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IOT-ENABLED SMART FARMING AND ITS CONVINCINGIMPACT IN THE FIELD OF PRECISIONAGRICULTURE

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Abstract
One of the most widely recognized name to scale and benchmark new models is the IoT (Web of Things). This is absolutely a definitive destiny of correspondence that has changed the objects of reality to insightful devices. Helpful piece of IoT needs to interface thing of the world so that individuals have some control over them from anyplace. Moreover, these things (objects) give updates to their end clients as per their ongoing status. Regardless of the way that IoT thoughts were proposed not many years back, this probably won't be misguided to refer to that the term has

turned into a norm for shaping correspondence between things. IoT represent the reference to distinguish the most perceptible applications and gives a precise overview for farming. This paper evaluates the responsibilities ordered by a few experts and scientists over ongoing years. Besides, hardships defied while performing agricultural activities have been highlighted close by the impending examination orientation to plan researchers of this area to assess and also upgrade them with every one of the really inspiring and imaginative considerations.

Keywords: "IoT in agriculture", "Internet of Thinks", "IoT", "Smart Agriculture", and "Precision Agriculture".

1. Introduction

Internet hasalwaysbeen escalated in each part of life during recent years. This is provocative work for scholars to recognize the ideal proximate of Internet use. With the progression of time, theterm "Internet" has been related with objects (things) and is now recognized as IoT, figure 1 shows relationship among three aspects related to IoT. The name IoT implies, things are related to Internet intensively by means of Bluetooth, WiMAX, WSN (Wireless Sensor Networks), RFID (Radio Frequency Identification), NFC (Near Field Communication), & various other communication techniques. This accessory helps to move information collected from numerous devices to foreordained setsabove the Internet. In today's date, IoT has a most significant reliable term in technological world, but it despite everything needs through the potential consistence that it is really prepared to do. After this all, this article expects to help to each one of the individuals who need a simple and more cooperative towards its channelization to serve as a way to disseminate thought and in the ideal way. This article portrays inquire about research articles identified with the field of agriculture research utilizing IoT, thereby to abstract the significant substance & unique studies throughout the years.

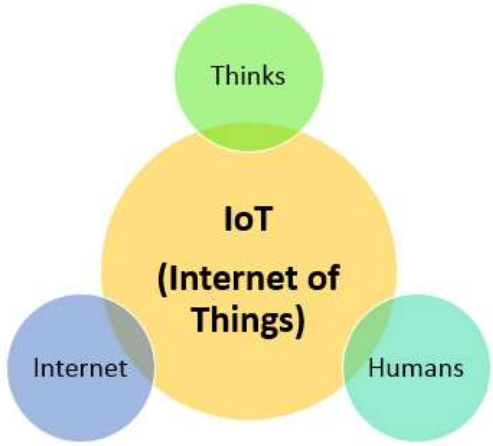

Figure1. Common relationship among Internet, Things and Humans

In the technological era, gap between crop producers and technologies has been reduced. IoT makes this possible to gain the profitability through the feasible development of nourishment for farmers and also proficient utilization of water which contribute to take care of the environment. Here the word smart agriculture incorporates with activities like automated irrigation, monitoring of plants remotely to protect them from insects, keep tracking of plant's germination process, frost

protection etc. The best tool which can upheld these exercises is IoT by using sensor and actuators interfaces, microcontrollers, cloud computing, machine learning, and various conditioning and interface units. The Cloud of objects (Things) is a joining unit of cloud computing and IoT, can help to accomplish the goal of the smart agribusiness. Thispaper is concern with a fundamental aspect that is Agriculture, which is firmly relates to the welfare of any country and the individuals. In India, Agriculture sector is reducing which can be a cause of lesser productivity of production. So, this is to necessitate to determine issue in thiszone to restore essentialness & improvement. Agriculture is mandatory to be progressively equipped to guarantee all-inclusive nourishment security.

2. Motivation

Research motivation behind this work is defined by following questions and their addressable motivation factor:

- What can be the profits of using IoT technologies in agriculture?

  Motivation: To find the profits of using IoT in agriculture.
- In which area of agriculture, IoT technologies can be used?

  Motivation: To identify theagriculture areas where IoT can be used.
- Which devices of IoT can be usefull in agriculture?
  Motivation: To find these devices of IoT, which can be used in agriculture.
- What are the IoT application till the date have been used?

  Motivation: To identify these application.

During the past few years, an adequate increment has been seen in quantity of related terminologies like IoT, expert system, genetic algorithms, machine learning, big data analytics and so forth. Thusly, continuing existing situation of steady progressions in the field of IoT as a top priority, a critical necessity of reconsidering the present structure and abilities of IoT ideas. This article concentrated on a current requirements and their healing options for agriculture and meet exactly the desires that is related to wellbeing of any country.

3. Literature Review

This observational paper has been prepared altogether through doing all assessment on literature work done in this field. To give this survey article a strong establishment, the study consider origination of IoT, included with current trends, tools, invention and innovations. Moreover, the goal was to clearly identify how this idea unfolded for the agriculture sector and what is its current status. The ultimate goal of leading a comprehensive research was to accurately isolate future bearings of IoT in agriculture. This broader context goes as a benchmark that helps to fully understand the nuts and bolts of space and takes the new age experts beyond expectations. Hence, a meticulous detailed survey of all recognized review has been done, to meet the goal. The structure of the existed study depends on reviewing article from various journals, conferences, & chapters. Indispensable works was recognized & extricated through searching the keywords like “IoT in agriculture”, "Internet of Thinks”, “IoT”, “Smart Agriculture”, and “Precision

Agriculture".Khanna & Kaur (2018) featured advanced necessities and their therapeutic choices in the field of agriculture and meets unequivocally to the desires dependent on present day IoT ideas. They also summarized the database so as to accurately recognize the current issues and challenges looked via abstract space & the quick therapeutic arrangements proposed by joining the idea of IoT throughout the years, has been introduced in the examination [3].Atzori, Iera & Morabito (2010) keeps an eye on the Internet of Things. Essential enabling variable of this promising perspective is the joining of a couple of advancements and correspondences courses of action, wired and wireless sensor & actuator frameworks, improved communication conventions & conveyed on understanding for objects are just the most appropriate [4].Alabaa, Othmana, AbakerHashema&Alotaibib (2017) focused around the best in class IoT security dangers and vulnerabilities by directing a broad study of existed work in the area of IoT security. The catalogue of present security dangers with regards to application, design, and correspondence is displayed. They investigate and analyzes conceivable security dangers in the IoT. They talk about the IoT security situation and give an investigation of the potential assaults and also depicted about various research concerns & IoT security execution problems. This study is to fill a valuable guidance for existed security dangers & susceptibilities dissimilar condition of IoT [5].

Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash (2015) gives a summary of IoT by accentuation to empowering advances, conventions, & application matters. Furthermore, they giving a framework to some specific subtleties that identify with the IoT enabling developments & conventions. They additionally give a review of key IoT challenges showed in the progressing exploration and give an overview of related research work and furthermore examine the association between the IoT and other developing advancements. [6].Bandyopadhyay and Sen (2011) considers IoT technology on top class and gives the description of innovative applications, challenges & future study areas of IoT. IoT definitions according to substitute perspective in academic and industry systems are similarly discussed and examined. Finally, some huge issues of future research in IoT are recognized and inspected rapidly. [7].Bauer, Siegmann, Jarmer &Aschenbruck (2016) offered a COTS based unique sensor methodology, which altogether upgrades the capability of IEEE 802.15.4. They used IEEE 802.15.4 Wireless Sensor Networks that is the most significant measurements for depicting bio physical yield situations [8].Chabla, Aviles, Moran, Grijalva, & Recalde (2019) offers a review of the applications of IoT in the field of agriculture like IoT based agricultural programming applications accessible in the marketplace and devices based on IoT used in the cultivating, similarly as the points of interest gave by this kind of advancements. [9].Lakhwani, Gianey, Agarwal and Gupta (2019) introduced an innovative IoT idea in agriculture, summary of some impending systems spaces where IoT is appropriate stand in the cultivation part, points of interest of IoT in cultivating, and shows an overview of some articles. [10].Nukala, Panduru, Shields, Riordan, Doody & Walsh (2016) summarized the study patterns & difficulties of food inventory network business, essentially concentrating on new produce, for example, meat, natural products and vegetables. They present uses of IoT innovations in Food Productivity, Distribution & Transportation. They finish up their research with future work

in the same field. [11].Verdouw, Wolfert &Tekinerdogan (2016) reviewed on papers of IoT in agriculture & offer an outline of existed systems, key issues.

Review shows the matter that an excessive contract of contemplation by mainstream scholars, mainly from China. Quality of their work is to managing the chain of food-supply. These chains are explained as the consequence of cleanliness & food quality management [12].Jayaraman, Yavari, Georgakopoulos, Morshed & Zaslavsky (2016) designed SmartFarmNet, a spearheading exertion in building a versatile sensor data acquisition, assessment, and demonstration of dedicated farming applications, taking into account the IoT. They present the architectural design of IoT that means to help for all intents and purposes any devices, allow quick absorption & opinion of IoT info using programming application. The proposed SmartFarmNet uses innovative constant measurable investigation method which allows ongoing responses to user inquiries [13].Shafi, Mumtaz, Nieto, Hassan, Zaidi & Iqbal (2019) offers a smart device for crop wellbeing checking. The device contained 2 components, first component is a remote sensor based framework for monitoring current crop condition and the subsequent component utilizes an elevation remote detecting stage for acquire multi-unearthly symbolism, which is additionally prepared to characterize solid and unfortunate yields. They also feature the outcomes got utilizing a contextual analysis and rundown the difficulties and future bearings dependent on our work [14].Jawad, Nordin, Gharghan, Jawad & Ismail (2017) traces the ongoing utilizations of WSNs in farming research just as characterizes and thinks about different remote correspondence conventions, the scientific categorization of vitality productive and vitality reaping strategies for Wireless Sensor Networks, which can be utilized in horticultural observing frameworks, and correlation b/w initial study takes a shot at agribusiness based WSNs [15].Garcia, Lunadei, Barreiro &Robla (2010) analysis the specialized and logical condition of WSN. They focused on WSN & RFID, introducing various frameworks accessible, current advancements and instances of uses, including Zig-Bee based Wireless sensor technologies & passive, semi passive and active RFID. Upcoming outlines of wireless communications for cultivation and food productivity have additionally talked about [16].

4. Research Methodology

The process of article selection for study consists of identifying the digital libraries like IEEE digital library, ACM digital library, Elsevier, Science Direct and high ranked open access journals. Then, identified the search keywords interrelated to topic like “IoT in agriculture”, "Internet of Thinks”, “IoT”, “Smart Agriculture”, and “Precision Agriculture”. This process of article selection includes 4 phases, based on language in which the articles were written, time period, keywords and other inclusion and exclusion strategies. The following figure 2, depicts the various phases of article selection for study.

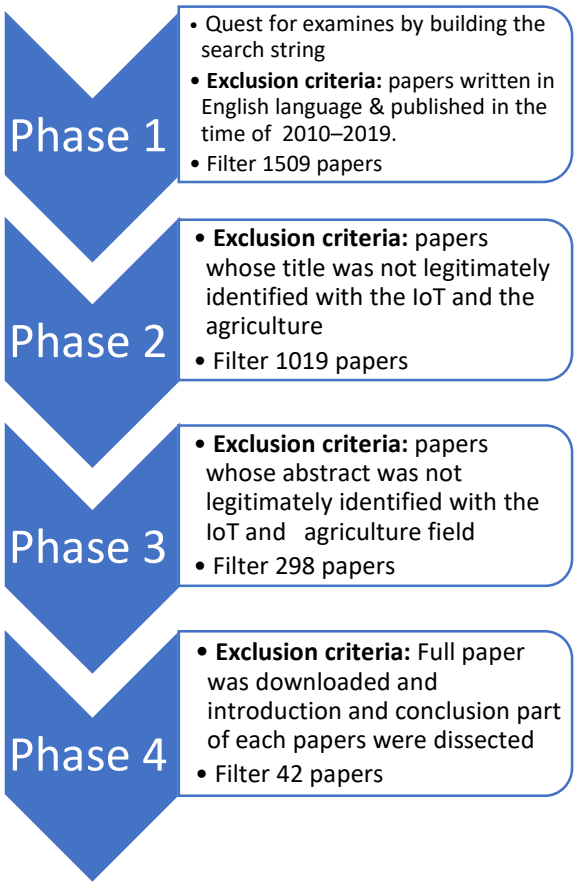

Figure 2. Various phases of article selection for study.

First phase of this article selection process comprised of executing the quest for examines by building the search string:

((“System” OR “Devices” OR “Application”) AND
(‘‘IoT’’ OR “Internet of Things’’) AND
(“Smart Agriculture” OR ‘‘Precision Agriculture’’)).

Besides this we have also apply the accompanying exclusion criteria: papers written in English language & published in 2010–2019. The aftereffect of this phase filter 1509 papers. In second phase of this process exclude of those papers whose title was not legitimately identified with the IoT and the agriculture. The aftereffect of this phase filter 1019 contemplates. In third phase, the process is done by excluding criteria of discarding of those papers whose abstract was not legitimately identified with the IoT and agriculture field. The aftereffect of this phase filter 298 papers. In last phase, we are in situations where we were ensuring the significance of the paper.Full paperswere downloaded, introduction & conclusion part of each papers were dissected. The aftereffect of the last phase filter 42 papers.

5. Communication protocols of IoT

Realization of the IoT concepts into this present reality is conceivable through the coordination of an empowering technologies. The coordination between these technologies can be made up by the

communication protocols. Few of them that makes actualization of the IoT concepts into reality are shown in figure 4.

Figure3. Communication Protocols of IoT

IEEE 802.15.4

IEEE 802.15.4 protocol used to monitor and control applications, which have low data-rate WPAN. This protocol can apply to prolonged life lowpowerconsumption usages. IEEE 802.15.4 protocol specifies only the physical layer, MAC for LR-WPAN. Additionally, the LLC (Logical-Link-Control) and SSCS (Service-Specific-Convergence-Sub-layer) in addition to interconnect with all other (upper) layers [17].

Zigbee

Zigbee is widely used protocol in developing automation, Healthcare services (Medical &Fitness monitoring), and Telecommunicationfacilities. Zigbee can be seen as enhancement of the IEEE 802.15.4 protocol. Zig-Bee is specified in OSI layer-3 and above and it has also work with the layers 1 & 2 for IEEE 802.15.4 protocol. Fig. 5 specified the ZigBee & IEEE 802.15.4 protocol specification to OSI reference model. ZigBee standard specified layers 3 & 4 to define communication upgradation that add authentication to the genuine nodes, security encryption and data routing & forwarding capabilities to enable mesh networking among nodes. In mesh networking topology, any node can interact with another node within range.If any node is not in range, messageis passed via intermediate node [18].

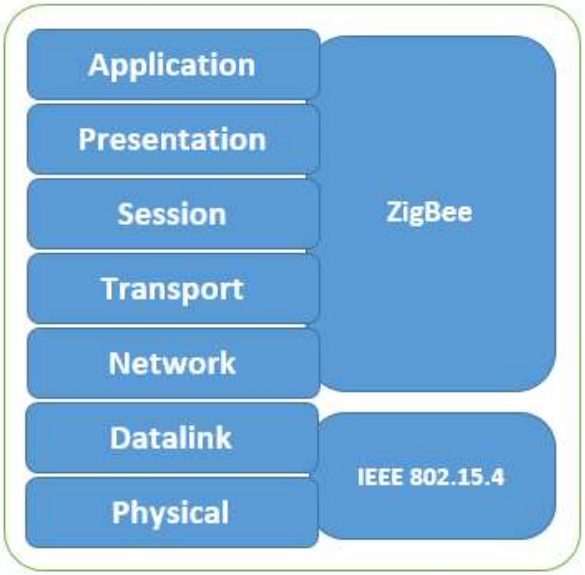

Figure 4. Specification of ZigBee and IEEE 802.15.4 protocol to OSI reference model

6LoWPAN

6LoWPAN is stands for Low-power Wireless Personal-Area-Network over IPv6, developed by IETF (Internet-Engineering-Task-Force). 6LoWPAN permits small devices with constrained handling capacity to transmit data over an Internet by using internet communication protocols. 6LoWPAN can applicable in IoT, Smart-grid and M2M application [19].

Wireless HART

HART protocol stands for Highway Addressable Remote Transducer, was produced for keen organized field devices. HART envelops the most number of field devices related to any field arrange. The wirelessHART protocol is the most recent arrival of HART to makes the usage of HART less expensive and simpler which, empowers device positions increasingly available and less expensive. Principle contrast among wired and wireless forms is in the physical, datalink and network layers [20].

ZWave

Z Wave is mostly used in automation of appliance of home. Z-wave enabled devices can control and operate typically within 100 meter of range. Devices or appliance are usually put into a network as a mesh networktopology. Z-wave frequency range is dividedglobally such as 865.2 MHz for India, 868.42 MHz-869.85 MHz for European countries, 921.4 MHz for Australia, and so on [21].

ISA 100

Like Z-Wave and ZigBee, ISA 100 is also used forwireless communication developed by the ISA (International-Society of Automation). The official portrayal of ISA 100 is Wireless methodto control & monitor of process for industrial Automation [22].

Bluetooth

Bluetooth is a well-known protocol; a layman is also knowing this name. Audio player, Home automation, Smartphones, Hands free headphones are the applications of Bluetooth. Unlicensed ISM (Industrial-Scientific-Medical) sector have range starts from 2.4GHz. to 2.48GHz. used to

perform Bluetooth. Bluetooth technology is based on Ad-hoc Piconets, have operating range classified in 3 classes. Class-3 covered the range of 1 meter/3 foot, Class-2 are commonly used in mobile phones have range of 10 meter/30 feet, and Class-1 covered the range of 100 meter/300 feet [23].

NFC

NFC (Near field communication) enabled protocols are usually seen in Smartphone based payments, Bar codes, Synchronization of toys in computer games, etc. NFC is a branch of RFID, designed to use for devices which are nearest to each other. Near field communication can send with data rate maximum of 424 Kbps. NFC enabled devices can communicate within range of <20 cms. NFC empowered devices can be of two type, Passive devices and Active devices. Passive devices (Example: NFC tags) contain data which is readable by different devices, however it can't peruse data itself. Active devices (Example: Smartphones) can gather and send transmit data [24].

RFID

RFID-tags are used to track and identify the object on which the RFID-tag is stick on. RFID stands for Radio-Frequency-IDentification. Common and very popular RFID application is Fastag to make the charges of tolls. Another application like Controlling access to restricted area (Door lock to unauthenticated persons), Inventory controlling & Object tracking, etc are the example of RFID. A RFID label comprises of a little radio transponder. This transponder can be a radio receiver & a transmitter. When activated by an electromagnetic cross pulse from a closed RFID reader, the RFID tag transmits data, generally a distinguishing number, back to the reader device [26].

Table1 differentiate the various communication protocols used in IoT, based on different parameters like range, operating frequency, hardware technologies and purpose.

Communication Protocols	Introductory Year	Operating Network	Operating Frequency	Range	Cost Comparison
IEEE 802.15.4 [27]	2003	Wireless	868, 915 & 2450 MHz	10 meters	Low
Zigbee [29]	2002	Wireless	ISM bands 2400MHz	10-100 meters	Medium
6LoWPAN	2006	Wireless	915MHz	30 meters	Low
Wireless HART	2007	Wireless	2400 MHz	225 meters	Medium
Z-Wave [26]	2013	Wireless	865.2MHz – India 868.42MHz – SRD Band 908.42MHz – United States 916MHz – Israel	30 meters	Medium

			919.82MHz – Hong Kong 921.42MHz – Australia/New Zealand		
Bluetooth[28]	1994	Wireless	2400MHz to 2485MHz	Class-1 covers 100 meters' range Class-2 covers 10 meters' range Class-3 covers 1 meters' range	Low
NFC [31]	2004	Wireless	13.56MHz	Less than 20cm	Medium
RFID [26]	1973	Wireless	0.12–0.15MHz for 10cm 3.56MHz for 10cm-1m 433MHz for 1-100m 902-928MHz for 1-12m	10cm – 200 meters	High

Table 1: Comparison of various IoT communication protocols

6. Challenge and future work

As we all are aware that IoT is the core technology behind the new era of digitalization especially in the field of agriculture. Since the technological growth of the world may also face some challenges that must be resolve to achieve the goals define by any particular concern area who is working with IoT technology. To design the roadmap of future of IoT, the following challenge aspect must be identified.

- Security related challenges
- Data Privacy and Security
- Data Encryption and Decryption
- Portability
- Continuous system network connectivity
- Procurement of complete instructive assistance

- Continuous operational assistance
- Appropriate administration of on-going services
- Physical wellbeing of items [32]
- Place Sensorsat physical areas [32]

Based on gartner.com study, approx. 21 billion things are associated to internet by 2020 [30]. The ultimate fate of IoT can possibly be endless. Progress to the modern world will be quickened through expanded system dexterity, Artificial Intelligence and the ability to implement, mechanize, organize and make sure about differing use cases at hyperactive scale. The potential isn't simply in empowering billions of object all the while however utilizing the huge volumes of significant information which can mechanize assorted business forms.

7. Conclusion

After the comprehensive study on IoT technology in the field of agriculture with respect tovarious technical aspect, we can conclude that the work progression foragriculture has been still challenging taskat a ground level. As for the most of the model, a simulation or theory has beenmadeto prove the concepts. In this paper, the study of various article has been done after applying the filter measurement. We have also included the study the various communication protocols, which can helpful for designing a device for smart agriculture. Thefollowing points are concluded from this study:

- IoT encourages farmers to control and monitor their crop field activities remotely in an effective manner.
- Since technology is not constraints to any limit, a more effective and reliable aspect of IoT overwhelmed in upcoming years.
- Information resultedfrom different sensors is of vital significance & should be overseen and assessed with an elevated level of accuracy.
- In the upcoming years, significant farming sensors and actuators would be associated over the Internet with the essential goal of assistance, controlling, and monitoring.

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