Greenhouse Environment Monitoring and Automation using Intel Galileo gen and IoT

V. Sagar Reddy, Gujjula Ramya,V. Moneesh Reddy.

***Abstract*: The IoT and cloud computing technologies can be effectively used to combat threats posed to agriculture by global warming and climate change. This work mainly focuses on monitoring the internal parameters of a greenhouse which are its temperature, intensity of light ,moisture level of soil ,relative humidity and soil pH and upload them to a cloud to facilitate remote monitoring and enable autonomous survival of the crop by automating cooling fans, artificial lighting ,heating and watering equipment. It will also enable agriculturists to grow a certain kind of crop year round irrespective of actual geographical location and realizing it in a low cost manner. Another major concern is to reduce the physical workload on farmers and prevent loss to the crop which leads to food scarcity. Green houses are artificial structures that can be viewed as short term measures against adverse environmental conditions. When implemented on a large scale, green houses have the ability to address the problems of food scarcity, damage to the crop and its yield and consequent financial distress on the farmers. They also enable farmers to be more decisive in choosing the right type of crop to cultivate without geographical location being a hurdle. Automation is proposed to eliminate the needs for manual intervention in carrying out all the tasks smoothly which are often tedious and physically demanding. Remote monitoring gives the farmers the opportunity to be aware of what is happening on the field without having to travel to the actual location.**

***Index Terms*: Global warming, Greenhouse, Internet of Things, Cloud computing.**

I. INTRODUCTION

Industrial advancement has led to the prevalence of global warming on a significant scale. this along with other forms of climate change have resulted in unprecedented changes in the natural seasons leading to untimely droughts, floods, heat waves etc. which have substantially damaged conventional agricultural ventures across the world including India. The result is a huge loss of yield, resources and a financial burden on farmers. With the population across the world increasing in exponential manner, the amount of food produced by conventional methods will be rendered inadequate and any damage to the food or yield will only exacerbate the problem of food scarcity forcing a huge number of people into starvation. Hence, the concept of greenhouse can be expected to gain popularity as a conventional measure in the coming future.

The internet of things refers to a digital environment in which physical objects are inter-connected and are accessible through the internet. A thing in IoT could be any physical object that is uniquely identified by methods like assigning IP addresses or any other unique identifiers and is capable of transferring the data over a network without manual intervention. Examples of such things could be any physical objects like a person with health monitors, cars with sensors or a network of sensors itself.

A green house is an artificial structure that shields the plants within from harsh environmental conditions like strong winds, pests, toxic gases etc. by automating the greenhouse environment and making its parameters available for remote monitoring through open source cloud platforms the need for human intervention can be eliminated thus giving the crop autonomy over its survival. By practising effective greenhouse hygiene, the amount of pests infesting the crop can be reduced thereby reducing the amount of pesticides and insecticides which ensure longevity of soil fertility by maintain its pH.

The primary goal is to develop a system that can accommodate plants and make them self sustainable. The temperature, humidity, pH, moisture level, light intensity is continuously measured from various sensors using an Intel Galileo gen2 board. The board will be programmed to maintain optimum conditions inside the greenhouse based on the type of crop and its requirement. The values from the sensor will be updated to thingspeak which is an open source cloud using Intel Centrinowifi card.

The desired temperature will be maintained based on the speed of the fan or intensity of heating equipment i.e. fluorescent light which is determined by the value of temperature sensor inside the greenhouse. The crop will also be watered automatically by a pump interfaced to the board to turn on whenever the moisture level dips below a threshold. The monitoring of pH will reflect on the fertility of the soil for further use.

II. LITERATURE REVIEW

Various national and international researchers have already published

Revised Manuscript Received on May 28, 2019.

V.Sagar Reddy,Assistant Professor,ECE, VNR Vignana Jyothi Institute of Engineering and Technology,Bachupally,Hyderabad,Telengana,India.
Gujjula Ramya, Assistant Professor,ECE, VNR Vignana Jyothi Institute of Engineering and Technology,Bachupally,Hyderabad,Telengana,India
V. Moneesh Reddy, Student, VNR Vignana Jyothi Institute of Engineering and Technology,Bachupally,Hyderabad,Telengana,India.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

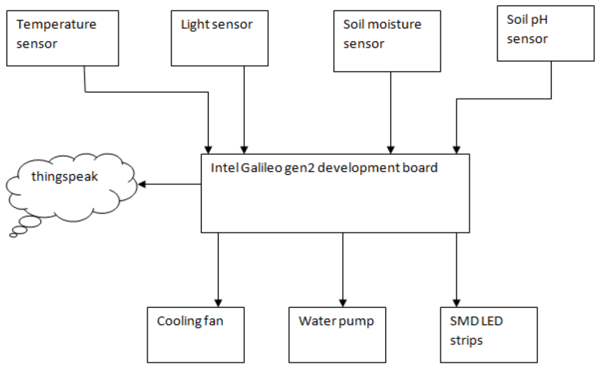
papers in this field. A brief summarization of them is presented below:
Some systems have employed GSM or android app technologies to control the lights, pumps, fans etc. in order to maintain the desired conditions but this requires human intervention in some way or the other which has been eliminated in the current proposal.

Most of the previous attempts have extensively been carried out using Arduino UNO which although is very economical and convenient lacks the capabilities to communicate over Linux shells and wi-fi without additional shields which is overcome in the current project by the use of Intel Galileo gen2 which is a relatively more powerful and IOT friendly development board that comes with onboard embedded poky Linux distribution and support for yocto Linux distribution from an SD card which makes the data exchange more secure as it uses SSH. It also gives more accurate results as its clock frequency of 400 MHz is superior to that of uno are which means that the parameters of the greenhouse are more frequently scanned.

[1] Performed similar work of monitoring and regulating environmental conditions but implemented it using arduino and used a different physical setup and extended his work to apiculture and RFID taaging for identification.
[2] Used an Atmega 328 based monitoring and controlling unit along with a GPRS module. The data from monitoring was displayed on a web portal and the users were kept updated by messaging through GPRS module.
[3] Is a sophisticated monitoring system that employed wireless sensor networks connected to a main mobile network through the internet to facilitate remote monitoring. No provisions for regulating the conditions were provided
[4] From references is a similar work that takes into consideration various other factors like dew point, leaf temperature etc. and processed the data using logical regression techniques to regulate the output. This would be required in research specific or precision specific agricultural models.
[5] Is a project related to precision agriculture that was dependent on wireless sensor networks.
[6] Is a monitoring model based on cloud and it harvested solar energy to power the setup and used a GSM module to update the users with latest conditions.
[7] Is a paper that gave an overview of an intelligent monitoring system that can be employed in greenhouses to monitor the environmental conditions while eliminating the need for physical presence.
[8] Was one of the earlier works which demonstrated the application of IoT in the field of agriculture using node MCU as the central component and IR module to collect wireless data from sensors and subjected it to further processing on software platforms and performed actions like sending SMS to users etc.
[9] Is one of the earliest works in the sector that explored the scope and proposed various applications and architectures of IoT and cloud computing technologies in agriculture.
[10] Is the official documentation referring to the Intel Galileo gen2 board.
[11] Discussed application of IoT and cloud computing to improve crop yield in agriculture and also mentioned a mathematical explanation for high yield based on above technologies.
[12] Proposed a general system for monitoring greenhouse environmental parameters and use cloud platform to send the data to farmers or concerned users.
[13,14] Discussed various methods of applying internet of things to agriculture to make it more sustainable and intelligent.
[15] Is a similar work that used a relay node connected to a control cabinet which controlled ventilation, roller blinds etc. Also, GSM was used to send SMS to the farmers regarding the events in his field. Solar energy was also involved in this work.
[16] Discusses various opportunities for application of internet of things in agriculture with references to the Indian ecosystem.

III. PROPOSED SYSTEM

The current proposal involves employing a set of sensors to monitor the environmental parameters in the greenhouse and corresponding output devices to regulate the conditions as desired by the user. The intel Galileo gen2 development board is the pivotal component of the system that collects, processes inputs, regulates the outputs and facilitates flow of data to the cloud.



IV. METHODOLOGY

4.1 Environmental parameter monitoring

All the major parameters that effect a plant's growth are monitored with the help of sensors interfaced to Galileo gen2 board. The sensors used in this project are LM35 temperature sensor, DHT11 temperature and humidity sensor,DF-SEN0161 for soil pH measurement,DF-SEN0172 for light intensity measurement and a capacitive soil moisture sensor. The values are recorded continuously and simultaneously uploaded to the cloud for remote access and monitoring.

4.2 Maintaining the desired environmental conditions

Based on the type of crop and its optimum conditions the Galileo gen2 board is programmed to take

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

corresponding actions with respect to output actuators based on the sensor readings.

In this project the threshold for soil moisture is set at 40 percent below which the water pimp will automatically turn on and water the plants until the desired moisture level is obtained. The relative humidity and temperature values determine whether to turn the fan on or off or more precisely determine the speed of the fan. In this work, various speeds have been assigned to various temperature ranges. Whenever the value exceeds 35 degree Celsius, the fan will rotate with maximum speed in order to provide maximum cooling. In geographical locations with sub zero temperatures, heating can also be realized artificially with the help of fluorescent lighting.

Adequate lighting is an essential factor in plant growth. So if the natural lighting is not sufficient, it is compensated with SMD LED strips that can give varying intensities of lights while consuming reasonable power. By providing required wavelengths, photosynthesis can be made to carry out even at nights.

The output actuators used here are rated 12V DC and 1-3A current. The output current from a Galileo gen2 output pin is limited to the range of a few milli amperes and hence the actuators and other devices cannot be directly connected as output to the Galileo gen 2 board and hence require the support of a relay or power transistors to switch the logic level from Arduino to the desired voltage and current coming from an external power source. TIP120 transistors have been employed in this case because of their cost efficiency and ease of operation relative to relays. The base of the transistor is connected to the output pin from the Galileo gen2 board and the emitter pin is grounded with the collector pin connected to the negative terminal of the output device. The other end of the device is connected to the DC power source. So the value at the base of the transistor determines what part of the power from the source must pass through to the device which is grounded through the emitter. Hence if pwm pins from the board are used to connect the base, the varying voltage will ensure varying output values corresponding to different speeds, intensities etc. A normal p-n junction diode is also used to ensure that no accidental current flows in the opposite direction hence guarding the devices and the board from damaging as it will block out all the reverse biasing currents.

V. IMPLEMENTATION

A. Software required

1.Arduino IDE 1.8.0 and above
2.Virtual terminal: putty/teraterm
3.Intel Edison virtual com port driver
4.Thingspeak cloud platform

B. Hardware required

1.Intel Galileo gen2 board
2.SMD LED strips
3.12V DC cooling fan
4.12V DC submersible water pump
5.TIP 120 /PN2222a transistors
6.Intel Centrino N6205 wi-fi card
7.6 pin FTDI header
8.Temperature, light intensity, soil moisture, humidity sensors.

5.3 Setup Description

The above figures show a snap of the set up that was employed as a part of this work's implementation. The transparent structure of the greenhouse was replicated using a plastic container for prototyping. Fig. 4.3.1 shows the initial setup of all the components and their connections. Fig. 4.3.2 shows the components encased in the artificial structure.

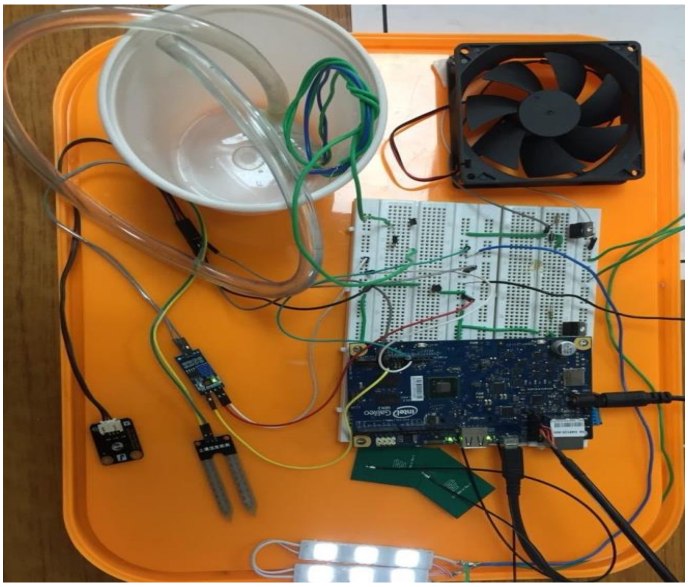


Fig.5.3.1. Initial Setup

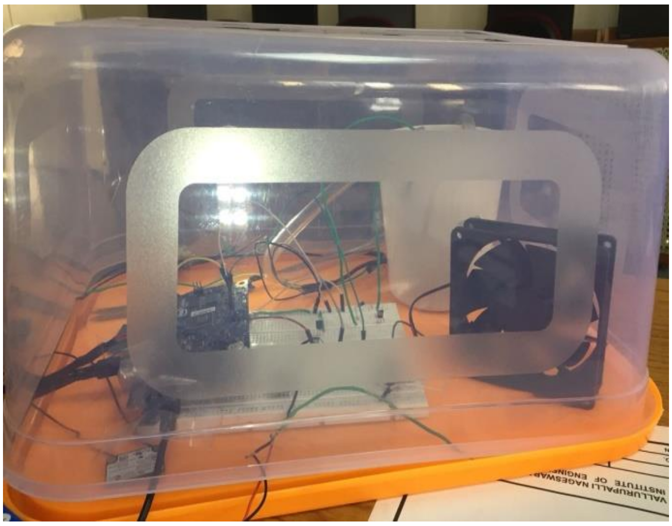


Fig.5.3.2. Final implementation setup

5.3.1 Salient features of Intel Galileo gen2 board. The central part of the set up is the Intel Galileo gen2

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

development board. It is based on the Intel quark processor which is a 32 bit Pentium class system on chip. The central clock frequency is 400 MHz It also comes with an integrated real time clock. The pin layout of the Galileo gen2 board is similar to that of Arduino uno and hence it is compatible with most of the general purpose Arduino shields. It has additional features like on board Ethernet port, SPI header, ICSP header and a USB host port. Another important feature missing in the Arduino but supported in the Galileo gen2 board is the capability to run Linux distributions. The quark processor supports the yocto 1.4 poky Linux distributions. The various Linux features can be accessed using the system ( ) call. It also facilitates the booting of the board from an SD card that can be used to store the present sketches hence even when the host system has been disconnected, the sketch can be retrieved and run from the SD card which is not possible in the Arduino uno board.

5.3.2 Sensors. In the proposed model, four sensors are used. The soil moisture sensor used is a resistive one, meaning the value of its output is a measure of the resistance value between its two leads. When it is powered properly, it passes current through the two of its leads i.e. through the soil. When moisture is high, the water in the soil increases the conductivity and hence the resistance value measured by the sensor decreases and vice versaThe light sensor used here is powered with a supply voltage of 5V. It internally uses a photo resistor that produces an output current based on its resistance which is in turn dependent on the amount of light it is exposed to. This current determines the output value of the resistor. Brighter light will have a higher output value and vice versa

The temperature and humidity are measured using the DHT11 sensor which internally has separate circuits for measuring temperature and humidity. The humidity sensing principle is similar to that of sensing the moisture level in the soil, with two electrodes and a substrate whose conductivity depends on the value of thee humidity. The temperature sensing component functions in a similar way as that of the light sensor but uses a thermistor in place of photo resistor.The pH sensor also has two electrodes, one of which is considered to be a neutral electrode. The potential difference of the solution, in this case soil, is measured using these electrodes and the corresponding hydrogen ion concentration is obtained from Nernst equation which gives the pH value of the soil.

5.4 Programming environment

The programming environment used in this project is the one used for Galileo boards which is the same as arduino software IDE. Any version of the arduino IDE above version 1.6.0 will be compatible with the Galileo gen2 board. It is also possible to make requests to the Linux shell using the system ( ) call which gives the board power to integrate with technologies like python, node.js, openCV etc.

The yocto Linux distribution is used to access the Linux in SSH .The program files required for this are stored on an SD card and the board is made to boot from the SD card .The serial communication used for this purpose is carried out by using a 6 pin FTDI header on the board and a serial COM port on the system. Virtual terminal software like putty or teraterm is used to carry out the serial communication from the host system and also to enable and connect the board to wi-fi networks. Such softwares are required because the network adapter used i.e. the intel centrino N6205 chip works only on a linux operating system. Hence they are used to emulate linux on a windows system.

VI. RESULTS

The properties of artificial structure of the greenhouse were replicated using a transparent plastic container. Other alternatives available were a transparent sheet but this wasn't viable because of its low strength and a proper glass structure wasn't viable because of the difficulties in its portability.

The setup was tested for various conditions of temperature, light and moisture levels. They were artificially created like covering the light sensor completely and placing it directly under a flash light etc. similarly the soil moisture sensor was inserted in dry soil and then in wet soil and the temperature sensor was brought in proximity to a lit match stick.

A few screenshots of the same are attached:

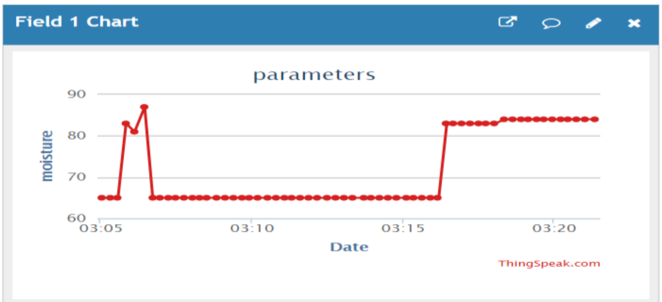


Fig.6.1. Moisture values on Thingspeak cloud

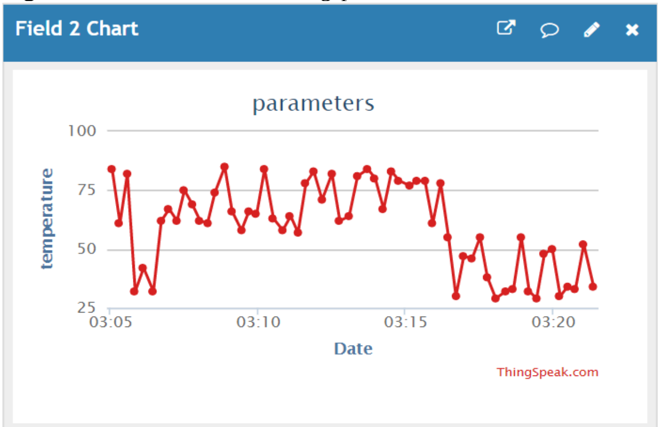


Fig.6.2. Temperature values on Thingspeak cloud

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

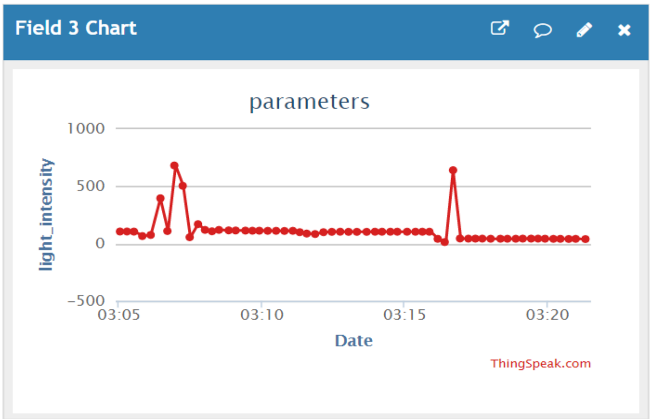


Fig.6.3. Light intensity values on Thingspeak cloud

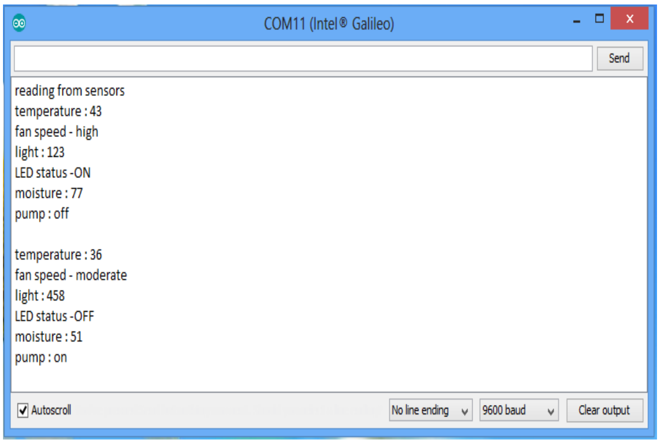


Fig.6.4. Displaying values on serial monitor

VII. CONCLUSION AND FUTURE SCOPE

Although the proposed project is implemented on a small scale, the same can be extended to a large scale by replacing the sensors with a network of sensors. So the concept of smart greenhouses need not be confined to one or few plants and hence it can supersede conventional agricultural practices as well.

With internet of things expected to have an impact on all fields of life in the future, agriculture can also be benefitted from it which can in turn address the problems of world hunger and food scarcity. Also, the budget can also be controlled as a lot of wireless technologies are becoming more economical by the day. The concept of greenhouse itself can be expected to be quite popular because of its ability to provide a safe and regulated environment for the crops within and by automating the greenhouse functions; the amount of physical effort required by owners will be significantly reduced making the whole process more robust.

It also saves valuable resources like power and water as the equipment is turned on only when needed and turned off later automatically. The constant monitoring and regulating of the environment within the greenhouse can also act as a short term solution the problems posed by global warming. The efficiency of the overall production process will also be increased because a lot of time that would have otherwise been wasted will be saved by automation and elimination of manual intervention.

REFERENCES

1. Ravi Kishore Kodali, Vishal Jain, Sumit Karagwal: " IoT based smart green house" at 2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)
2. D.O. Shirsath, Punam kamble ,Rohini Mane,Ashwini Kolap , R.S. more: "IOT Based Smart Greenhouse Automation Using Arduino" in International Journal of Innovative research in Computer Science & Technology, Volume-5 , Issue-2, March 2017
3. Ru-an Li, Xuefeng Sha, Kai Lin : " Smart Green house: A real time mobile intelligent monitoring system based on WSN" at 2014 InterNational Wireless communications and mobile computing conference
4. Alberto Castellini, Alessendro farinelli, Giovanni Minuto : "EXPO-AGRI : Smart automatic green house control" at 2017 IEEE biomedical circuits and systems conference
5. Yousef EM.Hamouda, Basel HY.Elhabil : "Precision agriculture for green house using a wireless sensor network" at 2017 Palestinian international conference on information and communication technology.
6. Keerthi V, GN Kodandaramaiah. : "Cloud based IoT green house monitoring system " from International Journal of Engineering Research and Applications'
7. Qin Linlin,Li Linjian :"Implementation of IoT based green house intelligent monitoring system". : An article in the transactions of the Chinese society of agricultural machinery.
8. J Zhao, J Zhang,s Y Feng. : "The study and the application of IoT technology in agriculture" in **:** Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference
9. Fan Tong Ke : "Smart agriculture based on cloud computing and IoT" from Journal of Convergence Information Technology(JCIT) Volume 8, Number 2, Jan 2013
10. Intel Galileo gen2 homepage, https://www.intel.in/content/www/in/en/support/articles/000006108/boards-and-kits/intel-galileo-boards.html
11. Mahammad Shareef Mekala,P.Vishwanathan : "A Survey: Smart Agriculture IoT with cloud computing" at 2017 International Conference on Microelectronic Devices, circuits and Systems.
12. S.Pallavi , Jayashree D, D.Mallapur , Kirankumar Y.Bendigeri. : "Remote sensing and controlling of greenhouse agricultural parameters based on IoT" at 2017 International Conference on Big Datta , iOT and Data Science.
13. Juntao Li, Weihua Gu, Hang Yuan : "Reasearch on IoT technology applied to intelligent agriculture" from Proceedings of the 5th International Conference on Electrical Engineering and Automatic Control
14. Jie Chen, Ting Hu, Jun Hui Wu : "Applications of Internet of Things in facility agriculture"Applied mechanics and materials,(volume 685) pg 517-523
15. Junyan Ma, Xingshe Zhou,Shining Li,Zhigang Li : "Connecting Agriculture to internet of things through Sensor Networks" at 2011 IEEE international conference on internet of things, cyber , physical and social computing.
16. Aditi Mehta,Sanjay Patel : "IoT based smart agriculture research opportunities and challenges" in International Journal for technological Research in engineering.
17. Liu Hai, He Chaobo,Tang Yong, Huang ShiPing." Research and Applicatoin of Service-Oriented Scholar Cloud Platform", Journal of Convergence Information Technology JCIT,Vol.7, No.5, pp.333-339, 2012.

18. Harjit Singh Lamba,Gurdev Singh, "Cloud Computing-future Framework for e-management of NGO's",International Journal of Advancements in Technology,Vol.2, No. 3, pp.400-407,2011.
19. Virtualization and Cloud Computing Group, "Virtualization and Cloud Computing" [M]. Beijing: Publishing House of Electronics Industry, China, 2009.
20. M. Mahdavian, M. B. Poudeh, N. Wattanapongsakorn, "Green-house lighting optimization for tomato cultivation considering realtime pricing (rtp) of electricity in the smart grid", Electrical En-gineering/Electronics Computer Telecommunications and Information Technology (ECTI-CON) 2013 10th InternationalConference on, pp. 1-6, May 2013.

V. SAGAR REDDY,Assistant Professor in the Department of ECE, Pursing P.hD in Speech Signal Processing and completed M.Tech in Embedded Systems and Interested in Research in Internet of Things and VLSI architecture for signal processing algorithms,Real time Embedded systems, Speech Signal Processing and Machine learning for Signal Processing.

GUJJULA RAMYA working as a Assistant Professor in the Department of ECE completed M.Tech in Wireless and Mobile Communications and Interested in Research in Internet of Things,5G communications,Speech Signal Processing and Machine learning for Signal Processing. Attended various Conferences and Workshops.

Author-3
Photo

V. MONEESH REDDY, completed B-Tech in ECE from VNR Vignana Jyothi Institute of Engineering and Technology and interested in IOT.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication