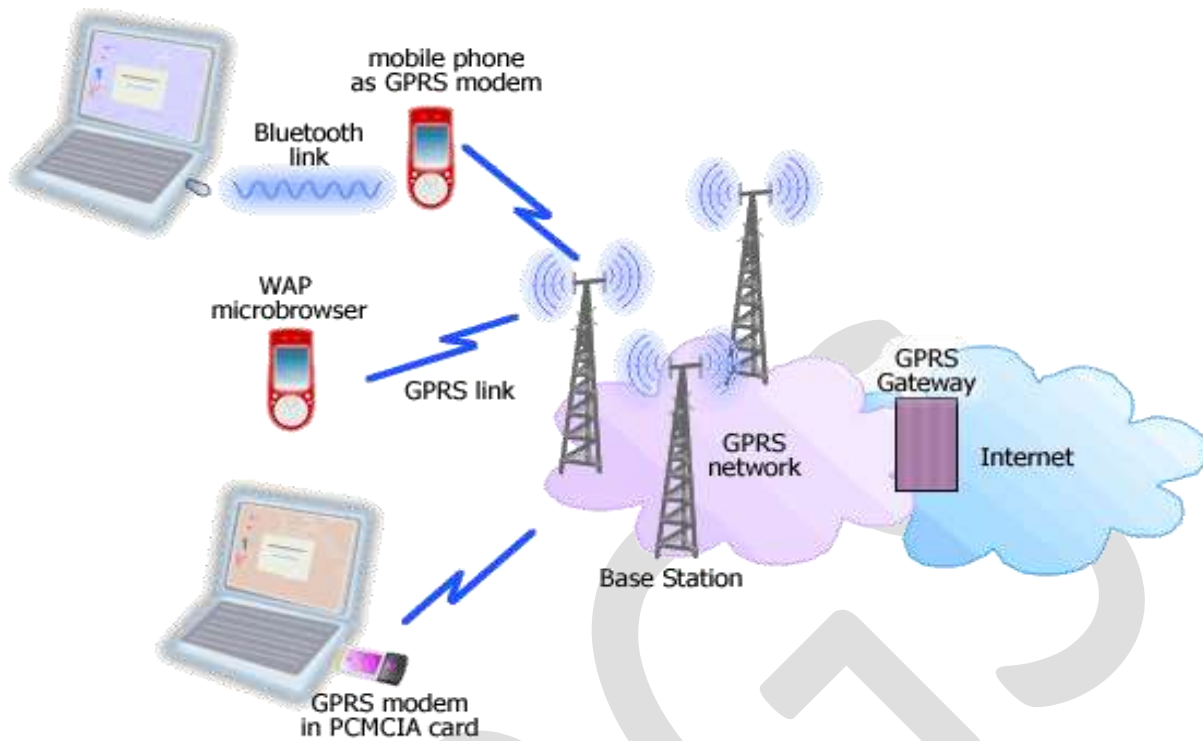


Figure 2: Short Message Service/General Packet Radio Service

The central monitoring module sends commands via channel 1. Data collection commands are sent out through TC35 to collect all sorts of data. After data are collected they are processed by remote clients and sent back to the central monitoring module by GSM short messages via channel 2. Each monitoring module can connect up to 128 sensors and equipment within the range of 1000 meters via RS485 interface. The server hardware consists of 8031 microprocessor, 74LS373, one 8 kB 2764 E2PROM, one 2 kB 6116 extended memory, and one 8155 programmable serial interface chip. One 4×4 keyboard is connected to the PI port and 8 LED displays are connected to PA and PB ports of 8155.

SMS based system for controlling of home appliances remotely was developed and providing security when the user is away from the place. Home appliance control system (HACS) consists of PC which contains the software components through which the appliances are controlled and home security is monitored and GSM Modem that allow the capability to send and receive SMS to and from the system. The communication with the system takes place via RS232 serial port.

ADVANTAGES OF WIRED NETWORKS:

Conventional wired monitoring system provides reliable solution for data transmission.

DISADVANTAGES OF WIRED NETWORKS:

Use of these cables also increases installation and maintenance cost. For outdoor application such as PV systems, continuous exposure to sun beam and rains may reduce the lifespan of the system

REMOTE MONITORING USING WIRELESS SENSOR NETWORKS (WSN), BLUETOOTH, WIFI, ZIGBEE TECHNOLOGIES

Many Wireless Technologies like RF, Wi-Fi, Bluetooth and Zigbee have been developed and remote monitoring systems using these technologies are popular due to flexibility, low operating charges, etc. Today Wireless Sensor Network are used into an increasing number of commercial solutions, aimed at implementing distributed monitoring and control system in a great number of different application areas. Figure 3 shows three network topologies which are supported by Zigbee devices; centralized star, cluster-tree-based and mesh network Zigbee devices have two types of capabilities which are reduced-function device (RFD) and full-function device (FFD).

A general purpose controlling module was designed with the capability of controlling and sensing up to five devices simultaneously. The communication between the controlling module and the remote server is done using Bluetooth technology. The server can communicate with many such modules simultaneously. The controller is based on ATmega64 microcontroller and Bluetooth communication TDK Blu2i (Class 1) module which provides a serial interface for data communication. The designed controller was deployed in a home automation application for a selected set of electrical appliances [3].

A home appliance control system over Bluetooth with a cellular phone was developed, which enables remote-control, fault-diagnosis and software-update for home appliances through Java applications on a cellular phone. The system consists of home appliances, a cellular phone and Bluetooth communication adapters for the appliances. The communication adapter hardware consists of a 20MHz 16bit CPU, SRAM and a Bluetooth module. The communication adapter board is connected to the home appliance and to the cellular phone through serial ports. The appliances can communicate with the cellular phone control terminal via Bluetooth SPP [3].

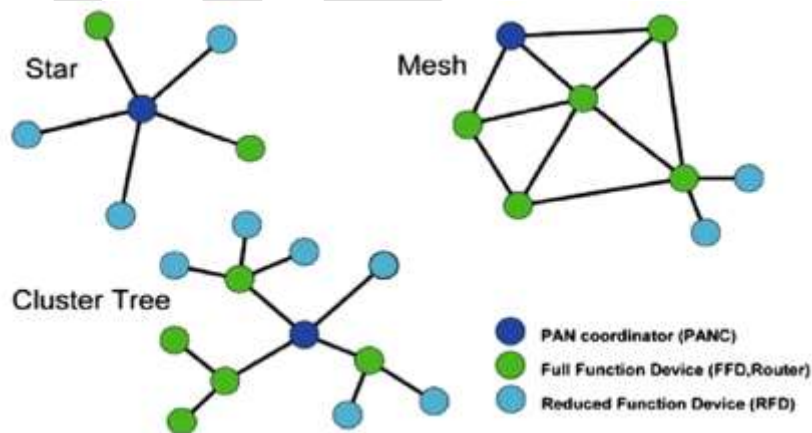


Figure 3: Topology of Zigbee wireless networks

A wireless patient monitoring system which integrates Bluetooth and Wi-Fi wireless technologies was introduced. This system consists of the mobile unit, which is set up on the patient's side to acquire the patient's physiological signals, and the monitor units, which enable the medical personnel to monitor the patient's status remotely. The mobile unit is based on AT89C51 microprocessor. The digitized vital-sign signals are transmitted to the local monitor unit using a Bluetooth dongle. Four kinds of monitor units, namely, local monitor unit, a control centre, mobile devices (personal digital assistant; PDA), and a web page were designed to communicate via the Wi-Fi wireless technology [6]. A novel architecture for environmental tele-monitoring that relies on GSM for sampling point delocalization was suggested, while on-field nodes implement local subnets based on the DECT technology.

Table 2: Comparison of Bluetooth, WIFI, Zigbee

| Standard | Range | Number of Nodes | Frequency Band | Data Protection | Power use |
|-----------|----------|-----------------|---------------------|-----------------|-----------|
| Bluetooth | 10 m | 8 | 2.4GHz | 16-bit CRC | High |
| Wi-Fi | 100 m | 32 | 3.1-10.6 GHz | 32-bit CRC | High |
| Zigbee | 10-200 m | More than 25400 | 868/915 MHz 2.4 GHz | 16-bit CRC | Low |

Table 2 explains the comparison of Bluetooth, Wi-Fi, Zigbee with respect to its range of distance, Number of nodes, Frequency band, Data protection and power use.

A novel architecture for environmental tele-monitoring that relies on GSM for sampling point delocalization was suggested, while on-field nodes implement local subnets based on the DECT technology. Local subnets contain two major blocks; Acquisition Station (AS) where sensors and actuators are located and Transmitting Module (TM), i.e., the module that handles several measurement stations and sends data to the control center (CC). Each AS acts as a data logger, storing in its internal memory device field data; communications between AS and TM are cyclic (round robin), with a cycle time of about 1–10 min. On the contrary, (personal digital assistant; PDA), and a web page were designed to communicate via the Wi-Fi wireless technology. Figure 4 shows IBSS and ESS configuration of WI-FI networks consisting of distribution system.

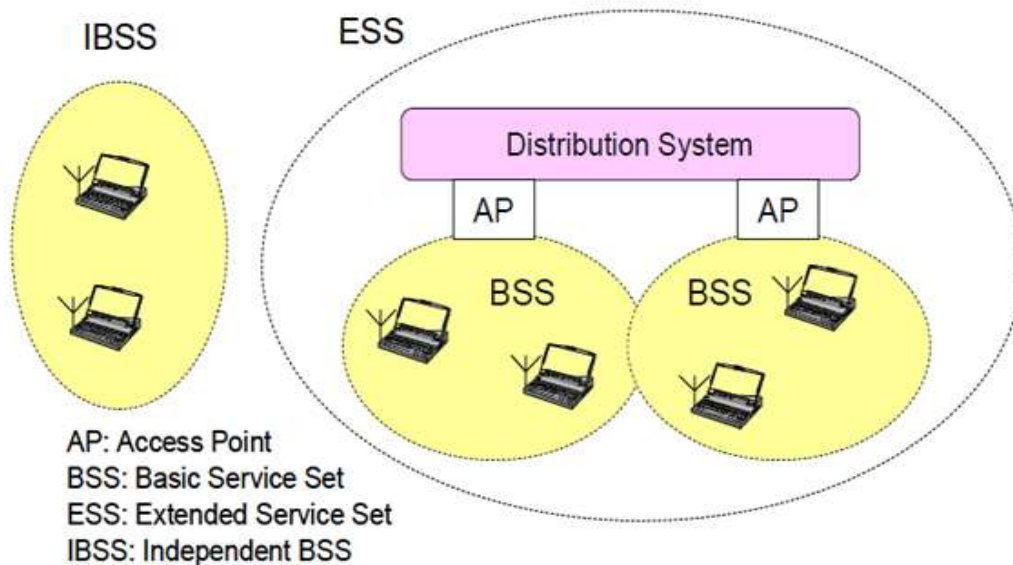


Figure 4: IBSS and ESS Configuration of Wi-Fi networks

Design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move irrigation system was done. Field conditions were site-specifically monitored by six in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station. An irrigation machine was converted to be electronically controlled by a programming logic controller (Siemens S7-226 with three relay expansion modules activated electric over air solenoids to control 30 banks of sprinklers) that updates geo-referenced location of sprinklers from a differential Global Positioning System (GPS) (17HVS, Garmin) and wirelessly

communicates with a computer at the base station. Communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost Bluetooth wireless radio communication through Bluetooth RS-232 serial adaptor (SD202, Initium Company). Figure 5 shows power observing structure via Bluetooth, Ethernet and GSM.

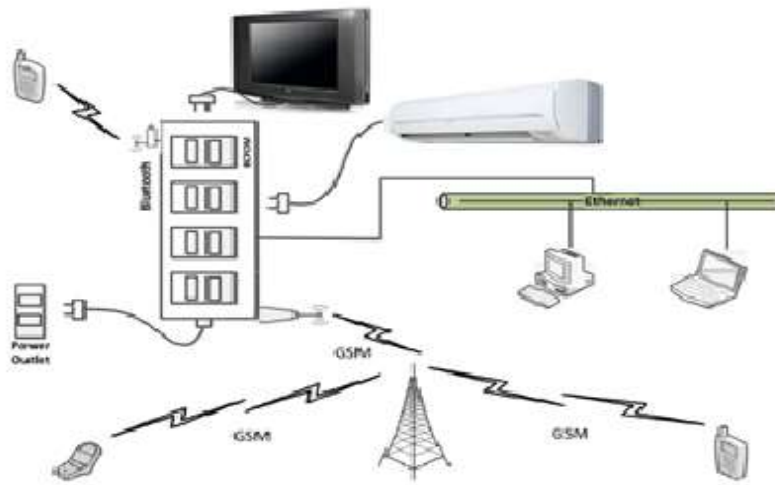


Figure 5: Power Observing structure via Bluetooth, Ethernet and GSM

A WSN based system for monitoring a series of physiological parameters in the vineyard to prevent plant vine diseases was developed. Sandy soils have very different behaviour to irrigation in respect to clayey ones; water retention capacity is completely different and measuring it exactly where it is needed can help in controlling the irrigation system and saving water. Monitoring air temperature and humidity in different parts of a vine can help in preventing and Fighting plants diseases, reducing the amount of pesticides only when and where they are necessary.

The master node of the Wireless Sensor Network is connected to a GPRS gateway board, forwarding data to a remote server, using the TCP-IP standard protocol. It included 11 nodes with a total of 35 sensors distributed on 1 hectare area; monitor common parameter using simple, unobtrusive, commercial and cheap sensors.

Forwarding their measurements by the means of a heterogeneous infrastructure, consisting of WSN technology, GPRS communication and ordinary Internet data transfer (TCP-IP protocol). Data coming from sensors are stored in a database that can be queried by users everywhere in world, only using a laptop or a PDA: the Smart User Interface also allows to read and to analyze data in an easy way. (Harms et al., 2010) describe the emerging wireless sensor networks (WSN) for autonomous Structural Health monitoring SHM systems for bridges. In SmartBrick Network, the base station and sensor nodes collect data from the onboard and external sensors. The sensor nodes communicate their data from quasi-static sensors, e.g., temperature sensors, strain gauges and seismic detectors to the base station over the ZigBee connection. The base station processes these data and communicates them, along with any alerts generated, to a number of destinations over the GSM/GPRS link provided by the cellular phone infrastructure. The data are reported by email and FTP to redundant servers, via the Internet, at regular intervals or on an event-triggered basis. The alerts are sent directly by SMS text messaging and by email. Wireless sensor networks are the key enabler of the most reliable and durable systems for long-term SHM and have the potential to dramatically increase public safety by providing early warning of impending structural hazards [1].

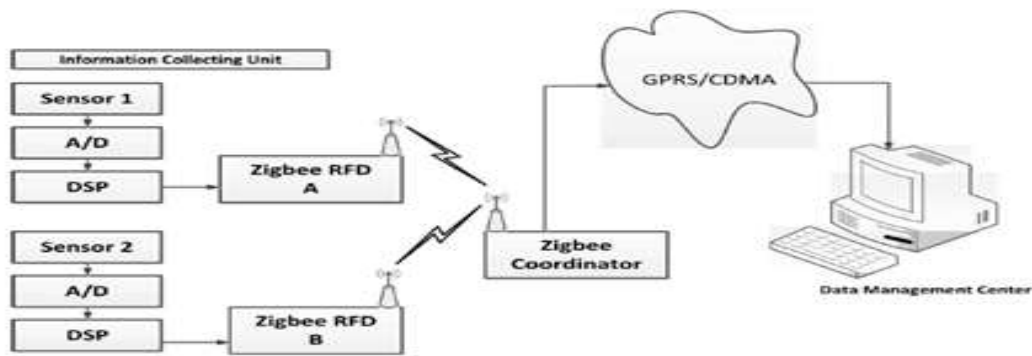


Figure 6: Zigbee-based Transmission Line Monitoring

Forwarding their measurements by the means of a heterogeneous infrastructure, consisting of WSN technology, GPRS communication and ordinary Internet data transfer (TCP-IP protocol). Data coming from sensors are stored in a database that can be queried by users everywhere in world, only using a laptop or a PDA: the Smart User Interface also allows to read and to analyze data in an easy way. (Harms et al., 2010) describe the emerging wireless sensor networks (WSN) for autonomous Structural Health monitoring SHM systems for bridges. In SmartBrick Network, the base station and sensor nodes collect data from the onboard and external sensors. The sensor nodes communicate their data from quasi-static sensors, e.g., temperature sensors, strain gauges and seismic detectors to the base station over the ZigBee connection. The base station processes these data and communicates them, along with any alerts generated, to a number of destinations over the GSM/GPRS link provided by the cellular phone infrastructure. The data are reported by email and FTP to redundant servers, via the Internet, at regular intervals or on an event-triggered basis. The alerts are sent directly by SMS text messaging and by email. Wireless sensor networks are the key enabler of the most reliable and durable systems for long-term SHM and have the potential to dramatically increase public safety by providing early warning of impending structural hazards [1].

A wireless medical interface based on ZigBee and Bluetooth technology. The purpose is to acquire, process, and transfer raw data from medical devices to Bluetooth network. The Bluetooth network can be connected to PC or PDA for further processing. The interface comprises two types of device: MDIZ and MDIZB. MDIZ acquires data from medical device, processes them using microcontroller, and transmit the data through ZigBee network through UART. MDIZB receives data from several MDIZs and transmit them out to PC through Bluetooth network. MDIZB comprises of ZigBee module, two processors, RAM, and Bluetooth module. It receives data from ZigBee network through its ZigBee module is shown in Figure 6. The data are then sent to processor 1. Processor 1 decides priority of MDIZs. In processor 1, the data frame is added with Start byte and End byte to mark the beginning and the end of data frame. After being processed in processor 1, the data are then sent to processor 2 through SPI (Serial Peripheral Interface). Processor 2 transmits data to PC through Bluetooth network [2]. Processor 2 controls Bluetooth module. It also receives commands given by PC through Bluetooth network.

Table 3 explains the comparison of Bluetooth, Wi-Fi, Zigbee and UWB with respect to their Standards such as IEEE spec, Frequency band, maximum signal rate, nominal range, nominal Tx power, number of RF channels, Channel bandwidth, modulation type, spreading, co-existence mechanism, basic cell, extension of basic cell, maximum number of cell nodes, encryption, authentication and Data protection.

Table 3: Comparison of Bluetooth, UWB, Zigbee and Wi-Fi

| Standard | Bluetooth | UWB | Zigbee | Wi-fi |
|--------------------------|------------------------|--------------------------------------|--------------------------------------|--|
| IEEE spec | 802.15.1 | 802.15.3a* | 802.15.4 | 802.11a/b/g |
| Frequency band | 2.4GHz | 3.1-10.6GHz | 868/915 MHz;2.4GHz | 2.4GHz;5GHz |
| Max signal rate | 1Mb/s | 110Mb/s | 250Kb/s | 54Mb/s |
| Nominal range | 10m | 10m | 10-100m | 100m |
| Nominal Tx power | 0-10 dBm | -41.3dBm /MHz | (-25)-0 dBm | 15-20 dBm |
| Number of RF channels | 79 | 1-15 | 1/10;16 | 14(2.4GHz) |
| Channel bandwidth | 1MHz | 500 MHz-7.5GHz | 0.3/0.6 MHz;2MHZ | 22MHz |
| Modulation type | GFSK | BPSK;QPSK | BPSK(+ASK), O-QPSK | BPSK, QPSK COFDM,CCK,OFDM |
| Spreading | FHSS | DS-UWB,MB-OFDM | DSSS | DSSS,CCK,M-QAM |
| Coexistence mechanism | Adaptive freq. hopping | Adaptive freq. hopping | Dynamic freq. selection | Dynamic freq. selection, transmit power control. (802.11h) |
| Basic cell | piconet | Piconet | star | BSS |
| Extension of basic cell | scattement | Peer-to-peer | Cluster tree, mesh | ESS |
| Max number of cell nodes | 8 | 8 | >65000 | 2007 |
| Encryption | E0 Stream clipher | AES block clipher (CTR counter mode) | AES block clipher (CTR counter mode) | RC4 block clipher (WEP) AES block clipher |
| Authentication | Shared secret | CBC-MAC(CCM) | CBC-MAC(ext of CCM) | WPA2(802.11i) |
| Data protection | 16-bit CRC | 32-bit CRC | 16-bit CRC | 32-bit CRC |

The interface is connected with four different medical devices through UART and analog port at 42 kbps of data rate. Table 3 explains the comparison of Bluetooth , UWB, Zigbee and Wi-Fi based on IEEE spec , frequency band, Nominal range, Channel bandwidth, modulation type etc.

CONCLUSION

In this paper, Web-based wireless system for remote monitoring is presented. Besides having control function which can monitor the system remotely, the system is also equipped with web-based function which made it accessible at any place and any time via the internet. We use both wired and wireless networks for remote monitoring. Wired network has some limitations to which we prefer wireless networks due to its reduced cabling costs and installation time. It lets you move your measuring device from place to place and remotely monitor conditions. You can log data from your existing devices wirelessly by adding appropriate adaptors or routers.

Here, from the above analysis we find both Wi-Fi and Zigbee are better than other monitoring systems. When data protection is considered as first priority, Wi-Fi is preferred over Zigbee. Zigbee is preferred to other monitoring systems due to the advantages such as security, long battery lifetime due to low duty cycle and low cost .It has large number of nodes up-to 65000 in a network. It is easy to deploy and is used globally

To improve on the monitoring system, some future works are suggested here. Firstly, the data obtained from the monitoring system is useful for future reference to determine the efficiency and stability of the PV system as it may reduce over times. Secondly, the data collected can also be used for fault detection. Thirdly, faulty notification to user by using messaging system may become an added value to the system. Lastly, sensors failure detection may be added to the developed system to improve its robustness.

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