Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 2, Issue. 6, June 2013, pg.32 – 36

RESEARCH ARTICLE

Remote Temperature Monitoring Using LM35 sensor and Intimate Android user via C2DM Service

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Abstract— This paper presents an embedded wireless sensor network prototype for remote room temperature monitoring. This network will be used for management of fire rescue operations. It will give the Android registered user freedom to continuously monitor the remote room temperature and in this way it provides better fire controlling technique. The proposed system provides an android user interface for registered user to access the current temperature and a flash/beep message in case of fire. LM35 sensor sense the remote room temperature and temperature status is transmitted to the smart phone via GPRS. Remote room temperature data transfer between the smart phone and application server that is connected to temperature sensor via USB cable is done using Google's C2DM service. The application server which analyzes the temperature data, then inform a registered user for taking proper action in case of fire. This work aims at monitoring of remote room temperature. Thus provides opportunity to quickly respond to fire emergencies.

Key Terms: - Wireless sensor network; Arduino; microcontroller; temperature monitoring; General Packet Radio Service (GPRS); Cloud To Device Messaging (C2DM)

I. INTRODUCTION

Fire hazards are the most threatening cause of global warming. In the same time, there are many technologies that can be used to resolve these problems and more over support better living. Wireless sensor network technology hold the promise of many new applications in the area of monitoring and control. Wireless sensor networks are an emerging technology consisting of small, low power, and low-cost devices that integrate limited computation, sensing and remote communication capabilities. This technology has enormous impact on fire emergency.

In the fire endangered areas temperature sensor are used from there manually a person deliver the temperature information on a fire extinguishers website, email-id or on to a landline number. In this manner, it is not possible that response to fire emergencies is made with in fraction of seconds because some time can be taken to access information from a website and email-id.

Whereas the LM35 temperature sensor mounted on bread board connected to Arduino uno + Ethernet shield via wires is portable temperature monitoring devices provide temperature information as per user request sent. In case of fire emergencies Android user is intimated through a flash fire warning message on his/her handset within minute time interval. They lack the capability of providing temperature information when GPRS connection is not made on application server as well as on Android user's handset.

With the ongoing rapid advances in wireless communication networks, and the emerging technologies related to small, low power and economically viable sensors, a new area of an emerging data communication technology is the wireless sensor networks, these devices consist of a monitoring power and remote communication capabilities.

II. SYSTEM ARCHITECTURE

Remote room temperature sensor follows an experimental prototype recently presented. However, there are many differences with the earlier prototype. Firstly, temperature sensors are populated inside the remote areas (see Figure 2). Secondly, GPRS is used instead of Bluetooth providing a much area coverage method for communication, USB cable and RJ45 cable is used for taking power and connecting sensor to application server. Finally, the mobile client side provides an interface to user for accessing remote areas temperature information. Remote temperature monitoring Application uses a three-tier architecture consisting of a sensor module, communication module, and Android interface module. A diagrammatic overview of the pipeline of our system is presented in Figure 1.

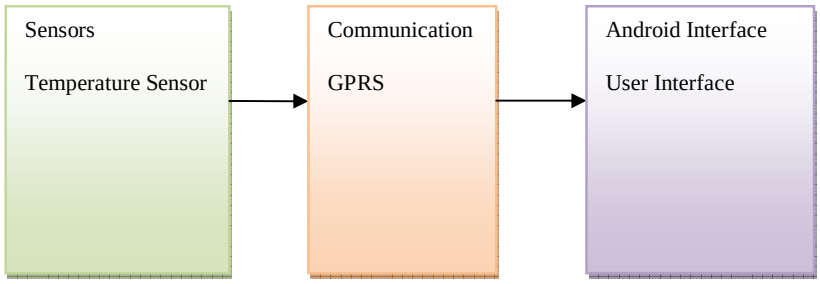

Figure 1 Architecture of Remote Temperature Monitoring Application

The sensor module handles current temperature and fire related data from temperature sensors, positioned at fixed locations within a remote area. These sensors are attached to application server node, which is capable of performing the initial processing before passing the data up the user end. In case of the application server node, the temperature data is formatted ready for transmission via the Google's C2DM service. The data is transferred over a GPRS link via cloud to device messaging service (C2DM) to a dedicated Android smart phone user. This link is bidirectional, and allows messages to be sent between application server and Android user. The Android module contains the handheld device running the user interface. The data received is represented using user interface of this android application.

A. HARDWARE

There are a variety of available embedded platforms for sensing applications. Communication technologies such as Bluetooth, WiFi and ZigBee [18] allow for network collection and transfer of environmental data to sensing devices. The hardware choice decision for the network discussed here was based on the available platforms' sensing capability, ease of software development and size.

Arduino uno board with Ethernet shield is selected as the main processing platform, popular for wireless temperature sensing applications, they are becoming more prevalent. These devices offer more processing power and memory (in terms of both EPROM and flash) than many similarly sized platforms. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. There are no onboard sensors provided, though a LM35 sensor mounted on bread board is connected to Ethernet shied mounted on Arduino uno board by using wires.

Arduino can sense the environment by receiving input from temperature sensor and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing).

The Arduino Ethernet Shield allows to easily connecting Arduino to the internet. This shield enables Arduino to send and receive data from anywhere in the world with an internet connection. It can be used to do fun stuff like control robots remotely from a website, or ring a bell every time you get a new twitter message. This shield opens up endless amounts of possibility by connecting the project to the internet in no-time flat.

Figure 2 Ethernet shield mounted on Arduino board for power connect to server by using USB cable

An LM35- temperature sensor mounted on the bread board is used for monitoring room temperature. The advantage of this sensor has more memory, processing and communication capabilities than other sensor nodes. The LM35 series are precision integrated – circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ^{0} Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of +_-1/4^{0}C at room temperature and +- 8/4^{0}C over a full -55 to +150^{0}C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60µA from its supply, it has very low self- heating, less than 0.1^0 in still air. The LM35 is rated to operate over a -55$^{0\ to}$ +150^0 temperature range.

A breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts will not be damaged so they will be available to re-use afterwards. The bread board has many strips of metal (copper usually) which run underneath the board. These strips connect the holes on the top of the board. This makes it easy to connect components together to build circuits. To use the bread board, the legs of components are placed in the holes (the sockets). The holes are made so that they will hold the component in place. Each hole is connected to one of the metal strips running underneath the board. Each wire forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node. On the bread board, a node is the row of holes that are connected by the strip of metal underneath. The long top and bottom row of holes are usually used for power supply connections.

The rest of the circuit is built by placing components and connecting them together with jumper wires. Then when a path is formed by wires and components from the positive supply node to the negative supply node, we can turn on the power and current flows through the path and the circuit comes alive.

For visualization, an android smart phone is used, having version 2.2 or higher. This makes it a suitable device to handle our WSN configuration and display the visualization with current temperature information.

B. SOFTWARE

At the heart of the sensing system is a collection of software libraries developed as part a software support system for WSN. The provision of a Android user interface to common sensor network tasks allows the implementation details of complex tasks to be hidden, thereby offering the systems designer a cleaner workflow. Software abstractions of sensing and communication tasks have been created, allowing the user to enter functionality into the application.

An Android user interface to temperature sensor has been implemented to allow access to data from the sensor module. Using an abstraction model for sensing interfaces, the process of gathering data is simplified. This in turn allows a modular approach to application development.

The framework supports Google's cloud to device messaging service for communication between the application server and Android user. It allows third-party application servers to send lightweight messages to their Android applications. The messaging service is not designed for sending a lot of user content via the messages. Rather, it should be used to tell the application that there is new data on the server, so that the application can fetch it.

An application on an Android device doesn't need to be running to receive messages. The system will wake up the application via Intent broadcast when the message arrives, as long as the application is set up with the proper broadcast receiver and permissions. It does not provide any built-in user interface or other handling for message data. C2DM simply passes raw message data received straight to the application, which has full control of how to handle it. For example, the application might post a notification, display a custom user interface, or silently sync data. It requires devices running Android 2.2 or higher that also have the Market application installed. It uses an existing connection for Google services. This requires users to set up their Google account on their mobile devices.

Communication module contains C2DM Bridge part for sending temperature information and Temperature Sensor part for sensor on/off operation. It is implemented using NetBeans 6.9.

The sensor module was developed using the above framework. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing).

The Android user interface module used the Eclipse Helios 3.6 for development of user interface. This interface is used for knowing remote areas current temperature. JDK is integrated in Eclipse IDE, coding is done by using android application fundamental concepts. This interface runs as android application on Android smart phone.

III. ANDROID USER INTERFACE

An Android user interface has been implemented in order to allow a user to experience the remote areas temperature information. Sensors collect temperature data in remote areas and relay this information to Android user. A user interface is then used for Google device registration Figure 3 illustrates how a user operating the interface on Android smart phone would perceive Google device registration ID.

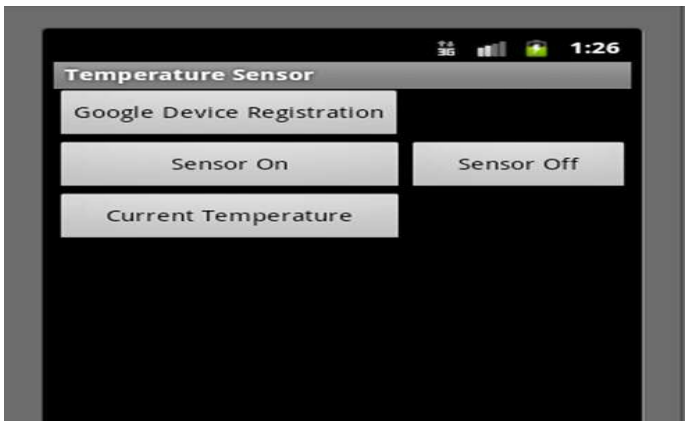

Figure 3 Google device registration ID, Sensor on/off and current temperature function by using Android user interface

Users can on or off the temperature sensor from the remote location that is placed in remote areas, get current temperature of the room. In Arduino programming current temperature value is compared with reference temperature if it exceeds the reference temperature then a beep/flash warning message will be displayed on the Android smart phone.

IV. CONCLUSION

This paper describes temperature monitoring application on Android device. We have presented here a research on Advances in electronic technologies, microcontrollers, and sensors which offers researchers a variety of new and inexpensive sensing, monitoring, and control capabilities. The concept of open source hardware designs, software programs, and development efforts are made freely available to all, which helps to facilitate and expand the adoption of these capabilities. The open-source hardware Arduino development platform has great potential for remote room temperature sensing, processing and communicating. This paper presents a research on wireless sensor network based remote room temperature monitoring application. Temperature information is transmitted wirelessly to registered user who is an Android user. Temperature exceeding information and current temperature is delivered from Application server to Android phone using C2DM service. The main advantage of temperature sensing application is that the flash/beep message delivered on Android user handset in case of fire. We believe that temperature monitoring application design principle is essential for the effective realization of ubiquitous computing.

ACKNOWLEDGEMENT

I would like to thank almighty and my family for their constant support during this work. I would also like to thank my supervisor Prof. (Dr.) Yusuf Mulge for his support and encouragement to complete work.

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