Secured Architecture For Internet Of Things (Iot) Enabled Smart Agriculture

A. Vimal Jerald, Dr. S. Albert Rabara

Abstract: Internet of Things (IoT) has gained popularity as it is an emerging paradigm in the field of Information Technology Today. Several researches are undertaken by the technocrats at the industry and academia. Many potential applications have evolved using IoT and many more smart applications and services are being deployed. As there numerous benefits, there are issues also especially the security issues. Agriculture is a major domain in which IoT can be used to deploy smart agriculture. This article proposes a secured architecture for IoT enabled Smart Agriculture. The architecture enables a secured transaction of agriculture data from the farms to IoT Kishan Kendra which processes or aggregates the data to be facilitate the farmers with the necessary information.

Index Terms: Internet of Things (IoT), Smart Agriculture, IoT Kishan Kendra.

1 INTRODUCTION

Internet of Things play a vital role in digital era. IoT applications are addressing the societal needs and the advancements to enabling technologies such as nano electronics and cyber-physical systems. The intelligent identification, positioning, tracking, monitoring and management system has been put into applications in various fields [TRAI TD Division 2015]. These days IoT has gained popularity by some of its applications like intelligent traffic system, electric meter reading, and logistics tracking and so on. Different focus groups of Melbourne city have identified Health care, transport, emergency services, defense, crowd monitoring, infrastructure monitoring, environment monitoring, building management and water quality check as fewer potential applications of IoT [J. Gubbi et al., 2013]. New types of applications can involve the electric vehicle and the smart house, in which appliances and services that provide notifications, security, energy-saving, automation, telecommunication, computers and entertainment are integrated into a single ecosystem with a shared user interface. Agriculture is another potential field where IoT can be deployed in an ample ways and means to actualize Smart Agriculture. IoT can be used to produce the best quality produce by controlling the factors which can be controlled by humans like the Soil pH, soil moisture, temperature, humidity, rate of application of nutrients. IoT can be used to automate the grading and packing system with proper identification and tracking mechanism during the time of harvesting. Monitoring the temperature of the produce at the cold storage and when it is in the container during transportation is also feasible using IoT. Real time updates from the retail stores to know the how many units are sold rather consumed, thus to help forecasting the need for more. IoT based analytics on the past data can be used to guide the farmers as to which crop will give them optimal price at what time of the year. [Jeetendra et. al., 2016]. Some of the specific applications using IoT in the area of agriculture are i) fertilizer and irrigation can be used optimally with soil sensors that whether monitor conditions ii) livestock's health and location can be monitored by RFID tags fixed with the animals iii) livestock buildings can be monitored and controlled. IoT involves several devices and objects connected with the help of sensors/devices/ RFID tags heterogeneous in nature. IoT based smart applications are of multifaceted in nature. Integrated networking, information processing, sensing and actuation capabilities allow physical devices to operate in changing environments will certainly have very many challenges. IoT based Agriculture also faces several issues particularly security issues. Hence, this paper proposes a secured architecture for Internet of Things (IoT) enabled smart agriculture.

2 REVIEW LITERATURE

[Jeetendra shenoy et. al., 2016] have explored the IoT based solution for reducing transportation cost, predictability of prices on the past data analytics and the current market condition, reduce number of middle hops and agents between farmer and the consumer. They have reported that they measured soil pH, soil moisture using pH and potentiometer at various points in poly houses and the data collected are sent to control server over WIFI or Bluetooth which controls the various pumps which feed trip irrigation in the poly house. During the harvest phase, sensors and RFID tags are used to collect the information of produce. During the transportation the vehicles are fit with temperature and speed sensors. If the temperature falls due to any reason, the driver is notified by the control server to take corrective action. The proposed solutions are tested in an experimental environment controlled with Arduino Boards using stepper motors. Solutions provided can be used for IoT based smart agriculture deployment. But, the experimental setup of the discussed work was not elaborately discussed. The security issues in the IoT agriculture have not been discussed. [Tanmay et. al., 2016] have come out with an idea of integrating additional methodologies with the latest technologies the IoT and Wireless Network for agriculture modernization. The authors have designed an IoT based device which is capable of analyzing the served information and transmitting to the users. The device can be controlled and monitored from remote location and it can be implemented is agriculture fields, grain stores and cold stores for the security reasons. The proposed concept eliminates threats to crops and delivering real time notification based on information analysis and processing without human interventions. The sensors and devices are controlled rather integrated using python scripts. The article reported that the test cases are carried out and proved 84.81 of success. It is

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put forth to extend the security system to prevent rodents in the grain storages. The system proposed may be helpful to design a smart agriculture system using IoT. But the security system proposed may not be adequate in preventing rodents in the grain store. [Fu Bing 2012] has contributed to agriculture intelligent system based on IoT for the fast production. The report said that the new design Agriculture intelligent system is used to control the crop growth environment and optimize fruit planting management. In the proposed system multiple sensors like temperature, humidity, light, chemistry to check growth process of fruit. In addition to that the RFID technology is used to trace sources of fruits, grade, cultivation, production and quality control, transportation and other specific identifiable information in real time. The fruit production automation is actualized with the help of software. The system starts automation or notify if there is a need for a manual operation. The article is concluded that the introduced IoT based agriculture system will benefit the farmers at large. It is essential to extend the fine tuning of control system. Plant disease identification, insect pests in time as the proposed work is at the experimental level and not yet implemented. [Keoma et. al., 2016] have evolved a project called PEACH to predict foist events by analyzing measurements from sensors deployed around on orchard. They authors developed a methodology for deploying the network and present the open-source tools to assist the deployment and to monitor the network. In the Temperature is measured at regular interval by spatially distributed temperature sensor. Low power wireless mesh network to interconnect sensors densely deployed in the orchard. There are other sensors used to measure as temperature, air relative humidity, soil moisture, soil temperature in the large number of sensing points at the orchard. All the information is collected by sensors are sent to network gateway, a smart mesh IP manager. Backend is the system which connects to the IP Manager, retrieves all the information produced by the mesh network and sends to the remote database. Sole manager and sole server are two software components of Backend. A Raspberry-bi single board is connected to smart Mesh IP manager. Sole manager is the application interface between mesh network and internet. Sole server is the application which allows users to visualize the sensors measurements after they were acquired from the field. The deployment of the work uses sensor object library which is used for generic representation of data produced by the mesh network. The performance results reveals that the proposed system is 100% end to end reliable, 97% stability and with 800 ms latency. Hence, the system in the cited article will be more useful in building IoT based Smart agriculture system. The security issues and their solutions are not discussed. [Duar yen-eet 2011] has attempted to introduce the concept of agricultural information management and analyzing the features of agricultural data by designing architecture of intelligent agriculture management Information system. The purpose of Agriculture MIS is to improve the level of agricultural information process and enhance the intelligent management and decision on agricultural production. The proposed system is composed of layers namely data collection, data transmission and data analysis and process. Data acquisition based on different environmental factors like soil moisture, sunshine temperature, fertilizer, is done using corresponding sensors. GPS is used for collecting location based information of the land. The tracking of crop status is analyzed through the acquisitioned data from the sensors. RFID tags are used for crop handling process including packing, transportation and for selling. It is concluded that the WSN is a suitable method for collecting real world information and when connected to internet for sharing contextual data by analyzing the collected data in remote premises finally implementing the decision back in the real world using actuators and sensors. The disadvantage is that the proposed work has been theoretically explained well but it is not implemented practically in real time rather as even prototype. [Ayush Kapoor et. al., 2016] have explored an approach to combine IoT and image processing for deploying IoT based smart agriculture system. In the proposed work IoT sensing network is created to measure the environmental factors and the images of leaf of lattice. The Collected data is processed in MAT Lab software. The temperature, humidity and soil moisture sensors are used in the system cited to infer the environmental factors. Simultaneously the images processing techniques is used to asses and analyze the health of the plant. Making use of IoT sensor network, exact variations in the plant faces are observed. The images obtained from SD card embedded into IoT sensing network are analyzed using histogram. The decision is made based on the analytics done. It is concluded that the system proposed will help farmers and collected information is communicated to farmers. It is essential to interconnect IoT with cloud computing for a complete consolidated system. Also the security breaches when IoT and Image processing integrated have not been dealt. The article by [Ibrahim Mat et. al., 2016] has reported that precision agriculture used wireless Moisture sensor Network (WM WSN) to enable efficient irrigation. In the proposed architecture, main controller is a major component which manages and optimizes the input and output. Many sensors are used to measure temperature, humidity and moisture. The inferred information from sensors are transmitted to the control panel wirelessly. WMSN reads the moisture condition of the crop and detect water level. The moisture data is sent to the gateway through X Bee wireless Module Gateway sent the data to the control system through WIFI module or GSM module. Central system is internet database which displays the data in graphical form in the device for the end user visualization. Precision Agriculture system which contains map of information related to the parameters like soil and weather for the specific location based on the information obtained, appropriate decision is made to proper irrigation. It is concluded that automatic irrigation using IoT will optimize the use of water and fertilizer and also to maintain the moisture level of crop advised by agronomist. Though the experimental results proves that the proposed system for smart agriculture will be efficient for saving water, the security threats have not be discussed. [Zhao et. al., 2011] have proposed a crop monitoring system using wireless sensor Network. The authors have designed hardware platform, scalar sensor node and image sensor node. The hardware platform consists of Radio Frequency module, Data Processing unit, data storage unit, sensor control matrix for dynamically controlling the sensors of heterogeneous in nature, power supply unit which is capable of powering supply to hardware platform which accommodates low power devices and sensors. Analog interface attached to hardware platform converts the received analog signals from sensors to Digital information for data aggregation. Image sensor node which is controlled by serial camera control bus interface equipped with image processing functions. The software platform consists of the operating system, the kernel and application. The kernel drives the hardware resources and the software drives the interfaces for the applications. It also facilitates the wireless communication protocol stack which enables interaction between the sensor nodes. The software system is responsible for collecting environmental information, information transmitting and the controlling of information collection. The experimental results show that real time temperature and the images captured facilitate the identification of crop growth. The images captured enable decision making in time. The system proposed is not fully automated as IoT which envisages for less human area of agriculture land. The system proposed is prone to security threats as it can be easily affected by attacks both hardware and software. From the above literature there are IoT based smart agriculture systems inadequate security measures. This paper proposes a security architecture which will facilitate mitigating the security breaches using Elliptic Curve Cryptography (ECC) enabled encryption and decryption for secured smart agriculture service.

3 PROPOSED ARCHITECTURE

The proposed Architecture consists of three major units known as User Interface, Smart Agriculture Environment and IoT Kishan Kendra. The functions of all the three units are presented below.

3.1 Components of the Architecture

The architecture for secured smart agriculture functions using internet as backbone and the smart services and applications are deployed in cloud environment known as IoT Kishan Kendra (IoT_KK) using Smart Gateway (SG). Sensors, Smart Readers (SR) and Field Gateway (FG) create IoT enabled Smart Agriculture Environment (SAE). User's device with user interface for accessing IoT enabled smart agriculture is known as IoT Client. The Smart Gateway acts as the interface between the IoT SAE and IoT Client. IoT_KK aggregates the sensed data from the smart service environment and issues the alerts or messages or commands to the actuators of IoT enabled devices in a secured manner. The sensor devices are connected with Smart Reader using short range wireless radio technology permitting peer to peer communication of devices for collecting raw data from the smart service environment. SR collects the sensed data in the form of analog signals or digital signal. In case of analog signal, the SR converts the analog signals into digital data. Soil Moisture sensor and Humidity senor is depicted in Figure 1.a and Figure 1.b Soil moisture sensor, Humidity sensor and Temperature sensor are the sensing devices used to infer the signals from the Smart Agriculture environment and the signals are passed onto SR. The electric signals are converted as the electronic signals transmitted by Smart Reader along with devices identity to the FG. The data communication between the constrained devices of SAE, FG and IoT_KK using Constrained Application Protocol (CoAP) which is suitable for constraint devices and for the constrained networks. Arduino Control board performs the role of SR which is depicted in the Figure 1. c

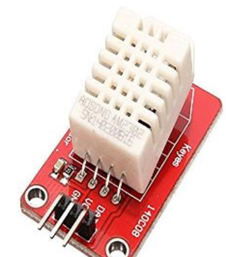

Figure 1b. *Humidity Sensor*

Figure 1a. *Soil Moisture and Temperature Sensor*

Figure 1c. *Smart Reader (Arduino Kit)*

3.2 Functionality of the Architecture

The registered user requests for the smart agriculture information using the registered mobile device. The request is handled by IoT Kishan Kendra. The data aggregated and analyzed in Application Programming Interface Server based on the raw information inferred from sensors. The raw data are inferred from the sensor such as soil moisture sensor, temperature sensor, and Humidity sensors fixed in the agriculture field. The raw data received by the smart reader further sends the same to the Field Gateway. The Field Gateway transmits the data to IoT Kishan Kendra for data analytics to be sent to the user based on the request or as alerts automatically. The Application Programming Interface processes the raw data and the processed data with the help Information Alert Server is sent as Alerts to the user. Also the processed information may be sent to the actuators for further action in the smart agriculture field. The service user and the device, service provider for agriculture service are authenticated and authorized by the security procedures proposed in the architecture furnished. The architecture is constructed with end to end security with different levels such as IoT Client level, Smart Agriculture Environment Level and IoT Kishan Kendra Level. Elliptic Curve Cryptography is incorporated with the design of security architecture to ensure confidentiality, authentication, integrity and privacy in the integrated IoT enabled smart services. These three levels of security are substantiated with multilevel authentication at various stages using Elliptic Curve Digital Signature Algorithm (ECDSA). This is a novel security architecture ensures security with enhanced performances eliminating ambiguity and realizes the vision of IoT enabled Smart Agriculture in a secured manner.

3.2.1. Architecture level Secure Data Processing

The registered user with the registered mobile device using the UI requests for agriculture service to SG at IoT_KK. The request from the user is sent using HTTP along with the user and device certificate which consists of the user and device credentials. Use and user device certificate authentication at SG based on OAuth authentication method is carried out with the credentials extracted from certificate registry. If the credentials extracted from service registry and the credentials with certificate match, the user and device are authenticated successfully. On successful authentication, user request is further sent from SG to APIS for the necessary action rather process. Similarly the raw data from SSE are sent through FG to SG at IoT_KK for data aggregation. The raw data is attached with the service certificate which comprises of service credentials and credentials of SG along with PtK. The CoAP protocol is used for data communication between SAE, FG and SG. If the credentials with the service certificate, PtK and the credentials extracted from certificate registry for the corresponding SAE match, the service is then authenticated. On successful authentication, the raw data fetched from SAE is forwarded to APIS by SG for further action. The communication channel from SAE to SG through FG and the communication channel from the user to SG are secured using the proper security mechanism proposed in the architecture. The process of secure data communication at the architecture is depicted in Figure 3.17.

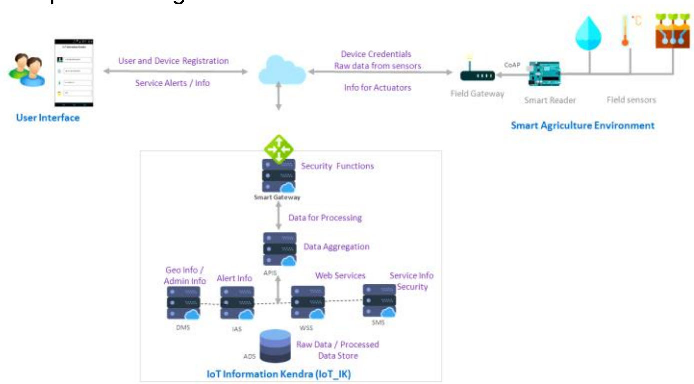

FIGURE 1. *SECURED ARCHITECTURE FOR IOT ENABLED SMART AGRICULTURE*

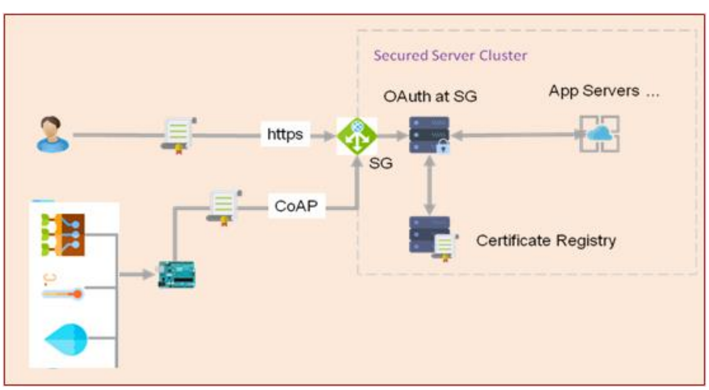

Figure 2. *Secured Data communication at the Architecture*

3.2.2. Secure Data Processing at IoT_KK

The inferred data from the sensor device after service authentication at SG, is sent to the APIS and a data log is stored with DMS. APIS processes the inferred raw data from the SAE based on the appropriate algorithm for smart agriculture applications. The processed information is transmitted with key pairs generated using ECC at SMS. The secured processed information from APIS is sent to the ADS cluster for storage. The WSS and IAS take care of the presentation of the data using HTTP and SMTP protocols.

4 EXPERIMENT RESULTS

4.1 Experimental Setup

The test bed of the proposed architecure consists of Generic K000007 Arduino Kit, Mobile device run on Android OS, Security Gateway, SSL environment and Azure Services Environment. Servers of varied configuration are used as Smart Gateway Server, Field Gateway Server and other cloud servers (Azure Cloud Services) The software requirements of the proposed architecture are Android Development tool kit, IoT User Interface, Open source Arduino software IDE, Parallax Data acquisition tool, Elliptic Curve Cryptography package, Open SSL Tool kit, , Microsoft Azure Cloud Services.

4.2 Data Acquisitioning from SAE

Data acquisition from Service Environment (Smart Agriculture) is achieved in simulated experimental setup with the help of Arduino Uno Rev3 by making use of Soil moisture sensor module, Temperature Sensor TMP 45, and Humidity Sensor Module SU-HS- 220. Open source Arduino Software is used for flashing the program into micro controller. The data from the service environment is inferred using Parallax Data Acquisition Tool. The soil moisture, Humidity and

Temperature data acquisitioned in excel sheet for the interval of 5 seconds. The experimental set up is given in Figure 3. Temperature record set, Humidity record set, Soil moisture record set are illustrated in figure 4.a, 4.b, 4.c, respectively.

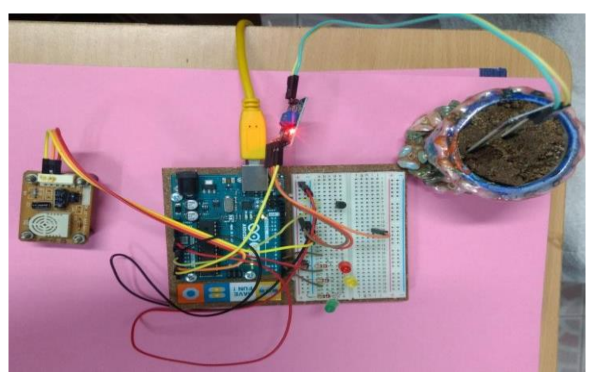

Figure 3. *Experimental Setup*

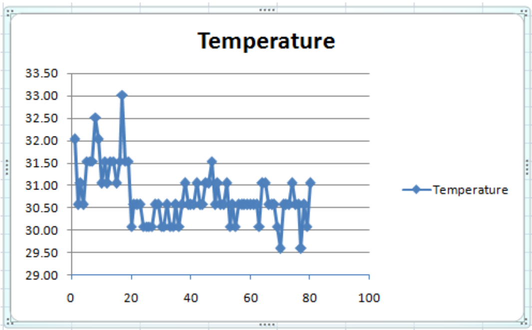

Figure 4.a *Temperature Record set*

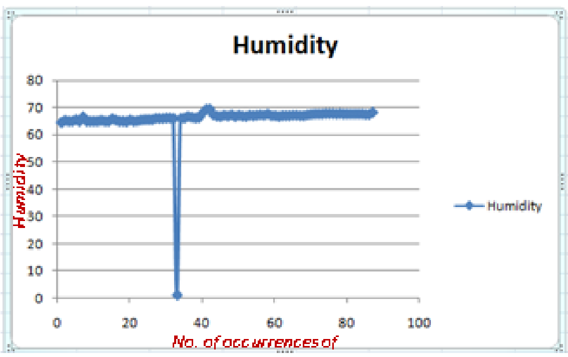

Figure 4.b *Humidity Record set*

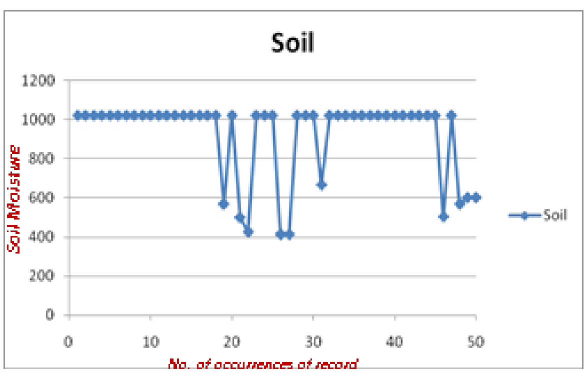

Figure 4.c *Soil Moisture Record set*

6 CONCLUSION

The IoT enabled smart applications and services are playing a major role in our day today life. IoT applications and services are found with security breaches. The proposed architecture facilitates the smart agriculture in a secured manner. The proposed architecture may be suitable for the real time environment. The Government may establish IoT_KK in every Taluk to host IoT enabled agriculture services to the farmers. So, the proposed architecture will be of great use to the farmers for availing IoT agriculture services anywhere, any time in a secured manner.

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