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Sensor Cloud to Monitor Cold Chain Logistics using Internet of Things (IoT)

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ABSTRACT :-The Internet of Things (IoT) is a new evolution in technological advancement taking place in the world today. This paradigm allows physical world objects in our surroundings to be connected to the Internet. This idea comes to life by utilizing two architecture; the sensing entity in the environment that collects data and connects itself to the cloud and the Cloud Service that hosts the data from the environment. The combination of wireless sensor networks and cloud computing is becoming a popular strategy for the IoT era. The cold chain requires controlled environment for sensitive products in order for them to be fit for use. The monitoring process is the only assurance which tells if a certain process has been carried out successfully. Taking advantage of IoT and its benefits to monitor cold chain logistics will result in better management and product handling. This project comprises a system of Arduino, sensor and Xively sensor cloud which can be an ideal system to monitor temperature of cold chain logistics.

Keywords :- *IoT, Cloud Computing, Cold Chain Logistics, Arduino, Sensors.*

I. INTRODUCTION

Cold Chain logistics refers to the transportation of pharmaceutical products, biologics and active ingredients in controlled temperature environment.

These temperature sensitive items require such environment to the very last stage of the cold chain so that they do not lose their potency and is fit for use or consumption. This applies to both high-risk and low-risk products such as insulins, vaccines and blood products. The counterfeit products are a real threat to public health and safety. In the early 1990's, Food and Drug Administration (FDA) and U.S. Department of Agriculture (USDA) began to convey the Hazard Analysis Critical Control Point (HACCP) rules as a systematic approach to food safety . The same principle has now been applied to other industries dealing with temperature sensitive products such as the pharmaceutical industry.

The HACCP management system addresses various circumstances for product safety and among them is the handling and distribution of the finished product. HACCP has become universally recognized and accepted standard for product safety and has been adopted by the WHO Standards Programme. At every point in the cold chain, precautions are taken to ensure that the external conditions do not have any effect on the quality and stability of the products.

The continuous progress in emerging sensor technologies such as WSNs has inspired IoT as this technology allows wide and cheap deployment of sensors on a large scale. The integration of WSNs to the Internet needs high performance computing and storage infrastructure to perform real-time data processing and storage of data from WSNs and analyzing processed information to extract events of interest. For this reason, cloud computing is proving to be a promising technology to provide flexible computing, storage and software services in a scalable and virtualized manner.

Sensor cloud infrastructure is a secondary form of cloud computing that has been proposed by several IT people in present times. Sensor cloud allows managing of physical sensors on IT infrastructure. By utilizing the sensor cloud platform, several matters such as storing of collected data and processing them have become simple. Many real life applications are being assimilated to the sensor cloud including environmental monitoring, structural monitoring, disaster monitoring, agriculture, health care, telemetry, etc.

1.1 A brief study on Internet of Things

The Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings and other items—embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data. In simple words, devices that collect and transmit data via the internet. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit; when IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist fire fighters in search and rescue operations. Legal scholars suggest looking at "Things" as an “inextricable mixture of hardware, software, data and service". These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. Current market examples include smart thermostat systems and washer/dryers that use Wi-Fi for remote monitoring.

1.2 A brief study on Cloud Computing

Cloud computing is a computing model based on networks, especially based on the Internet, whose task is to ensure that users can simply use the computing resources on demand and pay money according to their usage by a metering pattern. Therefore, a new business model is being created where the services it provides are becoming computing resources. In recent years, cloud computing as a new kind of advanced technology accelerates the innovation for the computer industry. Cloud computing is a computing model based on networks, especially based on the Internet, whose task is to ensure that users can simply use the computing resources on demand and pay money according to their usage by a metering pattern similar to water and electricity consumption. Therefore, it brings a new business model, where the services it provides are becoming computing resources.

1.2.1 History of Cloud Computing

Cloud Computing (CC) is a new term given to a technological evolution of distributed computing and grid computing. CC has been evolving over a period of time and many companies are finding it interesting to use. Without the development of ARPANET (Advance Research Projects Agency Network) by J.C.R.Licklider in 1960’s and many other researchers who dreamt of improving the interconnection of systems, CC would never have come into existence. The advent of ARPANET, which helped to connect (for sharing, transferring, etc.) a group of computers, lead to the invention of Internet (where bridging the gap between systems became easy).

1.2.2 Cloud Computing: Service models

CC can be accessed through a set of services models. These services are designed to exhibit certain characteristics and to satisfy the organizational requirements. From this, a best suited service can be selected and customized for an organization’s use. Some of the common distinctions in cloud computing services are Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), Infrastructureas-a-Service (IaaS), Hardware-as-a-Service (HaaS) and Data storage-as-a-Service (DaaS).

• Software as a Service (SaaS): The service provider in this context provides capability to use one or more applications running on a cloud infrastructure. These applications can be accessed from various thin client interfaces such as web browsers. A user for this service need not maintain, manage or control the underlying cloud infrastructure. Examples for SaaS cloud’s are Salesforce, NetSuite.

• Platform as a Service (PaaS): The service provider in this context provides user resources to deploy onto cloud infrastructure, supported applications that are designed or acquired by user. A user using this service has control over deployed applications and application hosting environment, but has no control over infrastructure such as network, storage, servers, operating systems etc.Examples for PaaS cloud’s are Google App Engine, Microsoft Azure, Heroku

• Infrastructure as a Service (IaaS): The consumer is provided with power to control process, manage storage, network and other fundamental computing resources which are helpful to manage arbitrary software and this can include operating system and applications. By using this kind of service, user has control over operating system, storage, deployed applications and possible limited control over selected networking components. Examples for IaaS cloud's are Eucalyptus (The Eucalyptus Open source Cloud-computing System), Amazon EC2, Rackspace, Nimbus

• Privacy and Anonymization as a Service (PAAS): This service is proposed as a demonstration model to provide data privacy and protection in a particular organization. It also proposes a work-flow oriented approach to manage data in cloud

• Privacy and Anonymization as a Service (PAAS): This service is proposed as a demonstration model to provide data privacy and protection in a particular organization. It also proposes a work-flow oriented approach to manage data in cloud. Examples for HaaS clouds are Amazon EC2, IBM's Blue Cloud Project, Nimbus, Eucalyptus, Enomalism.

• Identity as a Service (IDaaS): This service is targeted for third party service providers who provide Identity and access control functions (including users life cycle and sign-on process). This can be used in combination with various other services (software, platform or infrastructure services) and also for public and private clouds.

• Data storage as a Service (DaaS): This service allows user to pay for the amount of data storage he/she is using. With this service there is a separate cloud formed which provides storage as a service. Examples of such kinds of users are Amazon S3, Google Bigtable, Apache Hbase, etc

• Security as a Service (SaaS): This service allows users to create their own security policies and risk frameworks. In this kind of service cloud users must identify, assess, measure and prioritize system risks.

• Anything as a Service (XaaS): This is more general form of representing deployment of a service. These services could be of any type and 'X' in XaaS can be substituted by software, hardware, infrastructure, data, business, IT, Security, monitoring, etc. These days new service models are being developed. Examples are: IT as a service, Cloud as a Service (CaaS), Management as a Service (MaaS) , etc., are some other services that are identified in literature

1.3 Existing system

Flexible Tag Datalogger (FTD) to improve food and goods logistics during transportation, storage and vending. The device is composed of three sensors (temperature, humidity and light) and a microcontroller. The sensor data is transmitted on an infrared communication (as an alternative to the RFID technology) to enable the communication with most common personal devices such as smart phones or PDA with integrated infrared port. The device was tested on bottled wine by developing custom packaging to house the device to allow it to be easily wrapped around the bottleneck. The flexible tag collects data of its environment once the bottles leave the producer cellar for shop. When bottles arrive at the shop, the FTD attached to them downloads the data and is analyzed by PDA.

1.4 Objective of the Paper

The objectives of our paper are as follows

- To monitor the cold chain logistics
- To build a solution in low cost
- To enable the user to know whether the cold chain product is damaged or undamaged state

We, in this project have used Arduino Uno as the central device which controls the things. With a device such powerful it can sense temperature of the system can send the notify us via SMS and data is also uploaded to the cloud.2. LITERATURE REVIEW

2.1 Cold chain logistics

A lot of attentions on the cold chain logistics (CCL) are evident on various researches in recent years. Issues concern CCL is going to be presented, for instance, definition, composition and environmental effects. 2.1.1 Definition of cold chain logistics CCL also called cold chain management (CCM), which could be categorized into chain logistics or supply chain management (SCM). Jonsson (2008) describes Logistics as one kind of science of the efficient flow of materials. SCM is another term that has similar meaning with Logistics. Lambert (2004) defines SCM as an integration of key processes from end consumer through original suppliers, which provide adding value products, services, and information for customers and other stakeholders. The term SCM encompasses logistics, because SCM involves more process than logistics, such as marketing and product development. Food chain is defined as the process from the harvest of the food, through manufactory, to transportation and storage, and in the consumers' end use (Stringer et al., 2007).

2.1.2 The reasons for cold chain logistics development

Shabani conclude that cold chain was emerged because some products have limited shelf life and require special equipment and facilities for sales, storage and distribution. There are about 60% foods products need to gain good quality and extended shelf life though multifarious ways of refrigeration (Mattarolo, 1990).

According to Tirado, increasing temperature has a significant influence on Salmonellosis, Campylobacteriosis, Vibriosis and foodborne illnesses, thus higher temperature is strongly associated with diarrhoeal disease. The rising temperature due to global warming will lead the higher incidence of food poisoning. The development of cold chain is the inevitable outcomes of health and food safety requirements. The application area of cold chain serving is necessary for health, avoiding diseases and deaths. Due to the globalization, there is an increasing number of global food companies export food products. More goods are being transported further and frequently than ever before, and distance foods have drastically increased in recent years. It also concludes that growing food globalization has leading a need of global cold chain for growth. However, the food supply globalization also brings global food safety problems.

2.1.3 Composition of the cold chain logistics

Cold chain services of 3PL companies can be classified into three processes Cold processing, Cold storage and Cold transportation and distribution: ! Cold processing James and James (2010) define this process, as primary chilling and secondary cooling. The temperature of this stage is vital factor of food safety and quality. Cutting and quick-frozen machineries are needed in this stage, and a low-temperature workshop is also required. ! Cold storage Cold storage is defined by Akdemir (2008) as a process that storing perishable foods, pharmaceuticals, or other items under refrigeration. It is obvious that refrigerator is needed. While during the storage process, the monitor of the product quality should be paid special attention. ! Cold transportation and distribution Kuo and Chen (2010) describe cold logistics process as sorting, distributing and transporting various cold, chilled, frozen and fresh products to individual or enterprise consumers, in addition, the customer types are food manufacturer and channel dealer, and the transportation type is refrigerated transportation.

2.1.4 Temperature requirement

As mentioned above, the CCL is to control the temperature, while different kind of product demand different temperature and the required temperature also change according to the different stages. James and James (2010) state that a rise of the temperature would add up the risk for food poisoning and food quality declining. Most of the products that require cold chain technique are mentioned in the table above, while medicine and special vaccine is not included. The World Health Organization states that the temperature needed for vaccine is between 2℃ to 8℃

For applications involving complex processing, it is advisable to have an operating system. In such a case, you need to integrate the application software with the operating system and then transfer the entire software on to the memory chip. Once the software is transferred to the memory chip, the software will continue to run *for* a long time you don't need to reload new software.

Now, let us see the details of the various building blocks of the hardware of an embedded system. As shown in Fig. the building blocks are;

· Central Processing Unit (CPU)
· Memory (Read-only Memory and Random Access Memory)
· Input Devices
· Output devices
· Communication interfaces
· Application-specific circuitry

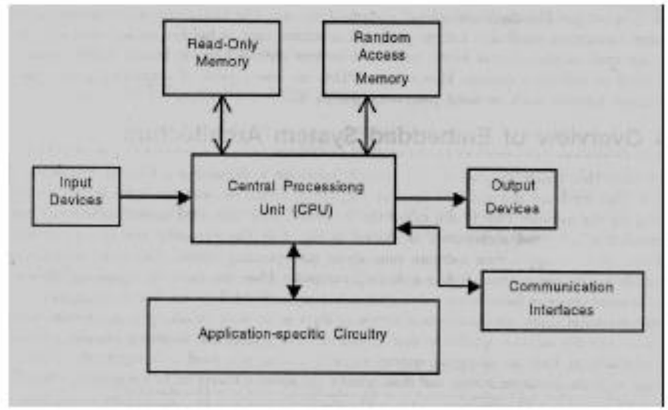

Figure 1: Building blocks of Embedded System

3.2.1 Central Processing Unit (CPU):

The Central Processing Unit (processor, in short) can be any of the following: microcontroller, micro-processor or Digital Signal Processor (DSP). A micro-controller is a low-cost processor. Its main attraction is that on the chip itself, there will be many other components such as memory, serial communication interface, analog-to digital converter etc. So, for small applications, a micro-controller is the best choice as the number of external components required will be very less. On the other hand, microprocessors are more powerful, but you need to use many external components with them. D5P is used mainly for applications in which signal processing is involved such as audio and video processing.

3.2.2 Memory:

The memory is categorized as Random Access 11emory (RAM) and Read Only Memory (ROM). The contents of the RAM will be erased if power is switched off to the chip, whereas ROM retains the contents even if the power is switched off. So, the firmware is stored in the ROM. When power is switched on, the processor reads the ROM; the program is program is executed.

3.2.3 Input devices:

Unlike the desktops, the input devices to an embedded system have very limited capability. There will be no keyboard or a mouse, and hence interacting with the embedded system is no easy task. Many embedded systems will have a small keypad-you press one key to give a specific command. A keypad may be used to input only the digits. Many embedded systems used in process control do not have any input device *for* user interaction; they take inputs *from* sensors or transducers 1'fnd produce electrical signals that are in turn fed to other systems.

3.2.4 Output devices:

The output devices of the embedded systems also have very limited capability. Some embedded systems will have a *few* Light Emitting Diodes (LEDs) *to* indicate the health status of the system modules, or *for* visual indication of alarms. A small

Liquid Crystal Display (LCD) may also be used to display *some* important parameters.

Application-specific circuitry:

Sensors, transducers, special processing and control circuitry may be required fat an embedded system, depending on its application. This circuitry interacts with the processor to carry out the necessary work. The entire hardware has to be given power supply either through the 230 volts main supply or through a battery. The hardware has to design in such a way that the power consumption is minimized

4. Arduino UNO System Overview

Before we can understand the UNO's hardware, we must have a general overview of the system first.After your code is compiled using Arduino IDE, it should be uploaded to the main microcontroller of the Arduino UNO using a USB connection. Because the main microcontroller doesn't have a USB transceiver, you need a bridge to convert signals between the serial interface (UART interface) of the microcontroller and the host USB signals.The bridge in the latest revision is the ATmega16U2, which has a USB transceiver and also a serial interface (UART interface).To power your Arduino board, you can use the USB as a power source. Another option is to use a DC jack. You may ask, "if I connect both a DC adapter and the USB, which will be the power source?" The answer will be discussed in the "Power Part" section from this article.

4.1 The Microcontroller

It is important to understand that the Arduino board includes a microcontroller, and this microcontroller is what executes the instructions in your program.

ATmega328 has three types of memory:

- **Flash memory:** 32KB nonvolatile memory. This is used for storing application, which explains why you don't need to upload your application every time you unplug arduino from its power source.

- **SRAM memory:** 2KB volatile memory. This is used for storing variables used by the application while it's running.

- **EEPROM memory:** 1KB nonvolatile memory. This can be used to store data that must be available even after the board is powered down and then powered up again

4.2 Power:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

4.3 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

4.4 Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

5. Study of Components

5.1 GSM Module

As for the above information we have understood the network of GSM which is used to transfer the data with the high speed and security by allocating the band width. To utilize the network over a long distance between the devices MODEM is used. The word MODEM means the process of Modulation and De-modulation. The device which acts as a GSM Modem uses a wireless network which is similar to a dial-up modem. But the dial-up is the fixed lines which transfers electronic signals over wire but whereas GSM Modem transfer the data via radio waves.

5.2 MAX232:

MAX232 is a line driver IC which is used in Microcontroller circuits for the interfacing of modules. Basically communication with MC or MP is not compatible with the standard protocols. Since to reduce this problem an IC is required to convert the RS232 voltage level to TTL voltage level. In general the communication with MC is done serially with certain band rates.

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5.3 RS232:

The RS232 is a cable which is used to transfer the data by adjusting voltages between the MC and modules through interfacing. As the voltages of MC are of TTL level and modules have RS232 level, so the MAX232 is used to convert the voltages in RS232 to TTL and vice versa. Actually the RS232 has 25 pins (i.e. DB-25) which is now replaced by the RS232 with 9pins (i.e. DB-9) because all pins are not used in present conditions.

5.4 LM 35 Temperature Sensor

Precision Centigrade Temperature Sensor

In this project, in order to obtain the fan speed based on temperature, initially this temperature value has to be read and fed to the microcontroller. This temperature value has to be sensed. Thus a sensor has to be used and the sensor used in this project is LM35. It converts temperature value into electrical signals.

5.6 Switch Interfacing

CPU accesses the switches through ports. Therefore these switches are connected to a microcontroller. This switch is connected between the supply and ground terminals. A single microcontroller (consisting of a microprocessor, RAM and EEPROM and several ports all on a single chip) takes care of hardware and software interfacing of the switch.

6 INTRODUCTION TO KIEL SOFTWARE

Many companies provide the 8051 assembler, some of them provide shareware version of their product on the Web, Kiel is one of them. We can download them from their Websites. However, the size of code for these shareware versions is limited and we have to consider which assembler is suitable for our application.

EVALUATION SOFTWARE:

. Code-Banking Linker/Locator . Library Manager.RTX-51 Tiny Real-Time Operating System

6.2 PERIPHERAL SIMULATION:

The u vision2 debugger provides complete simulation for the CPU and on chip peripherals of most embedded devices. To discover which peripherals of a device are supported, in u vision2. Select the Simulated Peripherals item from the Help menu. You may also use the web-based device database. We are constantly adding new devices and simulation support for on-chip peripherals so be sure to check Device Database often.

8.Overview

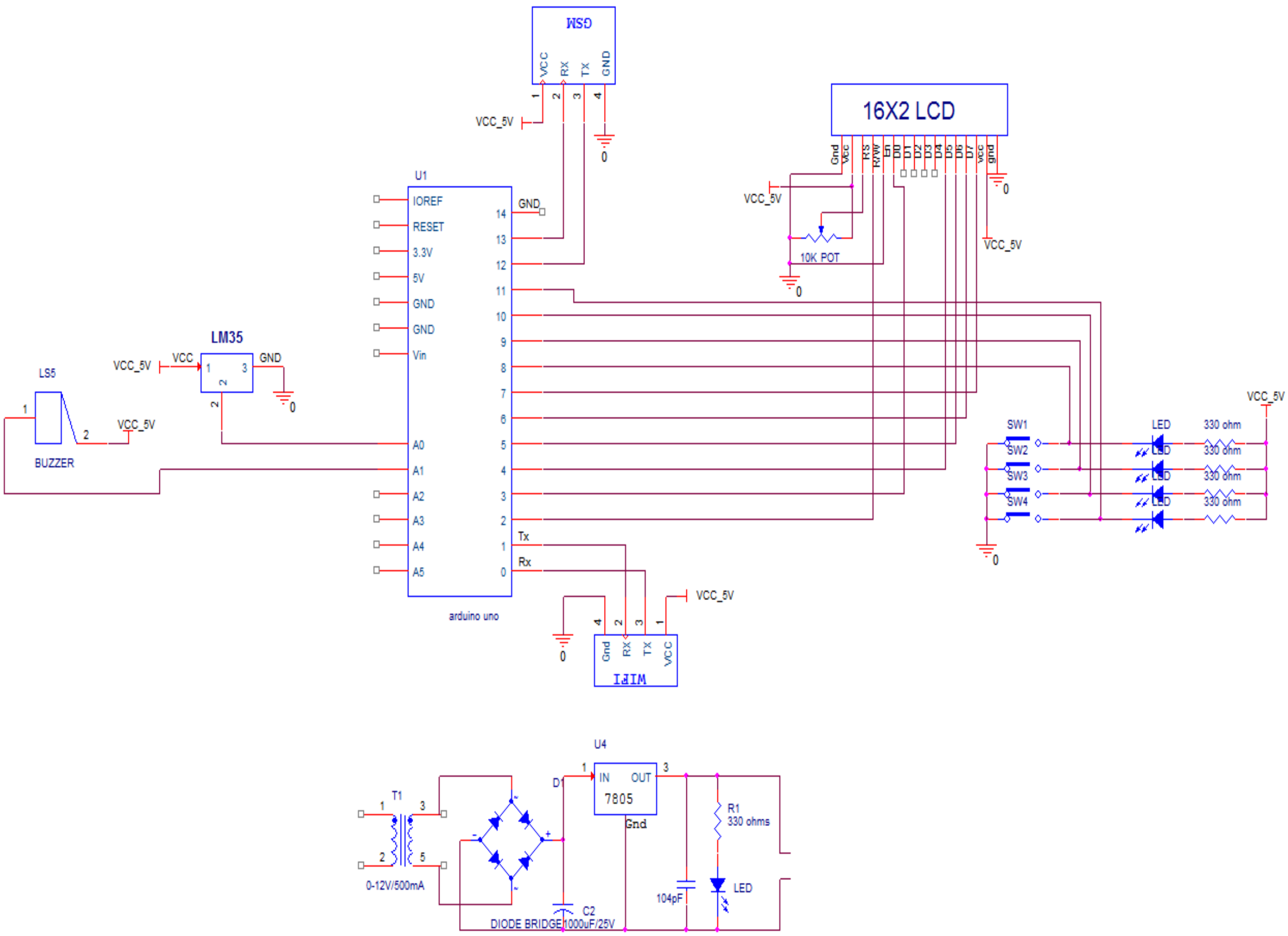
Overview:

The proposed system is an embedded system which will monitor cold chain logistics. In this project we used GSM module which will help the user to know about any cold chain product is exposed to some any un-suitable conditions by receiving a text message. The system comprises of sensor, microcontroller and actuators, LEDS, Wi-Fi module and LCD display.

Steps of Working: Firstly turn on the power and make sure all the components are powered

- Now the LCD display turn on and shows the status of all the components
- When all the status are shown and GSM module is properly configured with the inserted SIM it asks to send a message to the SIM
- It stores the phone number and sends the text message alert to the same number
- When phone number is stored successfully it now shows the value of temperature on the LCD
- Now at some point the value of the temperature exceeds the cutoff value and it sends the text message to the saved number
- At the same time the value of temperature is updated in the graph simultaneously

Figure-2: Block Diagram of the Project


GSM
VCC
RX
TX
GND
VCC_5V
16X2 LCD
10K POT
U1
IOREF
RESET
3.3V
5V
GND
GND
Vin
A0
A1
A2
A3
A4
A5
Tx
Rx
arduino uno
LM35
VCC
GND
LS5
BUZZER
SW1
SW2
SW3
SW4
LED
330 ohm
WIFI
Gnd
RX
TX
VCC
U4
IN
OUT
7805
Gnd
T1
0-12V/500mA
DIODE BRIDGE
C2
1000uF/25V
104pF
R1
330 ohms
LED

9. Results

Figure-3: System waiting to store a number

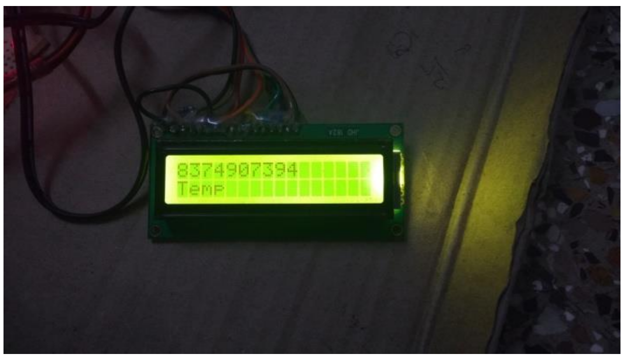


Figure-4: System received a message

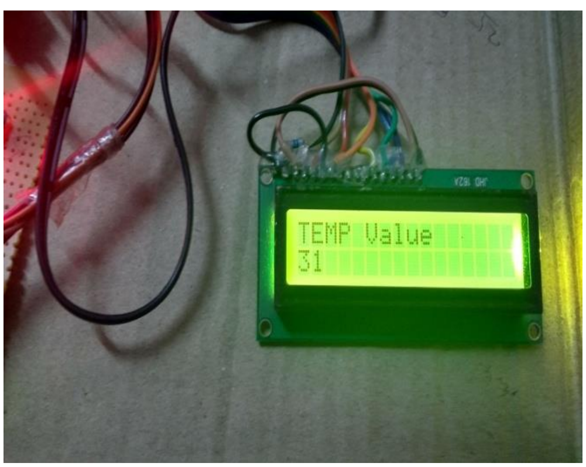


Figure-5: System sensing temperature

Figure-6: System sending message after crossing limit

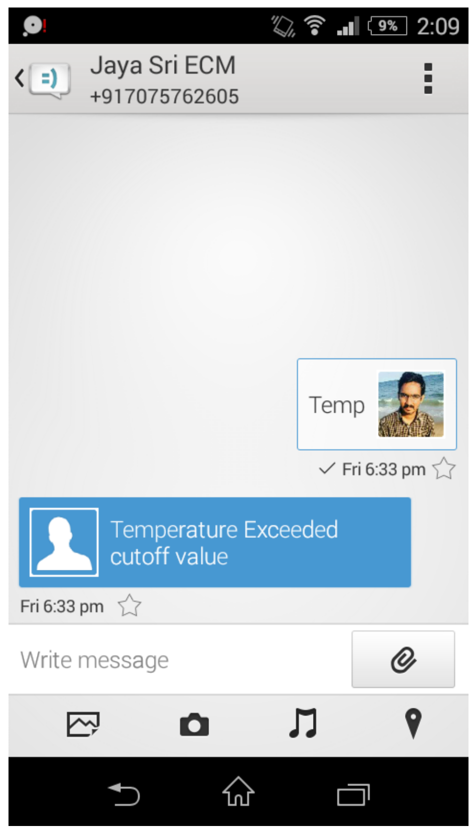


Figure-7: Message received to store number

10.Conclusion:

The expansion of embedded IC infrastructure has caused the deployment of wide range of embedded systems in our environment which points out the need for manageable and flexible sensing entity. IoT is a solution which proves to be a promising concept. We proposed the IoT concept for monitoring cold chain logistics that offers an easy way to manage and real time monitoring using sensor and cloud. With the integration of sensor infrastructure to cloud, there are numerous benefits where common processing, computational and analytical tasks can be hosted on the cloud service rather than the sensor architecture hence reducing power consumption and increasing the network lifetime. The data visibility also increases which enhances the monitoring and management.

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