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Smart Farming Architecture Using IoT and Amazon Web Services

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ABSTRACT:
Internet of Things (IoT) technology has brought a revolution to every field. It helps to common man's life by making everything smart and intelligent. IoT refers to a network of things that makes a self-configuring network. The development of Intelligent Smart Agriculture IoT-based devices is day by day turning the face of agriculture production. Not only enhancing it also making it cost-effective and reducing wastage. The objective of this paper is to propose an IoT-based Smart Agriculture System assisting farmers in getting Live Data (Temperature, Humidity, Soil Moisture) for efficient environment monitoring which will enable them to increase their overall yield and quality of products. The IoT-based Smart Agriculture System being proposed via this paper is integrated with NodeMCU which is a wi-fi module producing live data feed. It can be obtained online from efasal.herokaupp.com and mixed with different Sensors. This paper gives an insight on introduction to IoT, agriculture IoT, emerging wireless technologies of IoT, architectures, and applications of IoT.

Keywords Internet of things · Agriculture sensors · Hardware boards · Cloud platforms · Wireless technologies · Website Application.

INTRODUCTION:

Internet of Things is the group of devices with software, sensors, and networking that enables the communication and sharing of data between the devices. It has helped farmers to reduce costs and increase crop yields. One of the major purposes of the irrigation system is to provide and maintain the ideal environment in terms of temperature and soil moisture for the optimum growth of crops. With the usage of smartphones and computers, users can access the data stored in the cloud. Users can keep track of the crops and able to control the water, pumps, and fans in the control panel of the user interface.

In the field of smart agriculture (SA), the internet of things (IoT) plays a pivotal role. In India, agriculture plays the dominant lead in people's survival. Due to the poverty of farmers and the lack of proper agriculture systems, they depend upon rainfall. Agriculture requirements are expanding daily due to the huge growth in the population.

Agriculture is the backbone of India, yet it is the field that is facing issues. The food and agricultural arm of the United Nations predicted that worldwide food production should see a 70% increase by 2050 to feed the growing population. And the experts believe that IoT plays a crucial role in fulfilling this need.

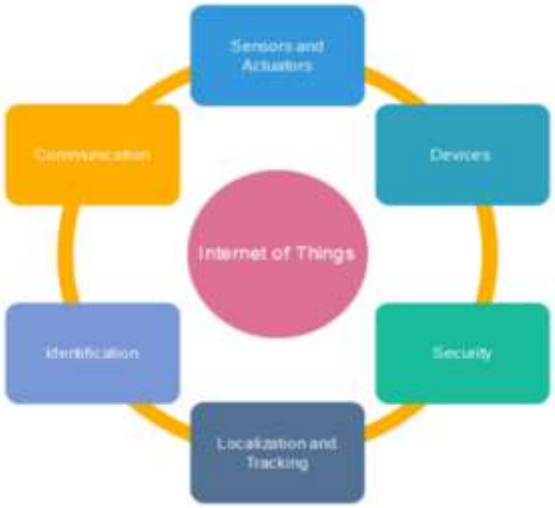

Fig 1: Six characteristics of IoT

The concept is developed on an idea, where there are a lot of devices - such as Radio Frequency Identification (RFID) tags, sensors, actuators, mobile phones, etc., that are connected with the Internet. Each of the devices has a different address and can interact with other devices. The devices are co-operating with each other to reach a common goal. IoT and Image processing are used to obtain quality production by controlling the factors such as soil moisture, temperature, and humidity in the field of agriculture. IoT can be used to provide the best irrigation facility to the field.

LITERATURE SURVEY:

In the existing system of agriculture, the crops are being monitored with the help of Arduino boards and GSM technology where Arduino boards act as a microcontroller but not as a server. Hence to overcome all these features Arduino Nano boards or Renesas microcontrollers are being included with the NodeMCU which the latest version is and also acts both as a microcontroller as well as server. The main feature of this methodology is its cheap cost for installation and multiple advantages. Here one can access as well as control the agriculture system on a laptop, cell phone, or computer.

PROBLEM STATEMENT:

The proposed paper aims to supply water when the farm is dry without human presence and avoiding water wastage in the Agriculture field. Also monitor the soil parameters like temperature, humidity, and soil moisture level. It will also be possible to control various operations of the field remotely from anywhere, anytime by mobile as well as a web application. This gives signals to the mobile phone whether to send water (that is when the farm is dry) to the field or not.

AGRICULTURE IOT:

Need for Agriculture Automation:

It is expected by the United Nation that the world population of the world by 2050 would reach 9.7 billion, which would require a rise in the global agricultural goods production in agriculture to about 69%. To reach this vision goal, farming companies started to adopt the Internet of Things for accurate analysis and higher better production of agricultural goods. Nowadays, smart Agriculture is already adopted by several

modern farmers and its use is increasing production. And also it becoming more and more common among the new generation of educated young farmers. In modern agriculture, the use of sensors, drones, and high-tech agriculture technologies is becoming quickly the new norm. IoT can mainly play a crucial role in the agricultural field such as water management (WM), crop monitoring (CP), soil management (SM).

IoT IN AGRICULTURE:

Fig 2. shows the role of the IoT in smart agriculture.

Fig 2: Role of IoT in agriculture

The key advantages of using IoT in enhancing farming are as follows:

1. Water management can be efficiently done using IoT with no wastage of water using sensors.
2. IoT helps to continuously monitor the land. So that precautions can be taken at an early stage.
3. It increases productivity, reduces manual work, reduces time, and makes farming more efficient.
4. Soil management such as Temperature, Moisture content, etc can be identified easily. So that farmers can sow seeds according to the soil level.
5. Crop sales will be increased in the global market. Farmer can easily connect to the global market without the restriction of any geographical area.

Benefits of IoT in agriculture:

1. IoT enables easy collection and management of data from sensors.
2. With the integration of cloud computing services like Agriculture field maps, cloud storage, etc., data can be accessed live from anywhere and everywhere enabling live monitoring and end-to-end connectivity among all the parties concerned.
3. With IoT productions, costs can be reduced to a remarkable level which will in turn increase profitability and sustainability.
4. With IoT, efficiency level would be increased in terms of usage of Soil, Water, Fertilizers, Pesticides, etc.
5. With IoT, various factors would also lead to the protection of the environment.

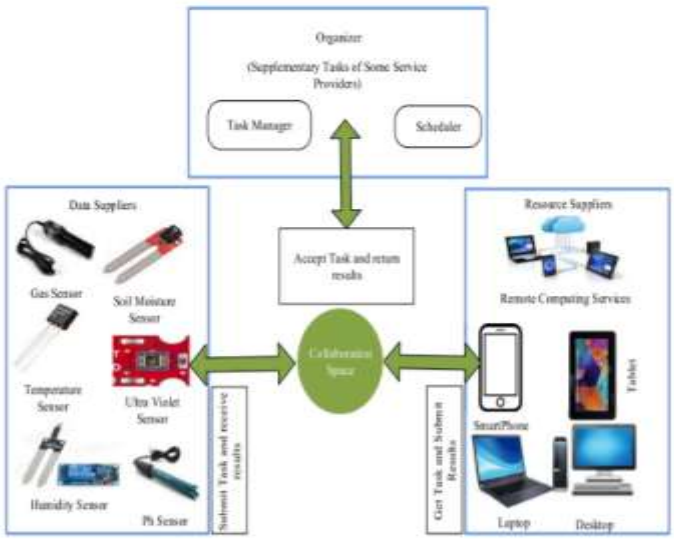

Fig 3: IoT-based ubiquitous agricultural solutions.

EXISTING WORKS:

Nowadays the emerging technologies are playing a major role in the agriculture field. And also with an automated system and implemented various system designs for smart agriculture, precision agriculture, and also drip irrigation. Good research is being done on agriculture. Few existing works are mentioned below.

Krushna Das et al. developed a smart agriculture system in India using the IoT. Farmers have committed suicide due to low crop harvest and unpaid debts. To overcome that issue, IoT-based smart agriculture system with different sensors and Raspberry Pi board and also proposed efficient food corporations of India with the supervision of pests and soil moisture, building intelligent seeds are used to increase yield. However, the design of the system is very robust but high cost. Naresh et al. discussed a smart agriculture system using IoT technology. The author proposed a system for smart agriculture with the help of different types of sensors like soil moisture, temperature, humidity, and water level indicator. These sensors are connected to an ARM 7 (LPC2148) Processor, which will give the analyzed data and send it to the cloud such as Thingspeak. Through the Wi-Fi module only, the data will be received by the farmer on his mobile. Here four sensors are interfaced with ARM 7 which is more robust when compared to the other boards. Ravindranath et al. Introduced a survey on the cloud of things for smart agriculture this model gives complete information regarding the detection of rodents that reduce the yield of crops through the integration of cloud and IoT using three-tier architectures namely back-end layer, gateway, and also Front-end layer. Various parameters are determined by the sensors such as temperature, humidity, and moisture sensors values respectively are displayed on board. The Three-tier architecture was implemented with high cost using layers. Prasanna et al. proposed a theory on controlling and monitoring the plant growth conditions using embedded systems. The system helps in monitoring the plant growth effectiveness with the excellent working conditions along with cost-effectiveness which makes farming easier. Various factors such as temperature, pH level, moisture level, and light intensity are responsible for plant growth. Interfacing all the sensors to the raspberry pi model B, and also has a high cost. The main benefit of this system is used more sensors. Barapatre et al. implemented a design on the determination of soil moisture using various sensors for irrigation water management. This method helps in irrigation and precision

farming methods with resistive and capacitive soil moisture sensors. Soil moisture can be measured by the conventional oven method with water content. Here comparison of resistive and capacitive moisture sensor values determines the soil moisture for irrigation of water management. The hardware implementation had used the Arduino Uno board with a moisture sensor with the help of mathematical modeling.

PROPOSED SYSTEM:

This system aims to enable smart agriculture which means reducing manpower. It overcomes the problems in cropping or any agriculture farms. And the data is right away to the required place of need using the internet of things (IoT). The system uses a NodeMCU along with the wi-fi module with the capability of connecting to the network. Fig 3. shows the conceptual illustration of IoT-based ubiquitous agricultural solutions.

Fig 4: Smart Agriculture Farm

The NodeMCU is initialized and synchronized with different sensors. And it makes a possible way to act as a mini system to control the Farm from anywhere in the world with the help of any smart device using one of the cloud networks. The system enables ease of access to information. that is to be immediately reached as well because we live in an era where the internet is reaching the destination faster than a clock ticking for a second. So this enables sharing data easier and cheaper. Fig 4. shows how the smart agriculture form works in real-time.

HARDWARE IMPLEMENTATION:

Sensors used for Smart Agriculture:

Fig 5: Sensors used in Fasal Kit

Working of Hardware Devices:
NodeMCU has integrated support for the wi-fi network. All sensors are connected to NodeMCU and sensor values are sent to the Flash memory of NodeMCU. The role of Flash memory is when the power is supplied to Fasal Kit it will be auto-compiled every time. To connect with the cloud, the 4G GSM module is used on NodeMCU to starts the communication between Fasal Kit and the cloud. Then all the data will be stored in the AWS cloud.

CLOUD SERVICE:
Cloud Storage on AWS: A reliable, scalable, and secure place for our data.
AWS offers a complete range of services for you to store, access, govern, and analyze your data. And also it reduces costs, increases agility, and accelerates innovation. AWS Cloud services are used to store the Sensor Data.

- The Services which are using in AWS Cloud

1. Aws IoT Core
2.Aws Analytics
3.Aws Sagemaker
4.Aws DynamoDB

NodeMCU to AWS IoT service:

Fig 6: Connecting NodeMCU to AWS IoT

The benefit of using AWS IoT is that it helps to trigger many other functionalities such as Lambda, etc. also helps to store data for further analysis. Once AWS IoT is successfully connected to NodeMCU, you can replace it with ESP8266 of your choice. Fig 6 and Fig 7 are shown how the NodeMCU is connecting to the AWS IoT and steps to connect respectively.

Create a 'thing' in AWS IOT CORE:
In AWS, the devices that connect to the IoT service are called T**hings**. To communicate with the AWS IoT services, some steps need to follow:

- Create a "Thing" in AWS IOT Core
- Generate Keys and Certificates (we will need these certificates in NodeMCU for communication)
- Attach necessary Policies

Fig 7: Steps to connect NodeMCU to AWS IoT

Convert Certificates from .pem to .der format:

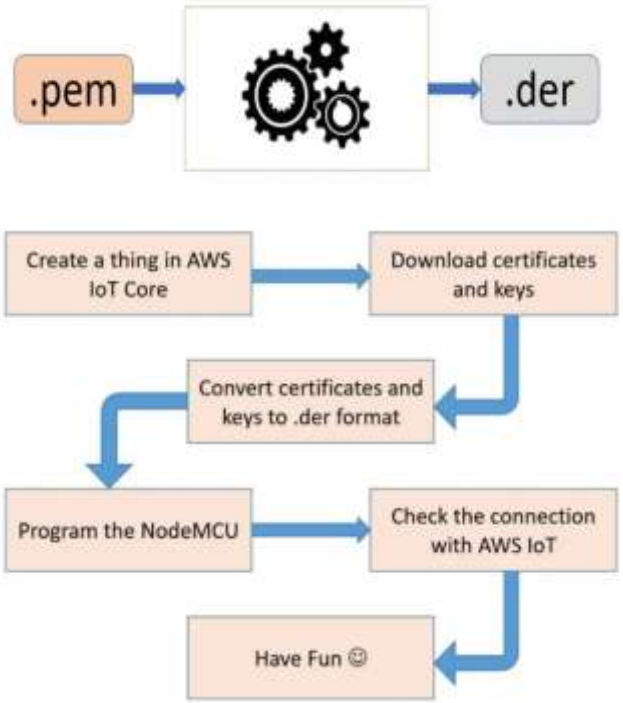

Fig 8: Converting .pem to .der certificate

There are two main methods for encoding certificate data – ".pem" and ".der".

- DER = Binary encoding for certificate data
- PEM = The base64 encoding of the DER-encoded certificate, with a header and footer lines added.

To use certificates with an ESP8266 or NodeMCU, it needs to convert from .pem to .der format. ESP8266 does not understand base64 encoding.

After converting the certificates, A Thing Certificate, A private key, and A Amazon root CA certificate are created. These certificates will be placed in the same folder with a .der extension. After that install the certificates and key in the NodeMCU.

Program to NodeMCU:

Now it is ready to configure and program the NodeMCU. There are two steps to be followed:

1. Upload the certificates and keys in NodeMCU flash memory
2. Program the NodeMCU

Connect NodeMCU to AWS IoT Core to send Data:

After programming the NodeMCU, send the following message from the NodeMCU:

```
{
"Message" : "Hello from NerdyElectronics.com" - 0
}
```

The zero at the end of the message is a count variable. It will update the count every time we send the message.NodeMCU will send the message every 5 seconds. So, you should receive the messages with the values 0-1-2-3…

Three information need to edit in the program:

1. The Wifi SSID or name

2. The Wifi password
3. The AWS endpoint of the thing which we created(To retrieve the AWS endpoint, login into the AWS Console and open the IoT core Services.)

Interaction or checking the connection between NdeMCU to AWS IoT:

- Program to Connect NodeMCU to AWS IoT Core and send data
- Check received messages in AWS IoT – Subscribe to Topic:
  -Once start transmitting the messages, you need to check in the AWS IoT Core if you are receiving or not. for that, we need to subscribe to a Topic.
- Send Message from AWS IoT – Publish to Topic:
  -For sending messages to AWS IoT you need to publish a topic in AWS IoT core.
- After that, you can see messages sent to AWS IoT in Arduino serial monitor.

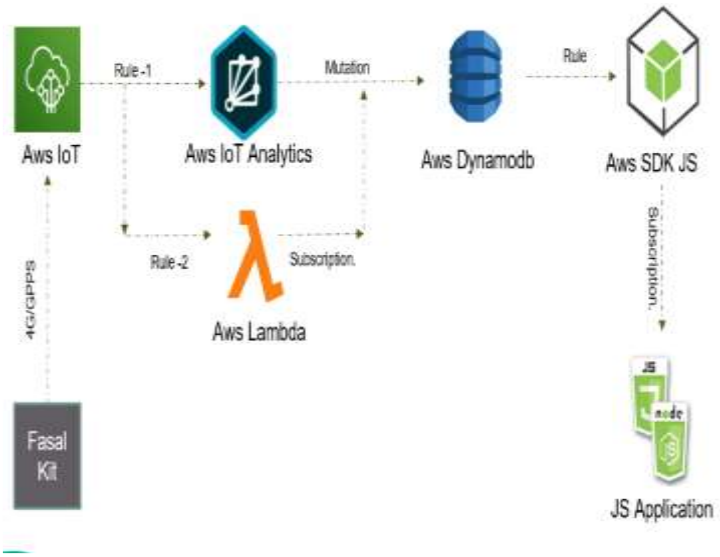

Fig 9: Overall working of Services used in AWS Cloud

Fig 9. Shows the overall working of AWS core to store the data are coming from Fasal Kit. The Fasal Kit is connected to AWS Core through 4G/GPPS. AWS IoT provides the cloud services that are connected to your IoT devices to AWS cloud services. If your devices are connected to AWS IoT, AWS IoT can connect them to the cloud services. AWS IoT Core supports some of the protocols like MQTT, MQTT over WSS, HTTPS, LoRaWAN. After that data will go to AWS IoT analytics, AWS IoT Analytics is a fully managed service that operationalizes, analyses and scales automatically. Also, it supports up to petabytes of IoT data.

AWS Lambda is a serverless compute service that runs your code in response to events. It automatically manages the underlying compute resources for you. You can use AWS Lambda to extend other AWS services with custom logic or After that, the data is stored in AWS DynamoDB. Amazon DynamoDB is a fully managed NoSQL database service that provides fast and predictable performance with seamless scalability. DynamoDB can handle more than 10 trillion requests per day and can support peaks of more than 20 million requests per second. Then the data sent to AWS SDK JS for the web application. The AWS SDK for JavaScript simplifies the use of AWS Services by providing a set of libraries that are consistent and familiar for JavaScript developers. The AWS SDK for JavaScript supports three runtimes:

JavaScript for browser, Node.js for server, React Native for mobile development. NodeMCU's is written in javascript.

WEBSITE APPLICATION:

For our system, a website or any smart device is required for end-users. Fasal is a web application is hosted on the Herokau.com platform. Heroku is a cloud platform that lets companies build, deliver, monitor, and scale apps - the fastest way to go from idea to URL.

Once a user is a login to the website through his credential, it navigates to another page called Dashboard. Here it has three tiles for different sensors(temperature, humidity, and soil moisture sensor) and sensor values on it. If a user wants any particular sensor's value, press on that particular tile. Below that user can see half pie graphs for sensors, it has average and maximum values of sensors. After that Fasal has line graphs for all three sensors, these are show the variation in the sensor values at different times.

One more important feather is check status, here the user can see two modules-check temperature and check moisture. If a user wants any particular crop's status, select that crop and see the result, it will show the sensor value as compared to the optimal value of that sensor. Also, it shows some important feathers to a user. That will helps every former to yield their crop and increases the production.

Fig 10: Login Page

Fig 11: Dashboard

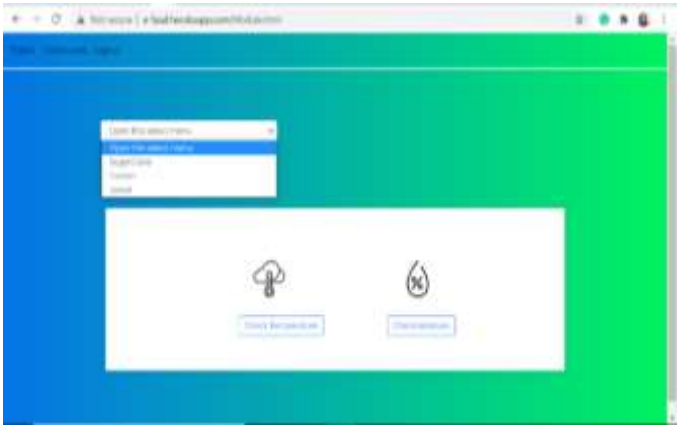

Fig 12: Check status Bar

Fig 13: feature of check status Bar

IOT ARCHITECTURES AND APPLICATIONS:

IoT Architecture:

IoT architectures are mainly classified into two categories such as IoT physical architecture (IPA) and IoT layered architecture (ILA) as shown in below Fig. 14 and Fig. 15 respectively.

IoT Physical Architecture (IPA)

The architecture of IoT consists of four building blocks. They are

A. **Sensors** are all accomplished the place, sensors sense the information from the environment.
B. **IoT Gateways** and systems As the name properly states, it is an entry path to the internet for every one of the things/gadgets that we need to be associated with it. It gathers data from the sensor hubs, and it will transmit to the internet.
C. **Cloud server** Data is transmitted through an entryway is kept away and handled securely inside the cloud server for example in a server farm using data observation.
D. **Mobile applications** The natural portable applications will help end clients to control and screen gadgets from remote areas.

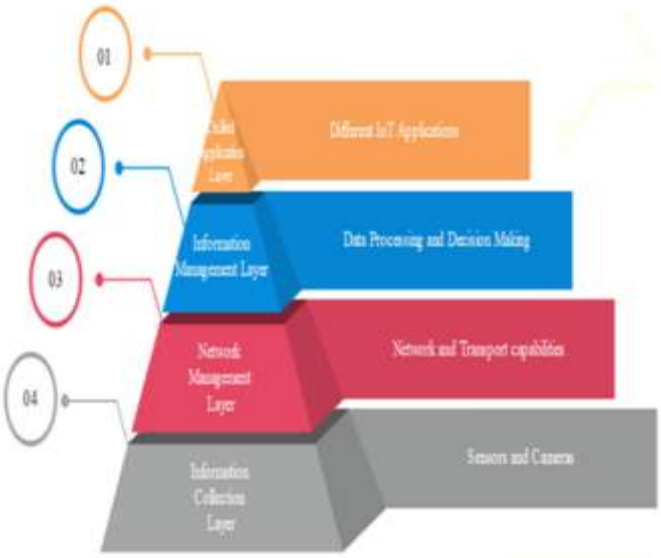

Fig 14: IoT physical architecture

IoT Layered Architecture (ILA)

The architecture of IoT consists of four layers. They are

1. Unified application layer (UAL). Unified application layer is a user interface layer. It consists of related agriculture applications such as cell phones and personal devices.
2. Information management layer (IML). The roles of classification and data formation, decision making, creating, monitoring, and so on
3. Network management layer (NML). This layer is mainly used for communication technologies such as Gateway, UMTS, RFID, GSM, Wifi-3G, Zigbee, and so on.
4. Information collection layer (ICL). It includes different types of cameras, sensors, etc. It consists of information about crop yields for simple and better agriculture.

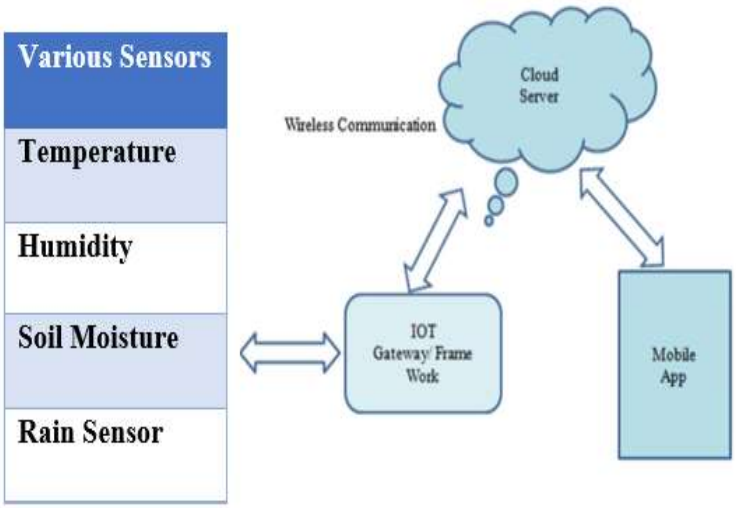

Fig 15: IoT layered architecture

IoT Applications:

Th Fig. 20 shows the complete classification of the applications of IoT primarily consist of home automation, logistics, smart cities, industries, medical equipment, agriculture, energy systems, and also on other domains.

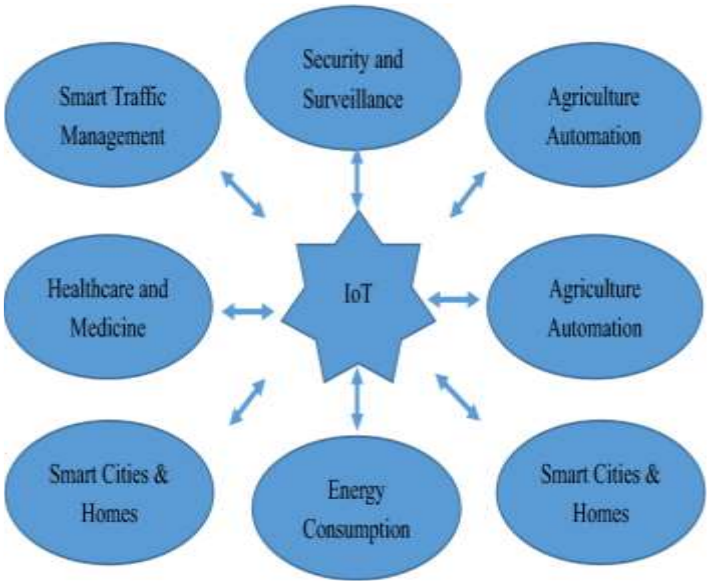

Fig 16: Applications of IoT

CONCLUSION:

IoT-based SMART AGRICULTURE SYSTEM for Live Monitoring of Temperature and Soil Moisture has been proposed using NodeMCU and Cloud Computing. The System has high efficiency and accuracy in fetching the live data of temperature and soil moisture. The IoT-based smart farming System being proposed via this report will assist farmers in increasing the agriculture yield and take efficient care of food production as the System will always provide a helping hand to farmers for getting accurate live feed of environmental temperature and soil moisture with more than 99% accurate results.

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