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An Internet of Things Approach to Monitoring and Control System of Agricultural Activities

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Abstract— Internet of things is a technology that encounters various remote monitoring and controlling of devices, which is connected to it wirelessly and here the concepts of wireless sensors networks and Ethernet protocols are made of use. This research paper mainly concerns its application towards agricultural and Irrigational activities such a soil moisture monitoring and water pressure monitoring and soil testing along with Protection against trespassing with motion detections and conservation of energy. This paper implementation holds division of systems into multiple to one of which is the main system and the rest three are the subsystems. The subsystem 1 consists of soil moisture monitoring control, and water pressure sensing along with pump set and vibration alert sensor for motion monitor in and around the related field. The second subsystem will be in use for protection against trespassing with detection of proximity of the object due to motion along the required field fence and will have voltage and current detection sensors for controlling, monitoring efficient energy usage.

The subsystem three will be in use for controlling that is taking all possible measures in accordance with the available current status of the incorporated alerted sensors wherein a user can control remotely access the sprinklers and protective measurable things like electrifying the fences and present activate status. The main system will take in the information from 1and 2 the subsystem communicating through ZigBee communication and will be monitoring and transmitted to the network Router through ZigBee from where the required data will be displayed on to a web home page with necessary Ethernet protocols and current running data.

Keywords: *Internet of Things, Wireless Sensor Networks, ETHERNET, UART, Raspberry Pi, ZIGBEE, IPv4, IPv6.*

1. Introduction

Internet of Things (IoT) is advancement in technology wherein it makes use of Wireless sensor networks nanotechnology and Miniaturization [1]. IoT is all about many physical devices interacting with each other may be person to person or machine to person which is further extended to things. Internet of things will provide seamless connectivity between the things in virtual world with real world thereby ensures anytime, anywhere, anything communications. It helps people to make better decisions such as taking the best routes to work or choosing their favorite restaurant. IoT intends to address challenges of society such as remote health monitoring for elderly patients and pay-as-you-use services.

In the future era of networked infrastructures for household appliances IoT will act as a catalyst in the evolution of a new generation services that will have a great impact on the social and

technological eco-system. IoT will help the user to approach various applications in a smarter way which might be a smart home, smart agriculture, smart industries or enterprise. IoT works with six Cs Connectivity, Communication, Collection, Convergence, Computing, and Content [2]. The user can check the status of any resources in the network. This introduces IoT which is brain of this architecture and it controls web server and remote embedded system module there by the approach will be made smart simple and more reliable towards perfection. This project here is designed to make agriculture smart so as to improve the productivity and also protect the products loss or theft. IoT in use here will have its approach for the local network created and there by monitor the status of embedded devices and take necessary measures passing commands controlling the devices which happen across the web server making use of Ethernet protocols.

2. Background

Ayush Kumar and at al used IoT and picture taking care of to find the enhancement and mineral inadequacies that impact the yield improvement. M.K. Gayathri and at al advance the brisk improvement of agrarian modernization and help to recognize splendid responses for cultivation and profitably clarify the issues related to farmers. Zhou Zhongwei and at al have proposed a strategy to picture and follow country things in a stock system. Li Sanbo and at al base on the gear building, orchestrated plan and programming process control of the precision water framework system. Crush and atal have proposed a way to deal with direct water in country fields. Bo Yifan and atal have focused on the examination of the utilization of circulated registering and the snare of things in agriculture and officer-administration. M.V. Latte and at al have used concealing and model examination to perceive various inadequacies in paddy leaf pictures

Agriculture is the establishment of our Nation. In quite a while, past days agriculturists used to calculate the readiness of soil and impacted assumptions to create which to sort of item. They didn't consider the clamminess, level of water and particularly atmosphere conditions which repulsive an agriculturist more. They use pesticides taking into account a couple of doubts which had leaded a real effect on the yield if the supposition isn't right. The benefit depends upon the last period of the reap on which agriculturist depends.

To improve the productivity of the item in this manner supporting both farmer and nation we have to use the development which evaluates the idea of gather and giving proposals. The Internet of things (IoT) is patching up the agribusiness drawing in the ranchers by the expansive grouping of procedures, for example, exactness and traditionalist development to go facing difficulties in the field. IoT progression helps in get-together data on conditions like climate, temperature, and profitability of soil, reap web viewing draws in the territory of weed, level of water, bug affirmation, creature obstruction into the field, adjust improvement, development. IoT uses ranchers to get identified with his habitation from any place and at whatever point. Remote sensor structures are utilized for checking the homestead conditions and little scope controllers are utilized to control and robotize the property shapes.

- **Internet of Things:** The Internet of things is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to connect and exchange data.
- **Wireless Sensor Networks:** A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or

environmental conditions. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes

- **ETHERNET:** Ethernet is a family of computer networking technologies commonly used in local area networks, metropolitan area networks and wide area networks.
- **Raspberry Pi:** The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries.
- **ZIGBEE:** ZigBee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations. ZigBee technology builds on IEEE standard 802.15.4 which defines the physical and MAC layers.
- **IPv4:** Internet Protocol Version 4 (IPv4) is the fourth revision of the Internet Protocol and a widely used protocol in data communication over different kinds of networks. IPv4 is a connectionless protocol used in packet-switched layer networks, such as Ethernet. It provides the logical connection between network devices by providing identification for each device. There are many ways to configure IPv4 with all kinds of devices – including manual and automatic configurations – depending on the network type. IPv4 is based on the best-effort model. This model guarantees neither delivery nor avoidance of duplicate delivery; these aspects are handled by the upper layer transport.
- **IPv6:** Internet Protocol Version 6 (IPv6) is an Internet Protocol (IP) used for carrying data in packets from a source to a destination over various networks. IPv6 is the enhanced version of IPv4 and can support very large numbers of nodes as compared to IPv4. It allows for 2128 possible node, or address, combinations. IPv6 is also known as Internet Protocol Next Generation (IPng).

Challenges in IoT based Agriculture

This section discusses some of the major challenges that need to be addressed in order to build the IoT. The solutions for these issues need to be come from technological, social, legal, financial, and business backgrounds in order to receive wide acceptance by the IoT community.

Standards and inter operability: Standards are important in creating markets for new technologies. If devices from different manufacturers do not use the same standards, interoperability will be more difficult, requiring extra gateways to translate from one standard to another. In addition, a company that controls different parts of a vertical market (e.g. the acquisition of data, its integration with other data streams, and the use of those data streams to come up with innovative solutions or to provide services) may dominate a market, stifling competition and creating barriers for smaller players and entrepreneurs. Differing data standards can also tend to lock consumers into one family of products: if consumers cannot easily transfer their data when they replace one device with another from a different manufacturer, they will in effect lose any benefit from the data they have been accumulating over time.

Security: As the IoT connects more devices together, it provides more decentralized entry points for malware. Less expensive devices that are in physically compromised locales are more subject to tampering. More layers of software, integration middleware, APIs, machine-to-machine communication, etc. create more complexity and new security risks. The agricultural resource control subsystem and production process control subsystem includes:

- Intelligent greenhouse that allows automatic adjustment of temperature

- Water irrigation that can automatically control flow and save water
- Scientific disease and pest monitoring
- Identification of individual animals allows healthy cultivation
- Monitoring of animal and plant growth
- Product sorting guarantees quality

3. Existing work

There have been a numerous attempts being made for the implementation of Internet of things which are taken as reference for this following work. One such attempt made is Implementation of IoT for environmental condition monitoring at homes [3]. This work mainly describes 4 systems wherein 3 subsystems will be in use for monitoring the environmental conditions in home which might include temperature control, electric and solar water heater status monitor system will also give way conservation of energy by current and voltage monitoring.

The home automation method proposed [5]can distantly measure electrical parameters and control domestic objects. The system comprehensively assists the inhabitants to avoid multiple systems to monitor their domestic utilization. This system can be operated with the help of any of the smart devices such as PC , Laptops or i-Pad .

The basic layout depicting key elements of the integrated WSN with internet system consists of

- Smart Sensing devices,
- IoT Gateway and
- Internet Server.

This system has its own disadvantages every device status which is monitored was not controlled accordingly for optimization of energy in consumption. When any of these devices are left uncontrolled then they will pose serious threat of damage or explosion. The advancements in technology expect that the availability of internet is everywhere and online at all time. Low-cost smart sensor node development enabled devices to be connected easily and corresponding information can be accessible globally. The features of scalability, fault tolerance and effective power consumption of nodes and transceiver IoT have facilitated ambiguity computational ability to internetwork heterogeneous smart devices easily and facilitate availability of data anywhere.

4. Proposed system

The implementation of IoT is here extended towards various agricultural activities which make the user to advance towards increased productivity. It has 4 systems on of which will be main system and the 2 other systems will be in use for monitoring the activities. The 4^{th} system will be in use for taking necessary actions in accordance with the monitored status. Schematically the systems will be represented as shown below.

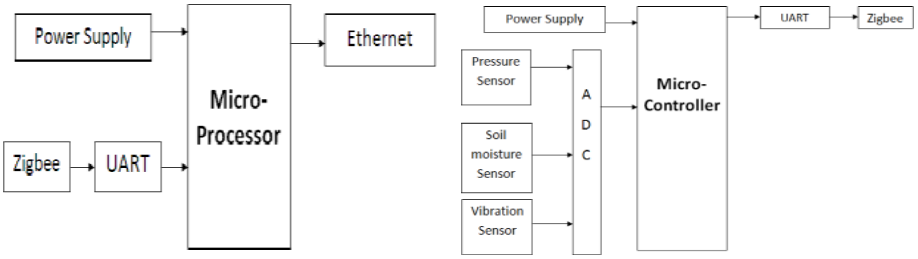

Figure.1: Main System and Sub System

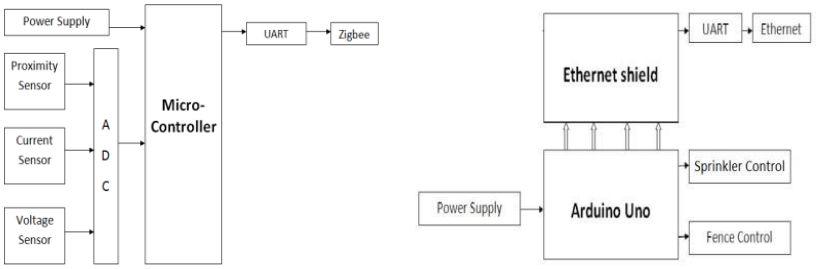

Figure.2: Sub System working process

System Description

The management of embedded devices such as sensor and motor which is done remotely over internet is implemented with the following architectural design and with application of Zigbee communication standards. The data sensed by smart devices is converged with Zigbee along internet which is performed with the help of internet gateway for the given wireless sensor network. The collected by the monitoring devices is collected and sent to coordinator over Zigbee wherein the translation of Zigbee protocol data format to IPV6 format is done at internet gateway.

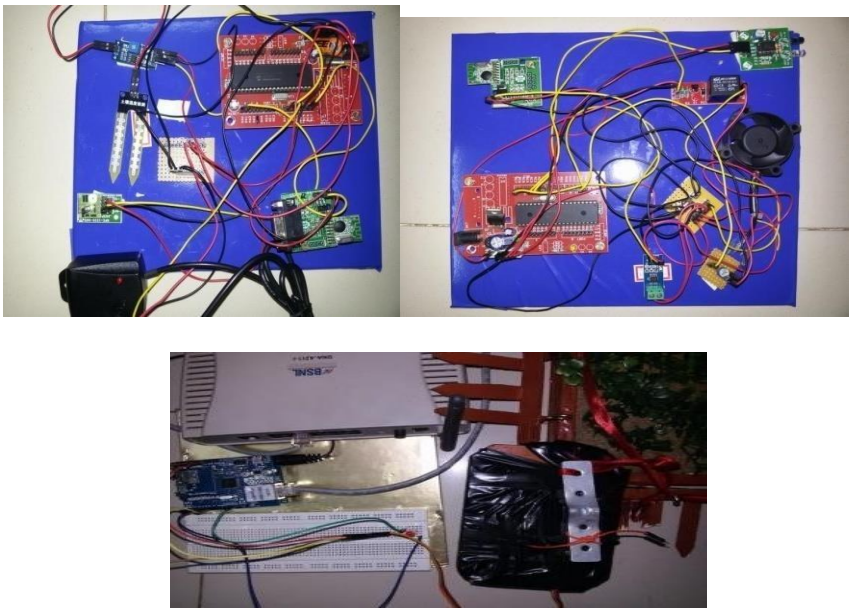

Figure.3: Practical working mechanism

The controlling operation proposed in this project will be done with the help of Arduino Uno processor where the Ethernet shield will act as the translator of controlling data to Ethernet protocol standards and then controlled wirelessly with the help internet gateway. The smart agriculture method proposed in this project will therefore help the user to monitor and control various activities wirelessly in a unified system and thereby reduced the complexity of multicasting of multiple systems. This can be achieved with the help of any of the smart devices laptops or smart phones. Controlling switches as shown in result.

Zigbee Wireless Communication

Zigbee wireless sensor network will be of X2 module and these will act as end devices for communication on transmitting as well as receiving end. This communication happens in the WSN with a mesh topology and could be altered in accordance with the application or with known sensor deployment in the network. The data packets can also be transferred with single or multiple hops for routing and consequently reach the coordinator. The coordinator will be connected to internet gateway through wired LAN connection the router. The router with (OPENWRT)[4] embedded source will access internet and inter connects Zigbee network to IPv6 network.

Sensing Units

Since there are three subsystems as shown below figures will communicate with Zigbee network with coordinator. The sensors so deployed are classified into two units. Type 1 sensing unit will make use of Soil moisture, pressure sensor and vibration sensor which work on the application of monitoring irrigational activities. The sensing will be done periodically with the duty cycle being set. This is the control head for monitoring operation which are being performed as explained. This system will take in all the conjugated data though Zigbee XS2 module and the data is processed in a 32 bit micro-processor with threshold being set and is transferred as characters to internet gateway through UART (RS-232) as in figures.

Subsystem

- First sub system will have Type 1 sensing units that are helpful in remotely monitoring agricultural activities. It consists of three sensors which are Soil moisture, pressure and vibration which are interfaced according to user requirement as in figure. These are analog sensors and are therefore digitized with ADC transmitted to main system with necessary Zigbee standard protocols.

- Second sub system will be of Type 2 sensors where the security concerns of the user and metering of energy will be addressed it includes Proximity(PrS), Current and voltage sensor which are analog again and thus movement across the field detected is converted to binary with precise values and then given away to main system with Zigbee Xs2 module data format as in figure .Same is true for current and voltage where a threshold value will be set as per user instruction and will be monitored accordingly.

- Third subsystem is quite different from the above two as it will not send or receive any data with main system. This itself will act as its control head where the user will control necessary actions for monitored data the Arduino microcontroller will perform actions of

controlling where as the Ethernet shield will host webpage which has moisture sensor, Pressure sensor and Vibration sensors will work with 2mA input of DC 5v to 2v.The soil moisture will be in test consistently but the data will be accessed periodically. The Pressure will be sensed only when the respective equipment mounted with it are turned on [6].

- Type 2 sensing unit use Proximity Sensor (Prs), Current and Voltage Sensor where Prs will come in for safety application detection any movement in the proximity. The Current and Voltage will have energy conservation applications. PrS will be sensed and analyzed continuously. Similarly Current and Voltage will be on for its devices intact on operation.

Control Units:

This will work with Adriano processor and Ethernet shield for wireless control. This includes two controlling one will be for switching on the Sprinklers in response with soil moisture monitor and the other is fence control for safety with respect to PrS. This will require a Power supply of its own and a separate router access as it works with individual IP address for that session connected devices.

Internet Gateway

This is considered to be IoT application gateway that will perform the job of translation of packets of transmission from Zigbee standard to webpage supportive IPv6 standard. The to which coordinator is wired with will be buried with a program that will transform Zigbee addresses and Data Ethernet protocol. The sensed data packets form Zigbee are encapsulated with its corresponding address and converted to IPv6. The gateway with User datagram protocol (UDP) will connect with server and there by helps in wireless communication. The control packets from server will be converted to Ethernet shield compatible by the internet gateway [7].

Address Translation

Since subsystems communicate with the main system through Zigbee protocol and we are displaying this monitored data through TCP Client, it is necessary for us to convert this received data which is in Zigbee frame format to the Ipv6 frame format.

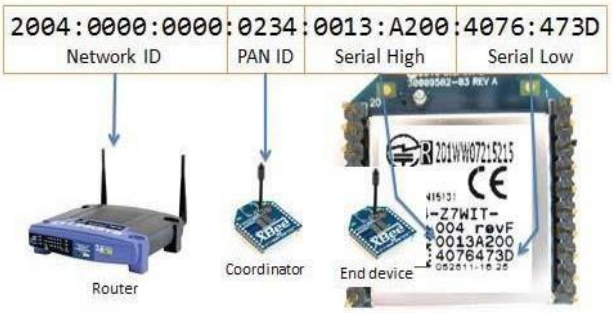

Figure.4: IP Network address

We know that in any given Zigbee network only one Zigbee coordinator should be present and there can be any number of Zigbee router or Zigbee end device. The Zigbee coordinator will create a channel through which the end device can connect to the it and can communicate through that channel. Each Zigbee coordinator will be having its own PAN ID. The sensor deployed in this case will become the Zigbee End Device(ZED). When these devices send their

data in the channel created to the Zigbee coordinator it will append its PAN id to the address to which the End Device are assigned [7]. The End devices address will be 64 bit wide and the PAN id will be 16 bit wide after appending the addresses the total length becomes 80 bit wide.

The PAN id will be used by the Zigbee Router to communicate with the coordinator and the addresses of the end devices will be used to communicate with the sensor nodes. After appending the Pan id to the end device ID the coordinator sends this frame to the Zigbee router. It should be noted that each router will be having its own network ID [9]. The network ID will be 48 bit wide and when this is appended with the PAN id and the END device addresses the total length becomes 128 bit wide. This 128 bit wide address is nothing but the Ipv6 frame packet which is used to display the incoming data in the TCP. It is the IoT application Gateway (Router) that is taking part in appending the Network ID to the PAN ID.

5. Results

The below Figures will be represent the effective representation of the monitored status and the web page being created in response to control operations respectively. These figures depict the remote access being provided to the user in knowing the deployed sensor status and also controlling required equipment accordingly, they will here represent the individual sensor status if soil moisture is found high/low then corresponding message of “high/low soil moisture”, if water pressure is high or low then “high/low water pressure”, if any movement found either by PrS or by vibration sensor then “Movement in proximity” or “movement detected” similarly for voltage and current sensors depicting their status given by the server listed below [3].

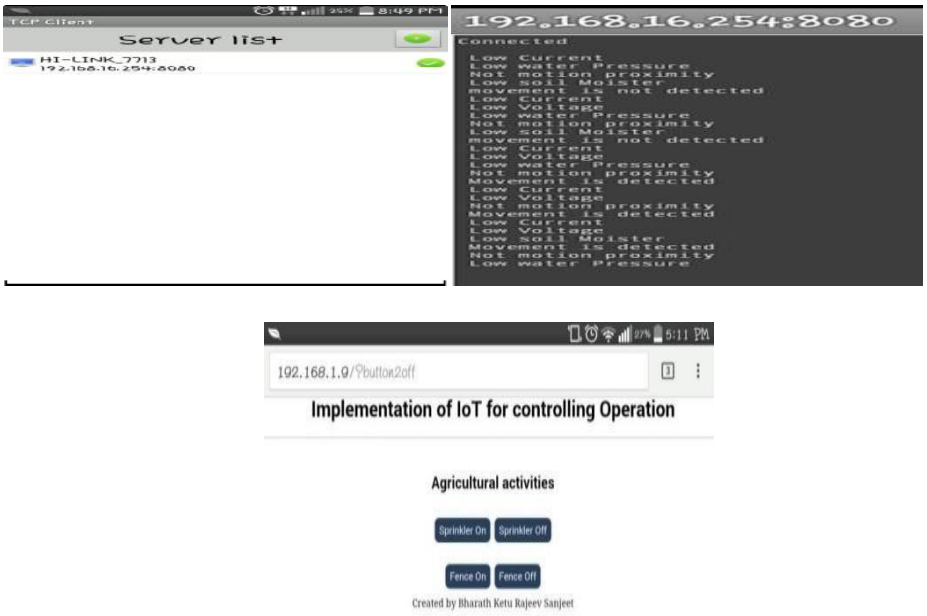

Figure.5: Programming structure and output results

The above figure represents the control operation conducted with the switches created on the web page here sprinkler on or off will turn on or off the sprinkler and fence on will rotate the motor in left to lift the fence and fence off will rotate the motor right so that the fence id let down.

6. Conclusion and Future work

This implantation of IoT will ease the user in monitoring and control of embedded devices remotely. This separation of monitoring and control subsystems will make the use handle the devices individually as per his needs or in accordance with monitored status. The energy metering has done also be extended to different fields such as smart border security, Industrial automation and A very low cost home automation device. As the implementation is referred with IPv6 frame format the edible and existing conversion to IPv4 format is to be employed. Network monitoring can be done in accordance with the reliability of WSN, resource management and deployment factors. Thus web page crash can be avoided and the method would be made more reliable.

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