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Design of Datalogger for Diverse Environmental Monitoring

Madasamy V
Student of VLSI Design
Anna University of Technology Madurai, India
E-mail : maddynice07@gamil.com

Dr. Malathi V
Director and Head of ECE department,
Anna University of Technology Madurai,
Madurai, India

Abstract- This study is aimed to design a gateway between wireless sensor network (WSN) and back end server via mobile communication network and also monitor and control the environmental parameters such as water level, water quality, Ground motion, Aerosol and Gas in the environment. Here with the help of some different sensors we are monitoring the different level of environmental parameters using GSM technology. The project is to design a data logger which will monitor and control the parameters level in the environment and also intimates the concerned authority when the parameters level exceeds the limit. This system also checks continuously the water flow, quality, Ground motion, Aerosol, Gas in environment and whenever parameters level exceeds the higher limit sends SMS to the concerned person using GSM technology. By using this project we can avoid the damage caused by the environmental parameters and we can reduce the man power for continuous monitoring of the parameters level in the environment. The system should also designed to cover a large spectrum where monitoring is needed.

Keywords - *Environmental monitoring, sensor data, threshold, wireless sensor network, WSN gateway.*

I. INTRODUCTION

In the past decade, the sensor-specific and service oriented architectures became one of the key issues for detection, analysis, and management of environmental information [1].Due to the rapid advances of technology in micro electromechanical systems (MEMS), integrated circuit (IC) and radio frequency (RF), the wireless sensor network (WSN) [2] has been widely spread out in a variety of surveillance applications such as environmental monitoring [3], [4], smart home facility[5], natural detecting and ecological tracking [6], industrial engineering and construction quality control [7], land sliding prediction [8], etc. The WSN is practically deployed as tiers of the sensor area to sense phenomena, the gateway devices to process sensed data, and the back-end server to take actions according to applications of the ubiquitous network [9]. Most of the algorithms offered the function for this manner by commercial software or middleware [10]–[13] and would be eventually implemented and approved by practical field measurement.

However, those WSN utilities mostly served relay transportation of identical type data to achieve specific tasks but lacked a generalized gateway model that can filter diverse sensor data prior to the back-end server. In this study, web designed a comprehensive WSN gateway model for the environmental monitoring system to bridge the tiers of sensor nodes and the back-end server while processing and monitoring various sensed data via mobile communication network by using GSM modem.
This system is designed using a Global System for Mobile Communications (GSM) modem. The GSM modem is configured as a receiver which sends the SMS to a computer after

receiving it completely. The SMS sent by the user is written in a particular format. The computer receives the message and decodes it and identifies the task to be done. Accordingly the computer sends one code to the microcontroller and the controller performs the task. In this way the devices connected to the controller is operated through a SMS.The diverse sensor data were implemented by practical field tests for the proposed gateway model and real time environmental monitoring system.

Herein, we propose the WSN gateway model for the following scopes: 1) aggregate diverse sensor data, 2) parse packets by threshold criteria, 3) connect the WSN with Internet, and 4) be easily adopted by the real-time presentation functions at the backend server. In which, the mobile GPRS or local area network (LAN) can help Internet connection for advanced data transportation [15], [16] to the database. The backend server will convert physical data by analytical modules in the application layers.

II. ENVIRONMENTAL SENSOR DATA

The WSN practical sensor is created by remodeling the industrial sensor with a mote, that supports the embedded micro control unit(MCU) for processing the sensed signals. The design requirement of WSN gateway depends upon the characteristics of sensor data, data filtering, and data conversion.

A. Characteristics of Sensor Data

Diverse environmental sensors for realistic monitoring are classified in five primary categories by levels of detection requirements, from water to air, including water level, water quality, ground motion, aerosol, and gas. These sensors are selected for the manners on power supply, voltage IO, and energy consumption.

The battery-powered mote reads sensed analog signals and transfers as analog-to-digital conversion (ADC) counts before writing into the packet. Then, the transport procedure is started to send packets to the gateway. At sensor nodes, the MCU will take responsibilities of sensor data receiving, analog-to-digital converting, essential packet validating, and Internet transporting; thus, the tasks about initial computation upon ADC-based criteria checking, packet parsing, and IP connecting can be assigned to the WSN gateway.

B. Data Filtering

The WSN gateway facility is applied as a mid station for remote online monitoring. Fig. 1 presents an infrastructure of the WSN gateway model as the pivot of data acquisition and transmission for environmental monitoring. The model receives signals from sensor nodes at the front-end and sends data to the data sink at the back-end server as well as controls the criteria fed back from the back-end server for data filtering. The major tasks of the WSN gateway includes identification of ADC count,string parsing and packet validating, criteria verifying, IP connection, and data backup, in addition to data transportation.

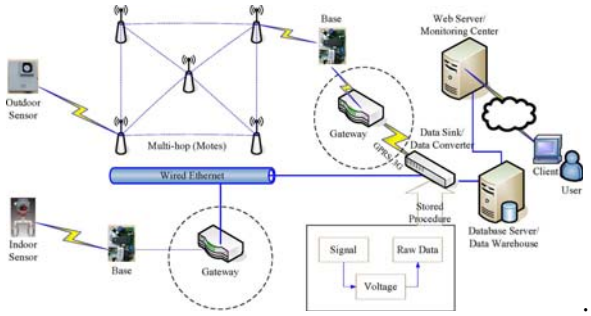

Figure 1: Infrastructure of the WSN Gateway Model for Environmental Monitoring

The GPRS/3G protocols should be kept in "always connected" status when they are working for outdoor field monitoring, meanwhile the data log in the gateway is requested to stock pending records until the network is reconnected [41]. Furthermore, the complicated Computation such as advanced physical data conversion and threshold analysis is suggested to execute in the back-end server for sharing loads of the WSN gateway.

C. Data Conversion

There are probably more ADC counts of internal voltage in the string, depending on the number of output channels of the sensor. Once the socket receiver of data sink detects the socket data, the process of data filtering and conversion will be activated for converting the ADC counts. The corresponding voltage can be calculated by the given formula as follows:

$$V = \frac{ADCCount}{2^{ADCbit}} * Vint$$

whereVint is the internal voltage of the mote, and ADC bit is the bit number of analog-to-digital conversions by the mote. To properly convert ADC counts as physical data by using the following formulations. They are rely forward, simple linearity, range mapping and Gaussian formulation.

1) Type 1: Relay Forward:

Typical relay forward data can straightly send physical data obtained by the sensor, i.e., the sensor has delivered physical data in binary or hexadecimal format. It only simply converts binary data to decimal format without advanced formulation.

2) Type 2:Simple Linearity

Most of sensors for environmental monitoring are classified as simple linearity that converts ADC counts of the internal voltage into physical data with a linear function. Based on the general form of linear function, the output voltage V can be converted as physical data like water level or gas concentration, and so on.

$$h(V) = aV + b$$

where*h* represents physical data, while the experimental parametersand can be referred from the specification of sensor.

3)Type 3:Range Mapping

Some sensors provide a nonlinearrelationship between output voltage/current and physical data within the specified range in which boundaries are confined by nonlinear functions, e.g., an output voltage is mapped to a concentration range but not a constant value.

4) Type 4:Gaussian Distribution

This category considers the algorithm of data conversion for random distribution when sensed data returns random variables and probably no confirmable value to substitute into relationship functions. In the other words, a range of output voltage might be mapped to the same physical data as a more-to-one relationship. One of the possible algorithms is finding an expectation value of random variables by regression. It initially gathers a set of sensed data distributed during a period and summarizes the number of times for each ADC count value. Thus, the probability density function (PDF) of probability versus ADC count can be determined as well as the mean value and variances of the PDF can be carried out through analysis tools such as Matlab. Then, it is able to generate a histogram of distribution mean mapping to the specification of sensor for data conversion.

III. WSN GATEWAY DESIGN

The output signal of the WSN sensors can be initially catalogued by analog or digital signals. The serial peripheral interface (SPI) bus or the universal asynchronous receiver/transmitter (UART) of the MCU is usually functioned for digital input signals. The ADC component of the MCU is typically set up as 10-or 12-bit digital levels for the regular resolution sensing. The high resolution sensor requires extra ADC circuits to generate the input signal and also produces a considerable amount of data which must be stored before the RF component reads and transmits them to the gateway. Herein, the development of the proposed WSN gateway model is mainly separated by hardware design and bridged gateway functions. Moreover, the criterion-based scheme for thresholds of monitored data can be remotely updated from the back end server.

I. Hardware Design:

As shown in Fig. 3, the proposed WSN gateway hardware consists of an ARM-based (advanced RISC microprocessor based) main-board with the battery supply and a WSN base mote with the USB-supported hub while the 3G modem enablesthe packet transmission. The ARM-based Linux OS is employed due to its flexibility and availability for development.

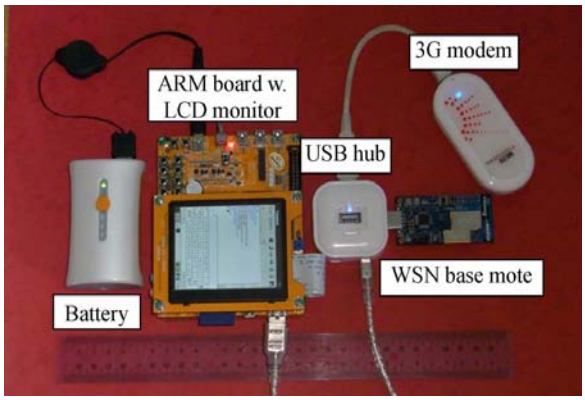

Figure 2: ARM-based gateway devices for simulation.

The WSN base mote is responsible for receiving monitored data from the front-end sensor nodes. A secure digital (SD) memory card can be utilized to store the embedded software, criterion tables, customized static libraries, data log files, and soon. A chargeable battery by solar power can work for environmentalmonitoring applications without wired power. The embedded software isdeveloped and cross-compiled on a Linux PC, and then the binary is downloaded to the ARM board. In further design, for the gateway to determine monitoring time, the network time protocol (NTP) module within the OS enables the gateway torecord the timestamp as receiving the sensed data.

II. Bridged Gateway Functions

The common functions of a bridged gateway can be summarized by listening to the serial port, transacting on the data log, and forwarding to the Internet protocol. Therefore, we design the serial listener to receive and validate the incoming WSN packets, and then the qualified packets can be sent to the remote sever by available protocols. On the other hand, we consider the Internet listener to process the transaction commands, and then those queries are copied to the serial port of the base mote. The functions are programmed with three threads in the flowchart illustrated on Fig. 4 and the components are detailed below.The proposed algorithm includes the serial listener, the transaction logger, and the Internet listener to drive the auto process; thus, a criterion-based scheme is designed to enhance the data aggregation and filtering function without the loss of packets.thus, a criterion-based scheme is designed to enhance the data aggregation and filtering function without the loss of packets.

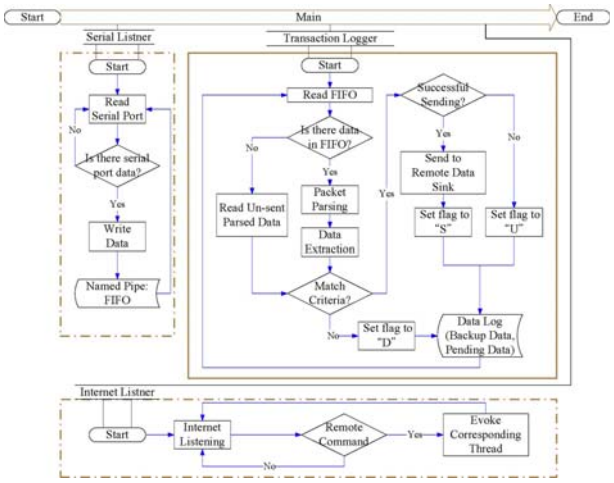

Figure 3: Flowchart of data processing in the gateway

In summary, the serial listener monitors the incoming sensor data and then writes the received data into a named pipe FIFO, with queue structure. The transaction logger reads FIFO data, parses the data with criteria, backs up validated data, and transmits the data to the remote data sink. The Internet listener accepts the commands from the remote data sink, while the outgoing connection is maintained by the PPP program.

IV. RESULTS AND DISCUSSIONS

A. Diverse Data Aggregation

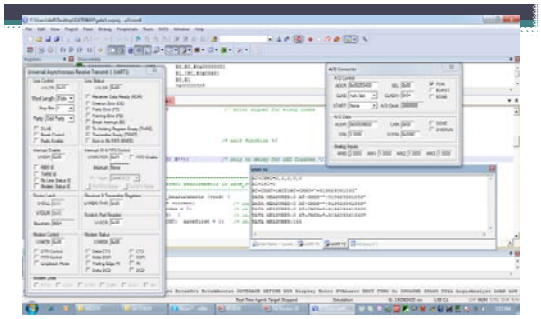

Figure 4: Data Measurement by Using ADC

Figure.4. is the simulation result of data measurement at initial stage. The data's are getting from the Wireless sensor networks (WSN) in the form of analog signals. Then the analog signals are converted into digital data's by using A/D conversion techniques. Depending on the type of data the conversion technique is changed for data aggregation. For example the measured data is in the form direct physical data means there is conversion mechanism is

used ,i.e., the data could be digital count or recognized string. The acquired data with either linear or non linear conversion request a formula to yield physical value at the back end.

The resultant measured data's are sent into the GSM modem by using bridged functions.The three basic bridged functions that are used for listening the serial port, transacting on the data log, and forwarding to the internet protocol. The data process within the gateway model extracts the desired information from the FIFO queue, filters out the invalid packets, formats the information by the required data format, backs up the formatted data in the data log file, and sends data to the data sink at the backend server if the corresponding criteria are matched.

B. Packet Filtering in the WSN

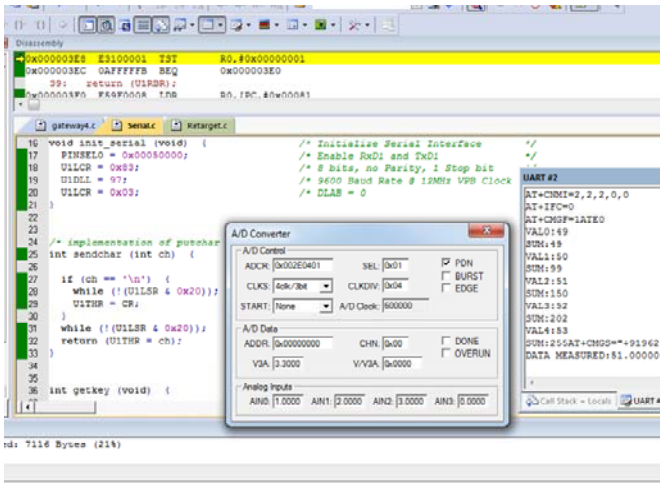

Figure 5: Packet Filtering in the WSN

Figure.5. shows an simulation result of Data Aggregation, the data acquisition process when the serial listener was detecting whether any sensed datum arrived at the serial port or not. The arrival packet was parsed by the defined payload and was written to pipes of the FIFO module. Meanwhile, the transaction logger created a thread to cyclically read the FIFO pipe and parse the sensed data. The transmitting process of parsed data flow of new incoming packets writing to the log and sending out. Consecutively, the thread validated the packets by the specific area for sending those qualified data or doping the incomplete data. The model receives signals from sensor nodes at the front end and sends data to the data sink at the back-end server as well as controls the criteria fed back from back end for data monitoring.

C. Data Conversion and Real-Time Presentation Interface

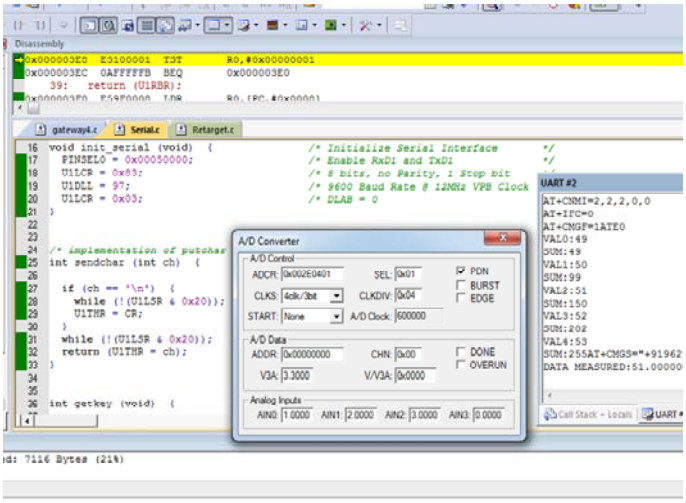

Figure 6:Data Aggregation at Various Channels

In this Fig.6, accelerator and aerosol sensors were discussed From the outdoor and indoor environment monitoring tests, respectively. For example of the accelerator sensor, if the regression values of initial voltage were 3.6 and 2 V, while the values of corresponding sensitivity were 360 and 195 mV/g, respectively, the sensitivity as 298 mV/g and updated the criteria in both of the gateway and data sink. Both types of signals were filtered and transported in the same WSN gateway model that was adaptive to the back-end server. The received data are logged into the designed data log file. Based on the this format, we can denote data information with fields, such as sending status, node ID, timestamp, packet sequence number, value of ADC counts, and residual voltage battery in ADC count as well as RSSI and LQI.

V. CONCLUSION

According to the environmental monitoring test in this study, the WSN gateway was designed with threads of serial listener, transaction logger, and Internet listener to implement necessary data processes, such as acquires data from the WSN's, Converting the data depends upon the type of measured data and filtering the sensor data. These techniques are used for determining ADC-based criteria, remaining data log redundancy, and mobile communication. A Data sink was created for physical data conversion. The proposed hardware and software adopted the embedded computer.

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