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IOT ARCHITECTURE FOR AGRICULTURE APPLICATIONS: A FORMAL ASSESMENT

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ABSTRACT: We are into the era where each individual, each device and each object is getting connected through the magical technology called "The Internet of things" on a scale that is inconceivable and it has turned out to be the popular innovation in the present situation. IoT empowers us to detect the physical medium to get to the information and transmit it by using the proper communication technology by interconnecting the detecting medium and the applications. IoT has numerous applications in every domain. Agriculture is one such domain. In this paper, we will look at farming applications from an IoT point of view and how fundamentally the impact of IoT can change the manner in which we do farming. Before structuring any of the IoT applications, it is especially required to have a short comprehension of the compositional perspective on the IoT architecture. In this paper, we have tried to explain diverse IoT architectures. Then towards the end, we have discussed an architecture that is appropriate unique for agriculture. We have, likewise, examined the interfacing technologies, challenges and applications for agricultureas considered from the IoT perspective.
Keywords:IoT,Architecture,Soilhealth,Agriculture

1. Introduction

Currently, the Internet of Things (IoT) has turned into a comprehensivelyexplored subject among researchers, experts, and specialists. Despite the fact that the Web has passed through few phases since it was developed in the mid-1980s, as it has changed from a couple of PCs speaking with one another to billions of computational gadgets and billions of PDAs over the time. With the

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IoT, we are moving towards a stage where all things will be associated with the Internet and will be able to speak with one another with the least human intervention.

IoT is considered as an all-inclusive nearness in the sense that contains an assortment of things that can be associated by utilizing wireless or wired associations. These items have a one of a kind tending to conspire,which enables things to communicate and coordinate with others to make new IoT applications and services such as, smart homes, smart health monitoring systems, smart agriculture and so on...

We have the standard architecture for the working of the Internet and we can also have a general design for IoT which can interconnect things by utilizing the available innovations of the Internet. But it has not been institutionalized yet. In this paper, we discuss diverse available models and we will look at which sort of engineering will be reasonable for the agricultural applications.

The cyber-world is connected to the physical world by a technology called the Internet of Things (IoT) (Atzori et al., 2010; Sterling, 2005; Internet Reports, 2005**).**IoT is defined indifferent ways by different experts. Some definitions are:

‘‘3A concept: anytime, anywhere and any media, resulting in the sustained ratio between radio and man around 1:1” (Srivastava, 2006).

‘‘Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts” (Networked Enterprise & RFID & Micro &Nanosystems, 2008). The semantic meaning of the ‘‘Internet of Things” is presented as ‘‘a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols”.

‘‘A global infrastructure for the information society enables advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies” (ITU work on Internet of things, 2015).

1.1 Current State of Agriculture in India

Agricultural productivity has been influenced by several components [1].The major components are the accessibility to theagricultural information, likethe type of seeds,water,land,the kind of composts farmers will get, how farmers will get credit for doing farming and the way they will protect their harvest and will they get sensible market for whateverthey are growing. The picture of the condition of agriculture in Asian countrieshas been expressed here to underline the task of itselfand the way it tends to be improved by embracing the rise of IoT innovations to enhance profitability.

The real commitment to the total national output (gross domestic product) is from the horticultural division which has diminished from 54% in 1950-51 to 15.4% in 2015-16, while that of the administration part expanded from 30% to 53% [2][3]. Absolute creation of nourishment grains was 51 million tons in 1950-51 and it has expanded to 252 million tons in 2015-16[4]. In spite of elevated amounts of growth, agrarian yield in India is lower when compared to other food grain-producing nations. The quantity of harvest created on one unit of land is known as rural yield.

By 2025[5], the nation's prerequisite for sustenance grains so as to accommodate its populace is anticipated to be 300 million tons. The gauge of sustenance grains generation in 2015-16 is 252 million. So, it suggests that an annual normal development of 2% in the yield is mandatory in the current development pattern. Despite the fact that the agrarian yield of sustenance grains has

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expanded by multiple levels since 1950-51, and was 2,070 kg/hectare in 2014-15[6], it is not adequate for the existing populace

Other than accommodating the work of ranchers and workers, the rural area additionally addresses nourishment security for the country. The Sustenance and Farming Association (FAO) of the Assembled Countries characterizes nourishment security as a circumstance where all individualswill get an adequate amount of nutritious food for a sound and dynamic life [7]. As the required amount of food grains are not produced, 15% of the populace keeps on being under-fed, according to 2014 appraisals [8][9].

Numerous components influence rural profitability. two among the most consideration that influences the agriculture potency are soil and composts. Asthis is often the vital issue that affects the agricultural domain,we must always technically tackle it.We must be able to adopt the IoT framework to provide solutions for implementing the soil health monitoring systems. We will nowinvestigate what specifically the quality of soil is.

1.2 Quality of Soil

Horticultural efficiency to the biggest degree relies upon the nature of the soil. Essential supplements present in Indian soil are nitrogen, phosphorus, and potassium; optional supplements, for example, are sulfur, calcium, and magnesium;small-scale supplements, for example, are zinc, iron, and manganese [10]. Overthe past few decades, we have expanded the food growth drastically, which has led to many issues like an irregularity of supplements in the soil, a decrease in the water levels, nature of water along with the quality of the soil as well. According to a survey on agriculture, the quality of Indian soil is deteriorating [11] drastically.They say each year about 6 billion tons of soil gets disintegrated at averythigh rate.

As the soil has lost its macronutrients the land has become junkyard where we cannot grow any good food. As farmers cannotgauge what type of nutrients are lacking in the soil, they cannot select the proper fertilizer also because of which the yields go down. To overcome this problem the soil health card scheme has been introduced by the Indian government.All farmers will be issued with the soilhealth cards under this scheme, which contains information about soil health, for example,details like the level of nutrient contents available in the soil currently and the fertilizers are suggested to improve the nutrient levels of the soil. Under this scheme around 2.9 crores, farmers have been issued with SHC [12].

The Ministry of Chemicals and Fertilizers controls the type and amount of fertilizers to be used under the Essential Commodities Act, 1955. In fertilizers, we use supplements like Phosphate (P), Nitrogen (N), and Potassium (K). The percentage of urea to be used which mainly contains N manure will be constrained by the authority. But P and K components were decontrolled in 1992 by the Joint Parliamentary Advisory group. This control has been initiated because the amount of urea consumption was more which will decrease the quality of the soil. The proportion of utilization of NPK composts should be 4:2:1 but it is getting adopted in the ratio 6.7:2.4:1. Misuse of urea is usually seen in many parts of India like Punjab, Haryana and Uttar Pradesh [5]. If we donot use urea in proper proportion, it will decrease the quality of the soil over time.The total requirement,availability, and usage of all the fertilizers in India is available in the annual report 2017-18,Government of India Ministry of Chemicals & Fertilizers Department of Fertilizers[13].

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Farmers decide on the type of fertilizer to be used depending on the type of soil nutrient content levels, type of yield they want, availability of water and the type of crop that can be grown in the agricultural land. Forexample, when compared to pulses certain crops like wheat, rice-like other grains and sugarcane require bigger amounts of nitrogen. Even though there is an increase in the number of fertilizers which India is consuming, it is consumed less compared to other countries like Pakistan or China. The quantity of compost for India has expanded from 106 kg for every hectare in 2005-06 to 128 kg in 2012-13. But this growth for Pakistan is 205 kg whereas for China it is 396 kg.

The soil quality depends on the number of micronutrients present in the soil. That's why it is very much required to know about the amount of PNK contents available in the soil. To achieve this, we can automate the process of getting the information from the soil through the incorporation of IoT.

1.3 Connecting Need to the Technology

As the quality of soil playsa serious role in the growth of food grains,the Government of India has initiated a brand-new theme referred to as soil health card (SHC) scheme in February 2015. Inconsistent with this theme,every farmer will be issued with SHC which will contain the advice in terms of nutrients levels and fertilizers for various crops to be grown. Thus, to perform this task of the generation of the SHC, previously the farmerneeds to take his lands soil samples to laboratories to get it verified. After the verification, the report is generated stating the micronutrient deficiency and also the instructed fertilizers. If the farmers use the instructed balanced fertilizers, they will definitelyfind themselves in obtaining a smart yield.

Currently,the Government of India isgenerating SHC once in 3 years. However, this periodic check of once in 3 years isnot appropriate for a few crops whose tenure is 6 or 3 months. As the fertility part of the soil gets deteriorated more quickly, the soil observance ought to happen more often. The frequency of soil testing cannot be increased with this static method and the available infrastructure. This process can be made more dynamic by incorporating the IoT framework. We connect our need forthe generation of SHC to the technology called IoT. Currently,the available IoT technology can be incorporated to connect many things together and they,in turn, can communicate with each other to achieve the goals. Sensor technology has grown tremendously so that we can sense the available physical medium to know about our surroundings. Then these sensed data can be communicated to the gateways or to the cloud by incorporating the available communication technologies. Then the decisions can be made after doing data analysis and we can derive actionable intelligent conclusions out of it.

On the other hand, agriculture as a part of the IoT ecosystem has acquired high attention especially in developing countries like India. Even though India is an agricultural country and its GDP predominantly depends on agriculture, its productivity, when compared to other countries, is less. This low productivity can be improved by adopting the technological revolutions which are currently available. The application of manures in terms of PNK has tremendously increased productivity to some extent, but it is not a wise way to adopt it. Because more use of these fertilizers will lead to contamination of surface and groundwater. At the same time, crop cultivation has many stages and each stage needs different nutrients levels. so continuously and dynamically we should monitor the soil health status. So,the farmer needs a solution to monitor the fields in a

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continuous fashion.Applications of IoT for agriculture will be a game-changer in the present scenarios of the country's farming status.

1.4 Characteristics and Key Features of IoT

1.4.1 Characteristics of IoT

Some basic highlights or characteristics of IoT are:

Enormous scale: IoT gadgets have expanded in billions. These gadgets have the option to speak with one another. The administration of information produced from these gadgets and their understanding of application purposes is the basic requirement.As the number of gadgets has grown exponentially the requirement needs to be addressed in an efficient way.

Dynamic and self-adoptable: IoT devices in the IoT framework should have the capacity to dynamically react according to the changing environment. For example, in the case of the soil health monitoring system, if any of the nutrient levels go down beyond a certain threshold level the farmer should be intimated with the change and he should be suggested with the fertilizers to be used. In this way, the system should communicate on the basis of the current context.

Self-configuring: IoT devices must be having the capability to configure themselves according to current processing needs. For example, in the case of a soil health monitoring system, we may have a WSN of many sensors sensing the environment.If any of the sensor nodes goes down because of some issues, the WSN should not stop working. It should be able to generate the sensed information to the gateway with the available nodes without human intervention.

Interoperable communication protocols**:**A number of communication protocols are supported by the IoT infrastructure to make the connectivity possible.

Unique identity: As IoT is all about things communicating with each other, every object in the IoT infrastructure needs to be uniquely identified. They can be either identified by IP address or URI. In the IoT framework, the applications should be enabled to inquire about any object's status and control them remotely. For example, in the soil health monitoring system if the sensors are identified by their GPS locations then applications may be able to question a particular sensor to get the soil status at a particular location.

Integrated into information network:

As the ultimate agenda of IoT is to communicate information from one stage to another stage they should be always integrated as an information network. For example, we can have a sensor network that can sense the environment and the consolidated information from the sensed nodes can be communicated to the gateway. The gateway can communicate it further to the application layer.The framework should be such that all the devices can be identified dynamically and it should be exposed to other user applications and other devices as well.For example, the soil monitoring hub should be able to communicate its information to the fertilizer module to initiate the recommendation for the status collected from the monitoring module. In this way, all the modules in the infrastructure need to be built in the form of an information network.

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Context-awareness: Usually in the IoT framework, billions of sensors will be connected. So, these many sensors will be generating a huge amount of data at any instance of time. But we cannot consider all the data collected from these sensors.so context-aware computing technologies must be adopted which will decide which data needs to be processed (Yang et al.,2014).

Decision-making capability: Why are we incorporating IoT? The answer is: we want to reduce human errors; so if we want to achieve this, we should impart intelligence to the infrastructure. To make the environment more intelligent we should enable the infrastructure with the available technology.The environment becomes intelligent if it has decision-making capability.

1.4.2 Important Features of IoT

The most important capabilities of IoT depends on its nature of implementation. As the name itself tells "Internet of things", it will provide great connectivity. As it has been designed to take the decision in a smarter way it possessesartificial intelligence. As most of the IoT applications like smart city, smart health monitoring, smart soil monitoring,smart structure monitoring have been proposed and implemented to sense the environment in one or the other way.sensors become the part and parcel of IoT infrastructure. Ithas been designed to actuate some processes depending on the triggered events by the sensors, it will be always into anactive mode of operation.

Artificial intelligence, active engagement, sensors, connectivity and incorporation of small devices make the key features of IoT. These key features are briefly explained below.

AI – This means how nicely we can make things to think and take decisions.For example, if we make our grocery boxes to be as part of IoT infrastructure then it becomes smart. In the sense, if we enable that box to identify the status of the food grain in the box and place the order to the nearest shop vendor when it becomes empty then we can say the infrastructure is possessing AI.That is the demanding feature of IoT.

One more model that we can cite is on account of the soil monitoring system, if the soil supplements level goes down, immediately it can be detected by the sensor and the rancher will be intimated about the situation and the structure can naturally propose the kind of manure to be accustomed to raise the supplement level of the soil.

Connectivity – Connectivity is the most required feature of IoT.The connectivity is there between theinfrastructure and the service provider. It also exists between the small devices which are part of the sensing networks. All these small devices are also enabled with connectivity.

Sensors – The working model of IoT for any sort of application cannot be imagined without sensors. This is one of the featured parts of the IoT infrastructure which transforms any inactive system into the most active segment.

Small Devices –As expected, gadgets have shrunk in size, have become less expensive and dominated overtime. IoT strives to create small devices to convey its accuracy, adaptability, and flexibility.

Earlier, we discussed the agricultural status in India and its importance. We also discussed the factors which majorly affect agriculture. Two important factors are the soil health status and the required fertilizer to be used. So, if we want to knowdynamically, the condition of the soil, we need to link our need to thetechnology. This need has been enabled through IoT.To know how we can make this particular need to be technology-enabled, we should understand the concept of IoT

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architecture. We will now understand a few of the IoT architectures proposed by different researchers.

2. IoT architectures

IoT infrastructure can be defined as an integrated system which behaves like an interconnected network by connecting many physical and virtual things thathave been enabled with the communicationprotocols*. Physical things thatare part of the IoT framework are sensors,actuators,servers, and the communication network. Along with these hardware components, we have many software components that need to be includedin the framework. Among these software components, the most important and demanding module is a middleware, which providesan abstraction between these heterogeneous components and the application layer.Even though we talk about many IoT applications and their implementations, IoT research is still in its infant stage.

Depending on the currently available technology, there are many IoT frameworks in use in the industry. But there is no standardized architecture available yet for IoT. When we want to define IoT architecture many factors need to be considered.These factors include Quality of Service (QoS), data storage reliability,scalability, etc. Another serious challenge with the design of IoT architecture is the interoperability. This exists with IoT frameworks because of the lack of global standardization for devices and other elements of IoT. Each vendor hasits own architecture [15].There is no single standardframework for IoT. Many experts have proposed many architectures [14]. To name few 3 Layer and 5-Layer Architectures, Fog and Cloud-Based Architectures, Social IoT, Standardized Architecture (IoT Reference Model), Architecture for IoT from Middleware Perspective and Application specific Architecture

Many of the architectures mentioned above has its own advantages and disadvantages.But when we are designing some specific applications from IoT perspective we need a special type of architecture called Appplication specific Architecture. As we have to address an application from a specific domain we need this kind of architecture.So let us discuss about an application specific architecture from agriculture perspective.

2.1 Application-Specific Architecture

This kind of middlewareis designed and utilized explicitly for a specific application [17].The entire engineering of this middleware programming is calibrated based on the application's requirement. If the middleware is developed for any particular application domain then the middleware and application are tightly coupled. That's why they are specific to anapplication. This type of architecture cannot be general and universal.

Having discussedseveral general architectural models of IoT applications, let us now discuss a specific architectural framework thathas been proposed for agriculturalapplications. Figure 5 depicts a detailed architectural view useful to provide full-fledged solutions using IoT for agricultural applications.

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Physical Layer

This is the lowermost layer in the agriculture application-specific architecture. This layer basically consists of different hardware devices like microcontrollers, actuators, sensors, and networking devices. Networking devices can be gateways, routers, and switches, etc. The sensors are responsible for sensing the environment. This sensed data to trigger events in the controllers, which activate the respective actuators. The microcontroller which acts as a coordinator transfers the sensed data from the physical layer to the upper layers and it also coordinates to incorporate other networking related functionalities.

Network Layer

This layer comprises of the networking elements required for connecting the devices in the IoT platform. It can use technologies like Bluetooth, Wi-Fi,802.15.4 standard based products, Zigbee, etc... to connect the sensor nodes to the gateways. We can use GSM, CDMA,3G,4G, etc. to connect from the gateway to the cloud. Thus, the network layer facilitates communication technologies as part of the architecture.

Middleware Layer

The middleware layer of the IoT architecture faces a lot of challenges as data from the monitoring field will be advertised by Things more periodically. And the further processing happens depending on this data and hence more device-dependent.SoAn IoT middleware must address non-operational requirements like scalability, timeliness, unwavering quality, accessibility, security and ease of structuring of the IoT infrastructure. In addition, an IoT middleware ought to include architectural highlights to support software abstraction, interoperability, versatility, context-awareness, autonomy, and distributiveness [16]. Hence, the IoT community has come up with many versions of middleware arrangements. Non-functional highlights of IoT middleware frameworks have been discussed in detail in [18-20].

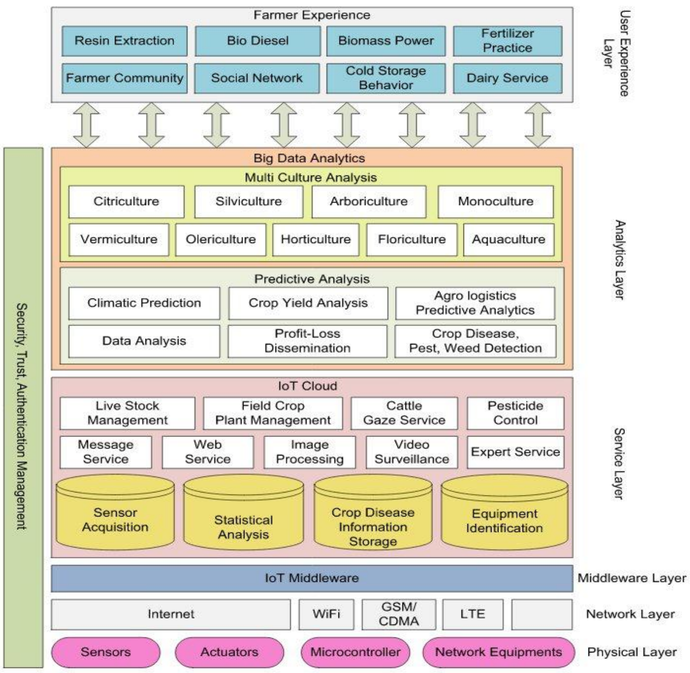

Figure 5: IoT Based Agricultural Framework

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Service Layer

As part of IoT agricultural applications, cloud service is required which can be provided by the IoT cloud. This layer provides cloud storage for agricultural applications.We have already discussed the cloud architecture which can be adopted here in this scenario. Service-oriented architecture for the cloud can be incorporated. If we consider the soil health monitoring system,the cloud service layer facilitates to store the captured sensor data in terms of soil nutrients,device identification, and analysis of acquired data to suggest the fertilizers. Apart from this, it can also support applications like cattle stock management, cropmanagement, irrigation,etc.Thus, we can manage the details of any agricultural applications in the cloud as part of the service layer.Through web services, farmers can be provided with the necessary information. We can also use other ways of communication like message service or expert service. If the cloud has been enabled with image and video analysis then real-time monitoring can be provided as one of the on-demand services. A web-based control panel can provide the required services to the farmers, For example,the farmer can come to know about the soil nutrient contents and the suggestions for the fertilizers, insects intrusion into the field, moisture level of the land, the exact location of the cattle and crop decease type,etc.All these services can be made available to the farmer through auser-friendly web portal.

Analytics Layer

Predictiveanalysis and multi-cultural analytics are required for many agricultural applications and it can be facilitated through the big data processing applied in the analytics layer. The questions like "What will be the yield for the next season? What will be the NPK values of the soil after growing a particular crop? What will be the yield of the crop if I use a particular fertilizer? etc" can be answeredthrough the prediction module of the analytics engine.Such predictions are done as part of the analytics layer. By doing such predictions farmer can come to know about the temperature levels, moisturelevels, climatic conditions,etc. in advance which can help the farmer in taking wise decisions.This can improve the efficiency level of the farmer in terms of the way he does farming. Through data analysis, the farmer can come to know about pest attack, weed origination, and crop disease and he can take actions accordingly to save the crop. Agro-logistics facilitiescan help the farmer to maintain the vehicles cost-effectively to increase the profit. Profit and loss can be predicted using data analytics. Technical aspects of data analytics can be applied to many agricultural applications to minimize many of the risk factors and improve efficiency.Multicultural analysis can also be introduced into the framework. The growth rate of water featured botanicals can be predicted by facilitating aquaculture with bigdata analytics.

User Experience Layer

This is the topmost layer of the architecture. This layer acts as the interface between the user and the applications. Through this layer,the farmer can access all the applications and consult any agricultural experts to know about the status of his farm using the social network. Forexample, he can study fertilizer practice to get more yield. This he can apply after knowing the soil nutrient level of his farm using the IoT framework. The IoT framework should be integrated with the soil health monitoring process to get to know the pattern of the crop to be cultivated depending on the nutrient contents of the soil along with the fertilizer's patterns for a particular nutrient level. Like this, we

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can integrate IoT framework related to any agricultural application with different services to provide a better experience for the farmers.

2.2 Communication Technologies

As the IoT domain is growing rapidly, smart IoT devices are also growing. These devices are battery controlled with limited capacity. Due to their constrained nature, the IoT framework has to face many challenges to enable communication among these devices within the IoT framework. These challenges can be listed as follows [21]:

- Since the IoT framework is a network of small constrained nodes connected through the Internet, their unique identification is a challenge. We can enable communication among these smart constrained devices only when they have a unique identification.
- Just assigning a unique address and enabling communication is not enough, we should also ensure that it should consume less power. The IoT framework should incorporate low power wireless technologies to enable communication.
- Constrained nodes do not have much memory. The type of routing protocols thatare incorporated into the IoT framework should satisfy the low memory constraints.
- Even thoughthe IoT framework consists of constrainednodes, the network should work with high-speed and non-lossy communication.
- The greatest challenge will be when smart devices have mobility.

These IoT devices will communicate with each other using the standard TCP/IP architecture but it is not a good way of communication because of the fact that the framework contains all constrained nodes. So, locally we can adopt different communication protocols that can support low power and low memory constraints.The major communication protocols used in the IoT frameworks are NFC, IEEE 802.15.4,802.11–Wi-Fi,802.16–WiMax,2G/3G/4G mobile communication,802.15.1–Bluetooth and WAN R1.0–LoRa and many more protocols for wireless communication. We will now briefly look into these communication technologies.

3. Challenges for IoT from Agricultural Perspective

We have already discussed the characteristics and features of the IoT framework. Some of the features become actually challenges. Implementation of any of the IoT applications is a challenge. But specifically, if we have to address the agrarian application it has its own inherent challenges. These challenges guide us to work on the betterment of the existing situation in agricultural applications.

Cost-effectiveness

As we develop solutions to the farmers, we should always deliver cost-effective products. So, we should work towards achieving proficiency by incorporating cost-effectiveness. To achieve the goal of cost-effectiveness, an attempt should be made to decrease the cost of hardware as well as software so that it becomes affordable for a common farmer. The technology has developed to the fullest extent but lacks the affordability. The developing countries should work towards the innovation of cost-effective products for the IoT framework. This challenge needs to be addressed deliberately.

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Standardization

Standardization is the biggest challenge of any IoT framework. As there exists heterogeneity to the greatest extent, standardization cannot be achieved to the fullest extent. If we can overcome the issues with interoperability, we can address communication, security, and hardware issues to achieve standardization. But to have a common set of standard prototypes for all IoT frameworks is still difficult because of too many variations in the working environment. We can achieve some sort of standardization with respect to a particular domain. Forexample, we can have a standardized IoT framework for the agriculture domain as discussed earlier like'IoT architecture for agriculture'. So, achieving standardization from the agricultural IoT framework point of view is a challenge.

Heterogeneity

IoT is always a network of heterogeneous devices. Addressing this issue becomes a research challenge from the IoT agricultural application point of view.If we consider any agricultural application then there will be a wide variety of heterogeneous devices available and each should be dealt in a different way as we map the physical medium to the cyber medium and hence the need to face the challenge.For example,consider a soil health monitoring system. In this application,we have a wide variety of sensors to choose from, each behaving in a different way.So we should have an abstract model to address all these things, which is a challenge. When we establish connectivity among these heterogeneous devices the complexity level of the system increases. The authors in [54] discuss how exactly we can efficientlymanage these heterogeneous devices by facilitating the IoT framework with a proper unique identification, addressing and optimization at different levels. Achieving all these features as part of the IoT framework is a challenge.

Context-awareness

Usually, in the IoT framework, billions of sensors are connected. These sensors generate too much data at any instance of time. But we cannot consider all the data collected from these sensors as all the data are not important for decision making all the time. So, context-aware computing technologies must be adopted which decide which data needs to be processed. Most of the agrotasks are lack of context-awareness. Hence, building such an IoT framework with context awareness is a challenge.

Middleware

We have already discussed the role of middleware from the IoT application's point of view.Designing such middleware for agricultural applications by considering all the required features like platform portability, interoperability, context awareness, device management,and security related issues is a challenge.

IoT Node Identity IoTenvironment usually contains a huge number of nodes. To enable communication among these devices every node needs to be uniquely identified. Usually, the unique identification is done by allocating IPv4 addresses to the devices which are getting depleted. The next contender is the IPv6.Soit's a

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great challenge to identify the nodes in the IoT infrastructure. This becomes a challenge because we have to be sure about the compatibility of communication protocols with the addressing which we use to identify the devices.

Energy Management

Sincethe IoT environment is always a resource-constrained network, we should give priority to energy management. In any IoT platform,energy management is the most important issue. So, all the hardware, as well as software components, should be provided with the proper sources of energy. Usually, all the devices are battery-powered. But this is not the best solution always. It is better to enable all these devices with the non-conventional type of energy like solar power,biomass,wind and vibration cloud. Hence, while designing the IoT infrastructure for agricultural applications, we should ensure that all the devices are tested with these power management constraints. To achieve such a power-efficientenvironment is a challenge.

Adaptation to Non-critical Failure

Fault resistance is, for the most part, missing in the above arrangements. To make an impeccable framework, adaptation to the internal failure level of the framework ought to be kept extremely high so that in spite of unintentionalerror, the framework continues working. Equipment modules may fail because of drained battery or some other reason so also,the age of the sensor may lead to flawed adjustment, and disappointment in correspondence will build up a shortcoming circumstance. While looking for an arrangement, solar power enabled modules will work in a better way in contrast to the battery-backed modules. Adoption of a particular communication convention may give the energy utilization a better picture by providing large availability. Facilitating the energy-efficient environment for IoT framework in terms of fault tolerance is a challenge.

4. Agricultural Applications Using IoT

Farming Drones

Farming drones can be used in many ways. These farming drones adopt the concept of unmanned aerial vehicles equipped with many sensors and high-end cameras to fulfill their needs. The major applications of the drones are crop monitoring, soil assessment, plant emergence and population, fertility, cropprotection, irrigation, and harvest planning.UAV innovation in agriculture is a vigorous and practical approach to acquire reasonable information on the field to improve yields and generally speaking productivity in manageable cultivating farms. It spares time, builds yields and gives a rate of return. The control of the UAVs ought to be robotized for both flying and landing purposes with less human mediation. Likewise, this innovation ought to be extremely recognizable to ranchers and henceforth augmentation projects ought to be masterminded to show them how to completely use and execute the innovation. Automation based IoT fuelled exactness cultivating is currently happening in different parts of the world (https://uavcoach.com/agricultural-drones/ accessed on 7th of September 2019) Automaton is being utilized to investigate the capability of utilizing flying imaging to give ranchers data on interest, about their yields.

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Smart Urban Garden

Urban planting is a new concept as faras IoT agricultural applications are considered. An IoT empowered nursery framework (http://postscapes.com/brilliant greenhouse sensor-huiaccessed on 7th of September 2019) has been proposed which can be incorporated by any clients in their places.

Precision Irrigation

The process of irrigation can be automated by incorporating IoT technology. The moisture level of the soil can be measured by the sensors and transmitted to the mobile application. If the moisture level of the soil is more then no action will be taken. If it is lessthen the sprinklers motors will be actuated to increase the moisture level. The water level inside the soil will decide the operation of the irrigation system. Machine movements can also be controlled using GPS based controllers.

Cloud Supported Plant Factory

Cloud supported plant factory can control the imbalance between the number of food grains grown and theirdemand. This imbalance can be addressed by connecting the producers and consumers. This cloud supported plant factory provides a platform where information from the consumers, retailers, and distributors can be collected and delivered to the producers (farmers) on time. By this,the farmer will come to know about the current need and the productioncan be planned according to the current requirement.Hitachi agricultural services have built up a cloud and IoT enabled "Plant Factory Production" (a nearby developing framework that empowers a rancher to accomplish consistent and normal creation of food grains consistently) [22] in Japan. Thisbridges the gap between the consumer and the producer in the horticulture segment.

Soil Health Monitoring Systems

This kind of framework can be implemented using IoT. The nutrient contents of the soil can be gauged using the sensor network. Then the sensed context data can be put on to the cloud. Then data analytics can be applied to decide upon the fertilizer to be used.

5.Conclusion

The adoption of IoT infrastructures for agricultural applications will be definitely helpful for propelling the agricultural and cultivating enterprises by presenting new directions and dimensions. In this paper, we have attempted to present an explicit IoT architectures for agricultural applications.

But its worth stating that none of the architectures are standerdized yet for any domain.still in the process of standerdization. The review likewise highlightedchallenges of incorporating IoT inthe agricultural domain and distinctive farming applications. As a whole, the entire concept of adopting IoT for agriculture has not been developed to the fullest extent. Still different parts of the IoT architecture can be improved from the agriculture perspective. Further research can be pursued in that direction.

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